ANATOMICAL STUDY FOR SUBGENERA *PRUNUS* L. AND *CERASUS* PERS. (ROSACEAE) LEAVES IN KURDISTAN REGION-IRAQ

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ABSTRACT

Mature leaves fully expanded, undamaged were used in this study for leaf anatomy (blade, midrib and petiole) for 12 taxa of subgenera *Prunus* and *Cerasus* (*P. cerasifera* Ehrh., *P. domestica* subsp. *domestica* L., *P. domestica* subsp. *syriaca* (Borkh.) Janchen ex Mansfeld, *P. domestica* subsp. *insititia* (L.) C. K. Schneid, *P. domestica* subsp. *italica* (Borkh.) Gams ex Hegi, *P. armeniaca* var. *armeniaca*, *P. armeniaca* cv. Saeede Meraime, *P. microcarpa* var. *pubescens* (Bornm.) Meikle, *P. microcarpa* var. *microcarpa*, *P. brachypetala* (Boiss.) Walp., *P. mahaleb* L. and *P. cerasus* L.). Also trichome length and frequency on areole part of leaf blade for each taxon were measured. All taxa were characterized by bifacial mesophylls which consist of palisade parenchyma in the upper side and spongy layer in the lower side. The investigated taxa divided according to the number of palisade parenchyma layers in three groups. The shape of midrib, petiole transverse section and shape of the vascular bundles were important diagnostic values used for identifications of taxa. The leaves of all investigated taxa of subgenera *Prunus* and *Cerasus* have unicellular trichomes with different shapes kinds present on leaves blade of all studied taxa. Mostly the trichomes in abaxial side areole longer than the trichomes in the adaxial side, also the frequency of trichoms in the abaxial face was significantly higher than in the adaxial face.

Keywords: leaf blade, midrib, petiole, trichomes, SEM.
***Part of Ph.D. Dissertation of 1st author.**

دراسة تشريحية لأوراق تحت الجنس *Prunus* L. subgenera و*Cerasus* Pers. (Rosaceae) في كردستان العراق

أمينة محمد حسن سليم إسماعيل شهباز شميران صالح عبدالرحمن
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المستخلص

استخدامت الأوراق الناضجة وغير التالفة في هذه الدراسة لعمل مقطع العمودي للأوراق (النصل، عرق الوسطي و السويق) لـ 12 نوعًا من تحت الجنس *Prunus* و *Cerasus*. كما تم قياس طول الشعيرات وعددها على (areole) من نصل الورقة لكل نوع. تميزت جميع الأوراق بوجود النسيج المتوسط ثنائي الوجه مكون من طبقة نسيج العمادية في الجزء العلوي وطبقة النسيج الإسفنجي في الجزء السفلي للورقة. كما تم تقسيم الأصناف التي درست وفقًا لعدد طبقات نسيج العمادية الى ثلاثة مجاميع. شكل المقطع العرضي للعرق الوسطي و السويق وشكل الحزم الوعائية كان ذات قيمًة تشخيصية مهمة استخدمت للفصل بين الأصناف. تحتوي أوراق جميع الأصناف التي تم فحصها من الجنيس *Prunus* و *Cerasus* على شعيرات أحادية الخلية بأنواع مختلفة موجودة على نصل الأوراق لجميع الأصناف المدروسة. في الغالب كان طول وعدد الشعيرات في السطح السفلي للورقة أطول و أكثر من الشعيرات في السطح العلوي للورقة.

