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Morphological and Palynological Studies on *Geranium tuberosum* L. (Geraniaceae)

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Abstract

Geranium tuberosum L. (Geraniaceae) is perennial tuberous herb and it is represented in Turkey by two subspecies (subsp. *tuberosum* and subsp. *deserti-syriacum*). In this study samples were investigated, morphologically and palynologically which are collected from different localities. The morphological features of various organs of the plants such as stem, leaf and flower are given in detail. In palynological studies, pollens were investigated with light microscopy and SEM.

Key words: Geraniaceae, *Geranium tuberosum,* morphology, palynology.

INTRODUCTION

The genus *Geranium* L. (Geraniaceae) is distributed most of the world, comprises ca. 400 species in temperate areas and tropical mountains, absent only in tropical lowlands, deserts and polar regions [1]. According to the currently accepted classification [2]. *Geranium* is divided into three subgenera: subg. Geranium, subg. Erodioidea (Picard) Yeo, and subg. *Robertium* (Picard) Rouy. [3, 4]. Subgenera *Geranium* is comprises six sections. The section *Tuberosa* is distributed in the Soviet Middle Asia, western Asia, East Europea, Siberia, Caucasus, Northern Africa [4]. *Geranium* is represented by 35 species and 7 subspecies [5, 6, 7, 8, 9] in the Flora of Turkey, *Geranium tuberosum* subsp. *tuberosum* and subsp. *deserti-syriacum* belong to *Tuberosa* Boiss. section [4]. *G. tuberosum* subsp. *tuberosum* is known from different grid square but subsp *deserti-syriacum* firstly only known from C7 square but now we collected it also from C6. Subsp *deserti-syriacum* was collected from C7 Ş. Urfa [10, 11] but there are no morphological and palynological research on this species.

The pollen morphology of the Geraniaceae has been studied by many researchers such as Erdtman [12], Moore and Webb [13], Oltmann [14], Kuprianova and Alyoshina [15]. Pollen morphology of the family studied by Hutchinson [16] and Bortenschlager [17] to find out the evidence of possible taxonomic significance. Also pollen morphology of some *Geranium* species have been studied by Perveen and Gaiser [18]. There are no reports on the pollen morphology and palynology of *Geranium tuberosum* subsp. *tuberosum* and subsp. *deserti-syriacum*.

MATERIAL and METHODS

G. tuberosum subsp. *tuberosum* were collected from K.Maraş Ahır Mountain, (A.Ilcım 1426 KSUH); K.Maraş, Türkoglu, İmalı Deresi, (M. Çenet 1012 KSUH) and Hatay, Belen (A. İlçim 1300 KSUH). *G. tuberosum* subsp. *deserti-syriacum* were collected between Nizip-Gaziantep (A. Ilçim 1609 KSUH) and Hatay, Reyhanlı from Syria border (A.Ilçim 1465). In the palynological research, suitable samples were taken from these materials for SEM and light microscope (Olympus CX21FS1) studies. Palynological studies were carried out according to Erdtman [12] with at least 25-40 measurement for each character. For SEM, pollen and plant parts were directly mounted on stubs using double-sided adhesive tape. Samples were coated with gold/palladium in POLARON SC 7620 ion-sputter and then observed by standard techniques using a LEO 440 scanning electron microscope. Polen terminology used according to Erdtman [12], Faegri and Iversen [19] and Walker and Doyle [20].

RESULTS

Geographical distribution

G. tubrerosum has 4 subspecies, two of them, subsp. *tuberosum* and subsp. *deserti-syriacum* are the native taxa of Turkey. *G. tuberosum* subsp. *tuberosum* diverses rangen within the Southeastern Europe, East Europe, Northern Africa, Caucasus and to Western Asia, The distribution of subsp. *deserti-syriacum* Western Asia. Subsp *linearifolium* (Boiss.) P.H. Davis, rangen within the Soviet Middle Asia, Caucasus and Western Asia. Subsp. *micranthum* Schönb is diverses within Western Asia.