الكلمات المفتاحية: نصل الورقة, العرق الوسطي, سويق الورقة, الشعيرات, المجهر الالكتروني.
***جزء من أطروحة الدكتوراه للباحث الأول.**

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INTRODUCTION

The genus *Prunus* L. belongs to the subfamily Prunoideae in the Rosaceae family, it is distributed mainly in the temperate regions of the northern hemisphere (18). Many species of *Prunus* are cultivated for their edible fruits, whilst others are planted for their ornamental or medicine value including plums, cherries, peaches, and apricots. Plant anatomy enters in to many scopes and sciences, it's important to the study of plant systematics, palaeobotany, evolutionary biology, physiology, science of developmental genetics and ecology (19). Leaf and stem anatomy of trees have been done as an important tool for identification of plants (21). In many plants, because of the toxic effect of oxalates free calcium accumulation excess quantities the plants could induce calcium oxalate crystal formation to remove excess oxalate or calcium (5). Saadi and Mondal (20) they mentioned the presence or absence of crystals has been used for understanding the evolutionary relationships of plant species. It could be located in specific tissues such as epidermis, cortex, phloem, xylem and pith or they may be distributed all over the plant (12). Trichomes consider special structures present on the surface of plant organs their morphology differs mainly depending on the tissue and the germplasms. According to Xiang *et al*. (22) that trichomes have been used as a taxonomic key in plant classification because of their wonderful characteristics. At the same time, detailed study on the kind and distribution of the vegetative organ trichomes in rosaceous plants has been conducted only in *Rubus* and *Rosas* (6, 9, 10, 11). Many questions remain on the delimitation of classification number of species, subspecies and cultivars within the subgenera *Prunus* and *Ceracus* and the broader classification of the genus *Prunus* as a whole therefore; the main objectives of this investigation were study anatomical differences of leaves, and trichome characters and used it in systematic work for these plants groups.

Materials and methods

The present study was carried out in the Scientific Researches Center Laboratory, College of Agricultural Engineering Sciences, University of Dohuk, Kurdistan Region, Iraq. Mature leaves fully expanded, undamaged were used in this study collected from different places of Kurdistan region of Iraq (Duhok city, Bekher mountside, Zawita Sarsang, Gara mountain, Shaqlawa, Choman city, Sekran Mountain, Helgord mountain, HajiUmran, Gali Ali beg valley, Sulaimanya city, Pira Magrun mountain, Hewraman Ballkha village near Halabje). The leaves were fixed in the formalin-acetic acid-alcohol (FAA) solution for 24 hrs. The fixed leaves were then dehydrated through ascending alcohol series (50, 70, 80, 90, 96 and 99%) for 45 min in each concentration, and embedded in paraffin blocks. The sections cutting were taken with a Rotary Microtome were prepared at 9 µm thickness. The sections were stained with saffranin and fast green stain (2). For leaf trichome equal volumes of glacial acetic acid and hydrogen peroxide (1:1 volume) were used left in oven at 60 °C for 24 - 36 hrs until the leaves became soft and colorless depending upon the species. Trichome length (mm) and frequency/ mm^2 on areole part of leaf blade for each taxon were measured. Terminology used for trichome types was based on Payne (17). The slides were examined by using compound microscope (Olympus (CX21). Slides photographed using digital camera (Sony, 16 mega pixels). The characteristics of the leaves trichoms were photographed also by using scanning electron microscope (SEM) model MIRA 3 TESCAN.

RESULTS AND DISCUSSION

1- Blade cross section

A study of anatomical features of mature leaves of 12 Rosaceae taxa shows variations between them (Table 1) and (Figures 1). Epidermal cells were covered by slightly thick cuticle layer; which act as a barrier against mechanical damages, insects, excessive light and loss of water (4). The cuticle thickness on the adaxial surface of leaves was slightly higher than on the abaxial surface except in *Prunus armeniaca* var. *armeniaca* and *P. armeniaca* cv. Saeede Mariame. Epidermal cells in upper and lower leaves surface consist of compact cells, it is an important structure that protects the plant against moisture loss, microbial, and physical harm (7). The adaxial cells were significantly larger than the abaxial ones in all investigated taxa. The shape of it

was (rectangular, oval, rounded or irregular) and not constant in both surface of blade leaf, it showed high variation in its shape even within the same individual and cannot take advantages of it in classification. Prismatic crystals observed in the epidermis cell in the adaxial surface of *P. domestica* subsp. *domestica* and in the epidermis cell in the adaxial and abaxial surface of *P. domestica* subsp. *insititia* as observer in (Figure 1, D), also druses crystals highly observed in the mesophyll cells in all investigated taxa (Figure 1, L). Some early studies on crystal types and distribution claimed that these two features were useful in resolving systematic problems (13). All taxa were characterized by bifacial mesophylls. Palisade parenchyma extending longitudinally it shape was usually elongated compact contain high number of chloroplast. Bacelar *et al*. (3) and Marchi *et al*. (15) mentioned that compact arrangement of palisade mesophyll layers results in enhanced mechanical strength of parenchyma tissue and protects the leaves against extra water loss. Also palisade paranchyma cells contain on chloroplasts, as previously mentioned by Nikolić *et al*. (16). The studied taxa can also be categorized according to the number of palisade parenchyma layers in three groups:

1. Two palisade layers: *P. cerasifera*, *P. domestica* subsp. *syriaca*, *P. domestica* subsp. *insititia*, *Prunus armeniaca* var. *armeniaca*, *P. armeniaca* cv. Saeede Meriame, *P. brachypetala*, *P. mahaleb* and *P. cerasus*.
2. Three palisade layers: *P. domestica* subsp. *domestica*, *P. domestica* subsp. *italica* and *P. microcarpa* var. *pubescens*.
3. Four palisade layers: *P. microcarpa* var. *microcarpa*.

Vascular bundles were arranged mostly in the middle part of the mesophyll and has three patterns crescent, ring or ovate. The spongy cells were highly variable in size and shapes (elongated, ovate, circle and irregular) even within the same taxa, and an irregularly arrangement of cells which consist of 2-5 or more layers of cells; the majority of taxa had loosely packed because of presence interspace air-lacunae, while other taxa exhibited densely packed such as *P. domestica* subsp. *domestica* and *P. domestica* subsp. *italica*. Spongy parenchyma cell constituted 20- 60 % of the total thickness of the lamina according to each taxa. These characters may constitute significant taxonomic application. The highest mean of lamina thickness was (217.25µm) in *P. microcarpa* var. *microcarpa*, whereas the lowest measurement noticed in *P. brachypetala.* (116.34µm). Blade angel (the angle between two halves of blade) was differ between the studied taxa, the biggest angle (174°) in *Prunus armeniaca* var. *armeniaca*, and the smallest ones (88°) in *P. cerasifera*.

2- Midrib cross section

Data shows in (Table 2) indicate to the cuticle layer on the abaxial midrib surfaces thicker than the cuticle layer on adaxial surface of midrib, except *P. brachypetala*, *P. mahaleb* and *P. cerasus* their leaf midrib cuticle layer on the adaxial midrib surfaces thicker than the cuticle layer on abaxial side, this was in contrast to the cuticle thickness differences covering the blade leaves. There epidermis cells were rectangular, oval or elongate shape, sometime in the upper side contained irregular cells shape. The upper epidermis cells were thicker than the lower epidermis cells; exception *P. domestica* subsp. *insititia*. Collenchymatous cells layers between (1-10) layers were located below the upper epidermis, and (1-3) layers underneath the lower epidermis in the midrib region of investigated taxa. Parenchymatous cells of midrib of all investigated taxa contained druses crystals. According to Lersten and Horner (14) present of druse crystals in the leaves of some *Prunus* species such as *P. virginiana*. The bundles were collateral type and cambium was not distinguishable. Only *P. cerasifera* and *P. cerasuse* contained discontinuous and unclear layer of sclerenchyma cells. One large central vascular bundle U or crescent shape was seen in the midrib of most studied taxa but sometimes there are more than one small vascular bundles about (1-3) were found embedded in parenchyma tissue in the upper sides of the main vascular bundle.

Shape of the vascular bundles is important diagnostic values may be used for identifications of taxa as indicated by (Fig.2). The following groups of midrib shapes were distinguished:

1. Adaxial surface flat, abaxial surface convex as in species: *P. domestica* subsp. *domestica*,

P. domestica subsp. *syriaca, P. domestica* subsp. *italica* and *P. brachypetala*.

2. Adaxial surface convex, abaxial surface concave as in species: *P. armeniaca* var. *armeniaca* and *P. armeniaca* cv. Saeede Mariame

3. Adaxial surface V-shaped, abaxial surface convex in species: *P. cerasifera, P. microcarpa* var. *microcarpa* and *P. cerasus*.