According to Grid square system, *G. tuberosum* subsp. *tuberosum* is distributed in A1(E), A2(E), A2(A), A5, A7, A8, B1, B3, B4, B6, C2, C3, C4, C5, C6 and subsp. *deserti-syriacum* is distributed in C6 (new record) and C7 in Turkey. Distribution of *G. tuberosum* in Turkey was given in Fig. 1.

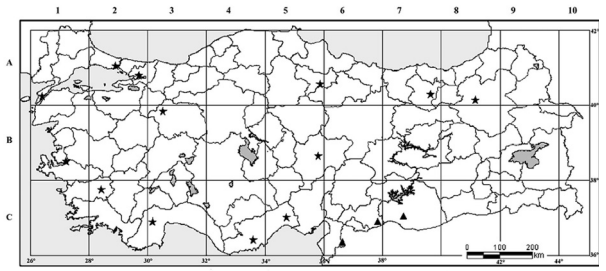


Figure 1. Distrubution of *G. tuberosum* subsp. *tuberosum* ( ) and subsp. *deserti-syriacum* ( ) in Turkey

Description

Erect perennial, 12-30 cm, rhizome slender and swollen into suborbicular terminal and distantly intercalary tubers. Basal leaves palmatisect to the base, segments rhombic to oblong-linear, deeply 1-2 pinnatifid or tooted. Stems pubescent, leafless below the pair of opposite, shortly petiolate leaves at the first dichotomy. Inflorescence cymose, with 1-2 flowered, bracts scarious, lanceolate, 4-5, 0.8-1.2 mm long, pilose with 0.1-0.2 mm long hairs. Pedicels 0.6-1 cm long, straight or curved, unequal, with eglandular hairs. Sepals 5-5.5 x 2.8-3 mm with an apical mucro 0.5-1.5 mm long in subsp. *tuberosum*, 6-6.5 x 3-3.1 mm with an apical mucro of 0.1-0.4 mm long in subsp. *deserti-syriacum*. Sepals are covered with eglandular hairs which are 0.3-0.5 mm long on surface and 0.8-1 mm long on margins. Scarious margine of sepals are 0.2-0.3 mm wide in subsp. *deserti-syriacum* and 0.4.-0.5 mm wide in subsp. *tuberosum*. Petals up to 8 mm long, clearly emarginate, pink, with violet veins, the base with 0.2-0.4 mm long eglandular hairs, upper parts glabrous. Filaments linear-filiform, 3-4 mm long, pilose at base, base expanded, expanded part 0.7-0.8 x 0.6-0.7 mm. Anthers versatile, yellow to brown, 1.6-1.7 mm long, 1 mm wide. Gynoecium 3.8-4 mm long; very densely pilose in subsp. *tuberosum*, sparsely pilose in subsp. *deserti-syriacum*, with 0.7-1 mm long hairs, stigma brown. Fruit light brown, up to 1.7 cm, pilose, mericarps 3.1 x 1.2- mm, pilose with 0.7-1 mm long eglandular hairs, rostrum 1-1.2 cm long, pilose; stigmatic remains 1-1.5 mm long, with 5 lobes coiled in subsp. *deserti-syriacum*. Seed 1.5 x 1.5 mm, smooth. Flowering and fruiting in May.

Key for subspecies:

1. Inflorescence narrowly dichotomous, narrower than height of stem, leaf segments 1- 2 pinnatifid; sepals ± villous, awn 05-1.5 mm…… subsp. *tuberosum*

1. Inflorescence widely dichotomous, broader than height of stem; leaf segments 1- pinnatifid or toothed; sepals not or scarcely villous, awn 0.1-0.4 mm ...subp. *deserti-syriacum*

Morphological Properties

These two subspecies are perennial herbaceous plants. They have slender rhizome which swollen into suborbicular terminal and distantly intercalary tubers or normal single tubers. Basal leaves arise directly from tubers.

Stems: The stems are weak and erect in subsp. *tuberosum* while they are erect (C6 Hatay-Reyhanlı samples) and prostrate (Nizip samples) in subsp. *deserti-syriacum*.