4. Adaxial surface U-shaped, abaxial surface convex in species: *P. microcarpa* var. *pubescens*, *P. domestica* subsp. *insititia* and *P. mahaleb.*

5. Vascular bundle U-shaped in species: *P. domestica* subsp. *insititia*, *P. mahaleb* and *P. cerasus*.

6. Vascular bundle crescent-shaped with the exception of taxa given in 5, all other taxa are crescent shaped.

On the other hand, the data displayed in (Table 2) revealed variations between taxa the upper and lower epidermal layer with largest epidermal cells mean was recorded (24.02 and 22.98 µm) were obtained by the species *P. cerasifera*, while the smallest upper and lower epidermal cells recorded by *P. domestica* subsp. *syriaca* and *P. domestica* subsp. *italica* respectively. The maximum mean of collenchyma thickness was recorded by *P. armeniaca* var. *armeniaca*, whereas the minimum mean value noticed in *P. microcarpa* var. *microcarpa.* Parenchyma thickness mean value varies from 262.82 µm to 60.93 µm. The smallest mean value of cortex thickness, phloem thickness, xylem thickness and pith thickness was obtained by *P. brachypetala*, whilst the largest mean of cortex thickness and Pith thickness founded in *P. armeniaca* var. *armeniaca*, and phloem and xylem thickness founded in *P. domestica* subsp. *insititia*.

3- Petiole cross section

The data shows in (Table 3) and (Figure 3) shows the anatomical characterizations of petiole were in a majority uniform with midrib features. The epidermal cells of petiole consists of compact layer, rectangular, oval or elongate cells shape covered by layer of cuticle, the lower cuticle layer of most taxa thicker than the upper layer as seen in midrib cross section. Collenchymatous cell layers about (1-9) layers were located below the upper epidermis, and in lower epidermis between (1-4) layers. Also, the parenchymatous cells of petiole for all studied taxa contained on druses crystals. Thus the shape and location of the crystals within a taxon are often very specific and may be represented as a taxonomic character (13). The thick xylem was bordered by a thin phloem. One large central vascular bundle of U or crescent shape was seen in the petiole of most studied taxa but sometimes more than one small vascular bundles about (1-8) on the upper sides of the main vascular bundle. According to outline shapes of the petiole cross section (Figure 3) the following groups of petiole shapes were distinguished:

1**.** Petiole adaxial face was concave between two distinct lateral lopes: *P. cerasifera, P. domestica* subsp. *domestica, P. domestica* subsp. *syriaca, P. domestica* subsp. *insititia, P. domestica* subsp. *italica* and *P. brachypetala.*

2**.** Petiole adaxial face was convex or slightly concave: *P. armeniaca* var. *armeniaca*.

3. Petiole adaxial face is U-shaped to V-shaped or with deep groove: *P. cerasus* (two shapes of the adaxial face, one is U-shaped and the other was with very long lateral lopes) and *P. microcarpa* var. *microcarpa*.

4. Petiole adaxial face flat to slightly concave: *P. armeniaca* cv. Saeede Mariame, *P. microcarpa* var. *pubescens* and *P. mahale.*

Petioles of intraspecific taxa belonging to the same species show high similarity in shape as seen in the subspecies of *P. domestica* and *P. armeniaca.* The results indicat that according to both upper epidermis cells and lower epidermis cells, the thickest were in *P. cerasifera*, whilst the thinnest were in *P. domestica* subsp. *italica* (9.22 µm) and *P. domestica* subsp. *syriaca* (9.11 µm) respectively. Mean value of collenchyma thickness (177.47µm) in *Prunus armeniaca* var. *armeniaca* which records the thicker collenchyma when compared to all other taxa. Parenchyma layer can be found as thickest as in *P. domestica* subsp. *insititia* (410.59 µm), while thinnest (95.88 µm) founded in *P. brachypetala*. The largest mean value of cortex thickness measured example was *Prunus armeniaca* var. *armeniaca*, while the smallest mean value of was recorded by *P. microcarpa* var. *microcarpa*. Mean of phloem