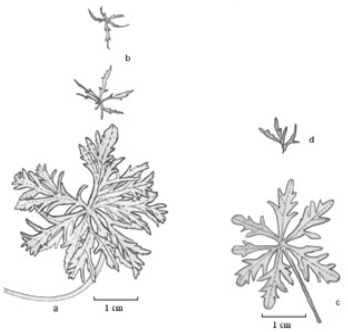
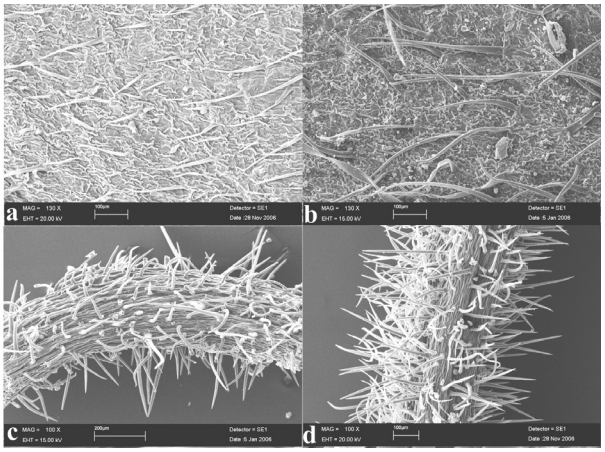


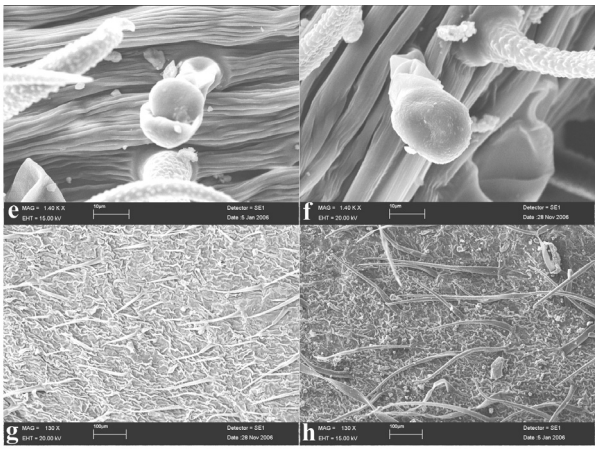
Figure 2. a: basal leaf and b: stem leaf of *G. tuberosum* subsp. *deserti-syriacum.* c: basal leaf and d: stem leaf of *G. tuberosum* subsp. *tuberosum.*

Leaves: The basal leaves of the two subspecies are polygonal in outline, palmatisect, with 5-7 segments, the segments in subsp. *tuberosum* rhombic to oblong-linear while in subsp. *deserti-syriacum* oblong linear (Fig. 2). Basal leaves directly arise from tubers. The first stem leaves are petiolate at the first dichotomy. Stem leaves are opposite and upper leaves are sessile.

Indumentum: Indumentum consist of two kinds of hairs. Unicellular, cylindirical simple hairs that are variable in length (0.1-0.5 mm) whose surface are tuberculated, and short stalked one or two celled glandular hairs. Simple hairs whose surface are tuberculeted were observed on stem, both basal and cauline leaves, pedicel, sepal and petal in both subspecies. Tubercules of simple hairs of subspecies *deserti-syriacum* are longer than tubercules of subspecies *tuberosum* (Fig. 3). Shape of the tubercules are elliptic and ovate respectively. However, glandular hairs were observed on stem, pedicel and sepal in both subspecies, but it is observed on cauline leaves only in subspecies *deserti-syriacum* not in subspecies *tuberosum*.

Surface sculpturing: Micromorphology of ventral and dorsal surface of leaves, pedicels and stems of both subspecies were found similar. Stem and pedicel surfaces have thickness along parallel to length of organs as fimbrilliar structures like a rope. Sepal and petal surface have different ornamentation in each subspecies. Cuticular sculpturing of sepals have muri that is longer and thinner in subsp. *deserti-syriacum* than in subsp. *tuberosum*. Petal surface is composed of dome-shaped cells whose periclinal walls are smooth in subsp. *deserti-syriacum*. Petal surface of subsp. *tuberosum* is composed of cells whose periclinal walls are straight and each cell has a projection (Fig. 3).





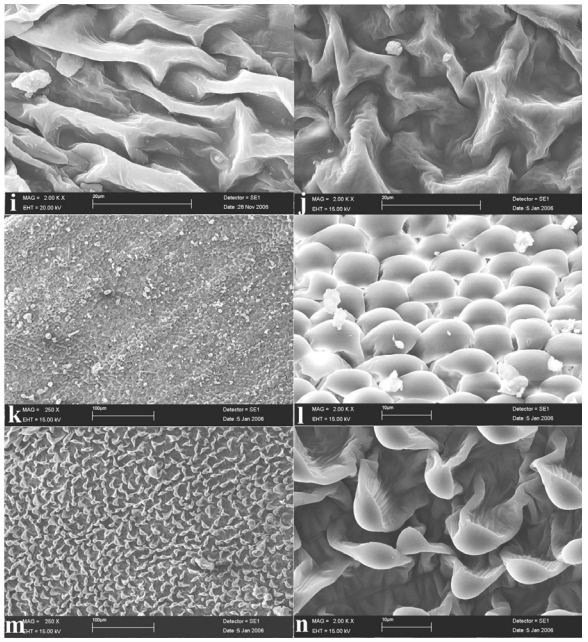


Figure 3. Trichom and surfaces: Leaf hairs of a: subsp. *deserti-syriacum*, b: subsp. *tuberosum*.. Pedicel hairs of c: subsp. *deserti-syriacum*, d: subsp. *tuberosum*. Glandular hair at pedicel e: subsp. *deserti-syriacum* f: subsp. *tuberosum*. Sepal hair of g: *deserti-syriacum,* h: *tuberosum,* Sepal surface of i: *deserti-syriacum,* j: *tuberosum.* Petal surface of k-l: *deserti-syriacum,* m-n: *tuberosum.*

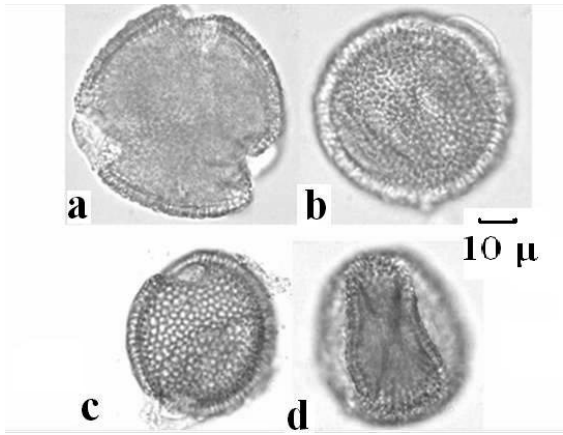


Figure 4. Light microscope view of pollens. a: Polar and b: equatorial view of *Geranium tuberosum* subsp. *tuberosum.* c: polar and d: equatorial view of *Geranium tuberosum* subsp. *deserti-syriacum*.

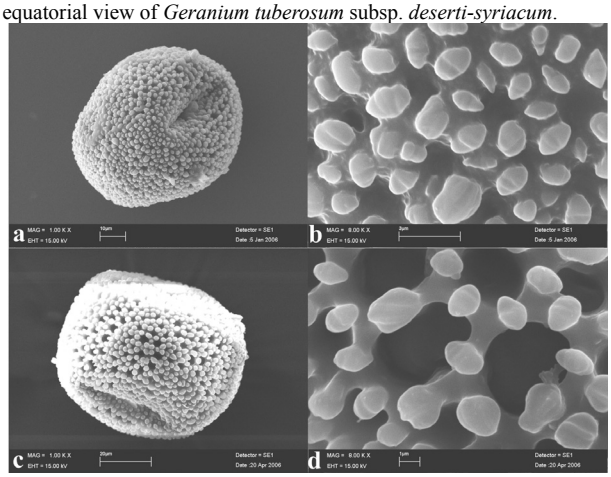


Figure 5. SEM view of pollens. a: equatorial and b: detailed view of *Geranium tuberosum* subsp. *tuberosum.* c: equatorial and d: detailed view of *Geranium tuberosum* subsp. *deserti-syriacum*