range from 97.53 to 33.29µm, while mean of xylem range values was 215.03 to 59.67 µm. Pith thickness changes between 81.60 to 31.29 µm as in *P. armeniaca* var. *armeniaca* and *P. microcarpa* var. *microcarpa* respectively. The variation in the shape of midrib and petiole observed in the studied species and infraspecies was useful to elaborate an identification key, corroborating its distinguishing value between studied plants, and these results agree with (8) they mentioned that the petiole anatomic structures are effective in certain taxonomical characters of species from some species of plants.

4- Leaf trichomes

Leaves of all investigated taxa of both subgenera have unicellular trichomes. It was present on all parts (petiole, midrib, lateral vein and areole) in adaxial and abaxial surface of leaves. The unicellular trichome was un-branched simple trichomes thin-walled and smooth, their apex was more or less acute, it base usually swollen form. Leaf petiole of studied taxa usually contained on strict and subulate kind of trichomes, whilst according to the observations with LM and SEM studies (Figure 4, 5), there was different shapes types of unicellular trichomes present on leaves blade of all studied taxa (papillae, appressed trichome, subulate, spiral, acicular, strict, pilose, and hooked). The distribution of trichome majority appeared densely in the base of blade between the midrib and areole, also it distributed sparsely along of midrib and lateral vines in all taxa, but it differ in their present on the areole, except *P. microcarpa* var. *microcarpa* which have trichomes distributed sparsely along on the blade leaf. The results in (Table 4) indicate that in most of the cases the trichomes frequency and length in the abaxial side areole was significantly higher than in the adaxial face, this similar results have been observed by Xiao *et al*. (23) they found that large trichomes are mainly distributed on the abaxial surface and margins and in the vascular bundles; whilst, there was some taxa did not have trichomes in their adaxial face of the leaf. According to the results the maximum mean of trichome length in the upper surface of leaf areole obtained by *P. domestica subsp. italica* (0.44 mm), whereas, *P. microcarpa* var. *microcarpa, P. mahaleb* and *P. cerasus* was not have any trichome in the leaf areole. The highest mean value trichome length in the lower surface was (0.88 mm) recorded in *P. cerasus.* The frequency of trichomes in upper and lower surface as mean reached to the highest number (211 and 260.5 trichomes/ mm^2) respectively in *P. brachypetala*. Different types of trichomes has role as a taxonomic criterion to plant systematic. The trichomes are a taxonomic value at the species level, even to varieties level in plant delimitation (1). According to Xiang *et al*. (22) that trichomes have been used as a taxonomic key in plant classification because of their wonderful characteristics.