Pollen morphology

General polen characters of these two subspecies are radial symetry, isopolar, sferoidal-suboblat, fossaperturat, tricolporat, with short colpa and thin sexin (Fig. 4-5). Tectum reticulate but also densely baculate or gemmate, müri is roughly reticulate. Pollen type of the these two species belongs to *Geranium himalayense* type [18]. In this type pollens are tricolporate; P/E ratio is subtransverse, rarely semi-transverse; shape is spheroidal and suboblate; aperture is ectoapertur-colpa small or large circular; sexin is thinner than nexin or equal; ornamentation is tectate, baculate or gemmate; müri is roughly reticulate. Polar lenght (P) is 69.28 µm, in *G. tuberosum* subsp. *tuberosum* and it is 58.62 µm in *G. tuberosum* subsp. *deserti-syriacum*. Equator length (E) is 71.41 µm in subsp. *tuberosum* and it is 67.46 µm in subsp. *deserti-syriacum*. Colpi longitidues (CLG) are 16.08 µm in subsp. *tuberosum* and it is 14.56 µm in subsp. *deserti-syriacum*. Shapes (P/E) are sphaeroidae (0.97) in subsp. *tuberosum* and it is suboblate (0.86) in subsp. *deserti-syriacum*. Mesocolpium of subsp. *tuberosum* is 13.57 µm, while it is 13.24 µm in subsp. *deserti-syriacum*. Apocolpium (t) of subsp. *tuberosum* is 14.02 µm, and it is 13.69 µm in subsp. *deserti-syriacum*. Exine thicknesses are 4.7389 and 5.073 µm in subsp. *tuberosum* and subsp. *deserti-syriacum* respectively. Detailed comparative pollen characters were given in Table 1.

Table 1. Comparison of the Pollen charecteristics of *G. tuberosum* subsp. *tuberosum* and subsp. *deserti-syriacum*

	Taxa	N	Mean	Std. Deviation	Std. Error Mean
P	subsp. *tuberosum*	35	69.28 µm	4.44	0.75
	subsp. *deserti-syriacum*	40	58.62 µm	5.60	0.88
E	subsp. *tuberosum*	35	71.41 µm	5.26	0.88
	subsp. *deserti-syriacum*	40	67.46 µm	6.26	0.99
Shape	subsp. *tuberosum*	35	0.97 (spheroidal)	6.57	1.11
	subsp. *deserti-syriacum*	40	0.87 (suboblate)	4.88	7.72
Amb	subsp. *tuberosum*	36	74.75 µm	5.37	0.89
	subsp. *deserti-syriacum*	34	68.20 µm	5.08	0.87
Clt	subsp. *tuberosum*	60	13.56 µm	4.12	0.53
	subsp. *deserti-syriacum*	40	13.23 µm	3.44	0.54
Clg	subsp. *tuberosum*	26	16.07 µm	3.95	0.77
	subsp. *deserti-syriacum*	25	14.56 µm	2.06	0.41
Plt	subsp. *tuberosum*	40	15.50 µm	4.40	0.69
	subsp. *deserti-syriacum*	27	15.35 µm	2.11	0.40
Plg	subsp. *tuberosum*	39	17.17 µm	5.38	0.86
	subsp. *deserti-syriacum*	28	14.51 µm	2.52	0.47
Apocolpium	subsp. *tuberosum*	40	14.02 µm	0.92	0.10
	subsp. *deserti-syriacum*	40	13.69 µm	0.61	7.07
Ektexin	subsp. *tuberosum*	72	3.92 µm	0.91	0.10
	subsp. *deserti-syriacum*	74	4.21 µm	0.60	7.07
Endexin	subsp. *tuberosum*	72	0.81 µm	0.25	3.06
	subsp. *deserti-syriacum*	74	0.85 µm	0.22	2.61
Intin	subsp. *tuberosum*	71	1.40 µm	0.49	5.87
	subsp. *deserti-syriacum*	74	1.47 µm	0.41	4.85