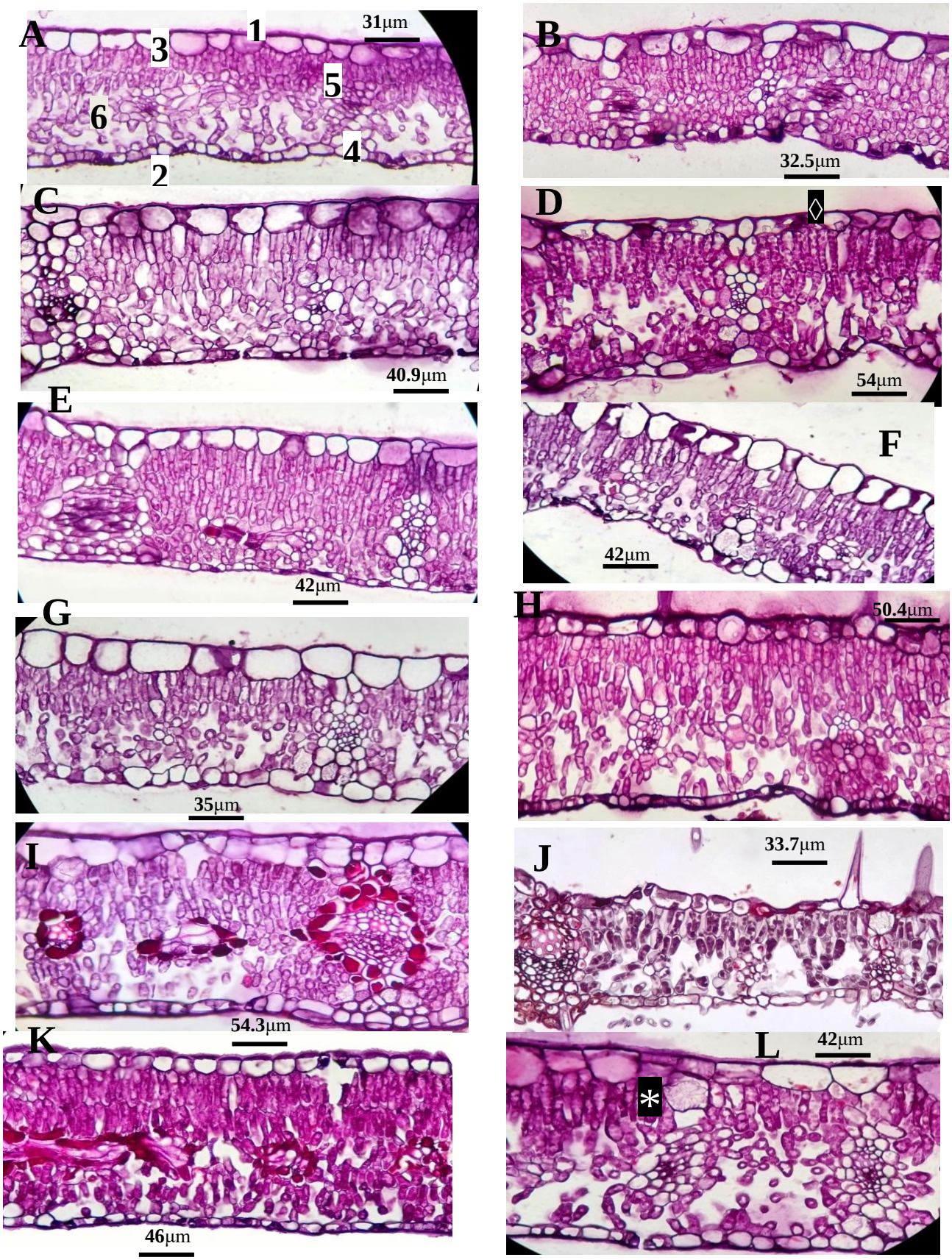

Figure 1. Blade cross section. A. *P. cerasifera*, B. *P. domestica* subsp. *domestica*, C. *P. domestica* subsp. *syriaca*, D. *P. domestica* subsp. *insititia*, E. *P. domestica* subsp. *italica*, F. *P. armeniaca* var. *armeniaca*. G. *P. armeniaca* cv. Saeede Meriame, H. *P. microcarpa* var. *pubescens*, I. *P. microcarpa* var. *microcarpa*, J. *P. brachypetala*, K. *P. mahaleb*, L. *P. cerasus*. 1. Upper cuticle, 2. Lower cuticle, 3. Upper epidermis, 4. Lower epidermis, 5. Palisade layer, 6. Spongy layer. ◊ Prismatic crystals. *Druses crystal.