Table 2. Comparison of some morphological and palynological characters of *Geranium tuberosum* subsp. *tuberosum* and subsp. *deserti-syriacum*

Characters	subsp. *tuberosum*	subsp. *deserti-syriacum*
Stem	erect	Erect/prostrate
Leaf segments	rhombic	oblong linear
Inflorence	narrower than height of stem	broader than height of stem
Glandular hairs on cauline leaves	exist	absent
Stigma	straight	sometimes coiled
Sepals	± villous	scarcely villous or not
Sepal awn	05-1.5 mm	0.2-0.3 mm
Tubercules of simple hairs	ellipsoid	ovate
Sculpturing of sepals	have short and thick muri	have long and thin muri
Outer periclinal walls of petal epidermal cells	Straight and have projection	Convex and smooth
Pollen shape	spheroidal	suboblate
Exine thickness	4.738 µm	5.073 µm

DISCUSSION

Two subspecies of *G. tuberosum* were investigated and compared morphologically and palynologically. Some morphological differences were observed between the two subspecies *tuberosum* and *deserti-syriacum.* Furthermore, basal leaf shape, sepal awn and pollen type were found clearly different between these two subspecies. These differences and similarities are shown comparatively in Table 2.

The basal leaves of the two subspecies are polygonal in outline, palmatisect, with 5-7 segments, the segments are rhombic to oblong-linear in subsp. *tuberosum* while they are oblong-linear in subsp. *deserti-syriacum*. Sepals are 5-5.5 x 2.8-3 mm diam. in subsp. *deserti-syriacum.* However it is 6-6.5 x 3-3.1 mm in subsp. *tuberosum*. Sepals having apical mucro that is 0.1-0.4 mm long in subsp. *tuberosum*. However it is 0.5-1.5 mm in subsp. *deserti-syriacum*. The sepal margines are scarious in subsp. *tuberosum* and subsp. *deserti-syriacum*, 0.2-0.3 and 0.4-0.5 mm wide respectively. Gynoecium is very densely pilose in subsp. *tuberosum*, but sparsely pilose in subsp. *deserti-syriacum*. Stigmatic remains are coiled in subsp. *deserti-syriacum* but straight in subsp *tuberosum*.

Surfaces of leaves, pedicels and stems have similar micromorphological patterns in both subspecies but sculpturing of sepal and petal surface differentiate the subspecies. Sepal surface of subsp. *deserti-syriacum* has muri that is longer and thinner than muri of subsp *tuberosum*. Periclinal walls of petal surface of subsp. *deserti-syriacum* are convex and smooth while they are straight and have projection, one at each cell. Tubercule shape of hairs are also different in both subspecies.

General pollen properties of these two subspecies are tricolporate. P/E ratio is subtransverse, rarely semi-transverse. Shape is spheroidal and suboblate. Aperture is ectoaperture-colpa that is small or large circular. Sexin is thinner than nexin or equal. ornamentation is baculate or gemmate; müri is roughly reticulate. Those characters mentioned above fit the *Geranium himalayenese* pollen type [18]. Pollens of subsp. *tuberosum* are bigger than pollens of subsp. *deserti-syriacum*. Pollen shape of subsp. *tuberosum* is sphaeroidae while it is suboblate in subsp. *deserti-syriacum*. Sexine is thicker than nexine or as thick as nexine in both subspecies. Ornamentation is tectate, coarsely reticulate with baculate or gemmate muri, muri with striation in subsp. *tuberosum*. Ornamentation is also tectate, but very coarsely reticulate with baculate or gemmate regular pattern of

muri, muri with striation, lumina ± hexagonal in shape, 3.5-4 µm in diameter in both subspecies.

As a conclusion, studied two subspecies of *G. tuberosum* have some similar and different characters. In addition to the morphological similarities and differences, new ones were added palynologically and micromorphologically that utilize to more effectively differentiate the studied subspecies by this study.

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