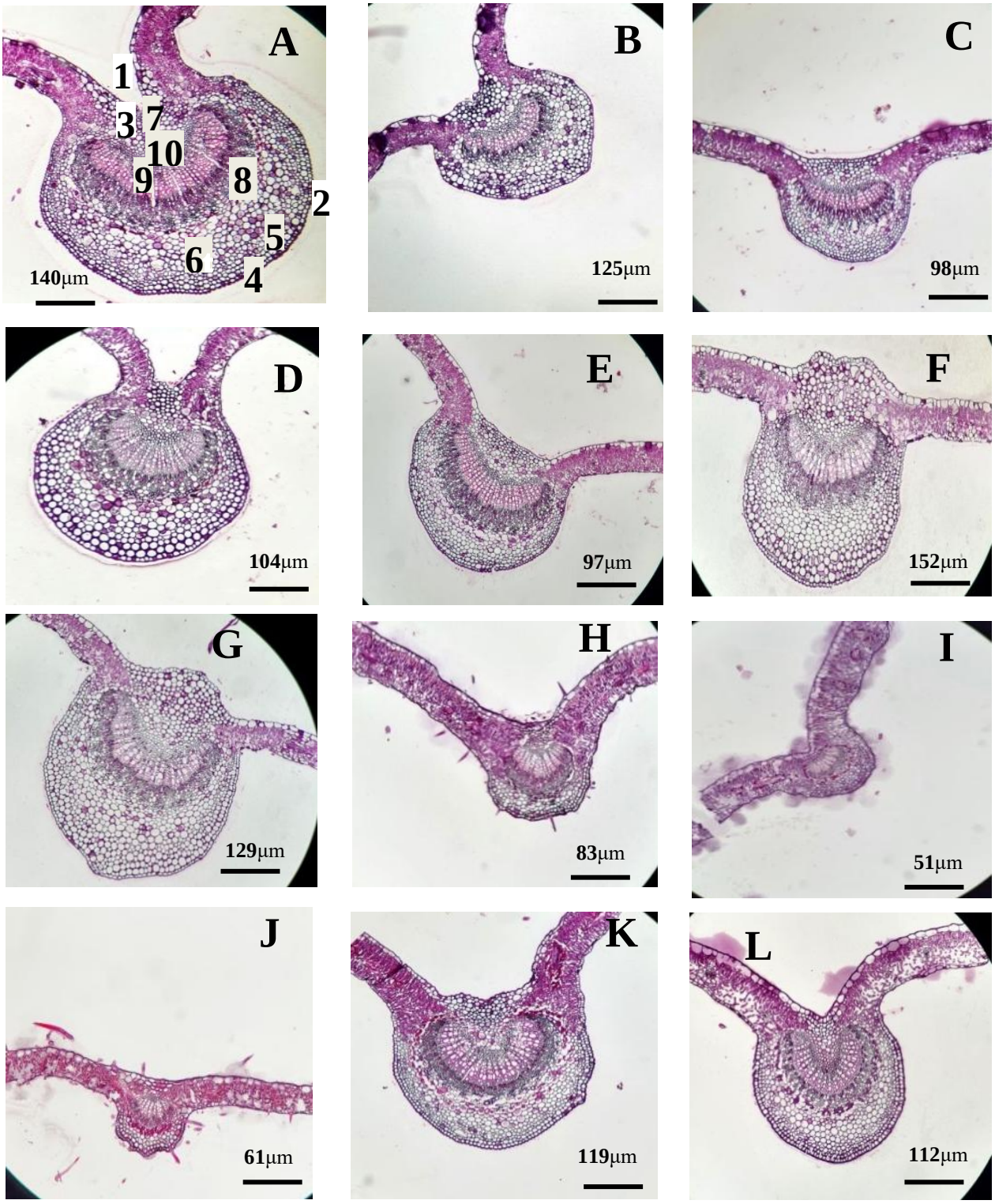

Figure 2. Midrib cross section. A. *P. cerasifera*, B. *P. domestica* subsp. *domestica*, C. *P. domestica* subsp. *syriaca*, D. *P. domestica* subsp. *insititia*, E. *P. domestica* subsp. *italica*, F. *P. armeniaca* var. *armeniaca*, G. *P. armeniaca* cv. Saeede Meriame, H. *P. microcarpa* var. *pubescens*, I. *P. microcarpa* var. *microcarpa*, J. *P. brachypetala*, K. *P. mahaleb*.L. *P. cerasus*. 1. Upper cuticle, 2. Lower cuticle, 3. Upper epidermis, 4. Lower epidermis, 5. Collenchyma, 6. Parenchyma, 7. Cortex, 8. Phloem, 9. Xylem, 10. Pith.

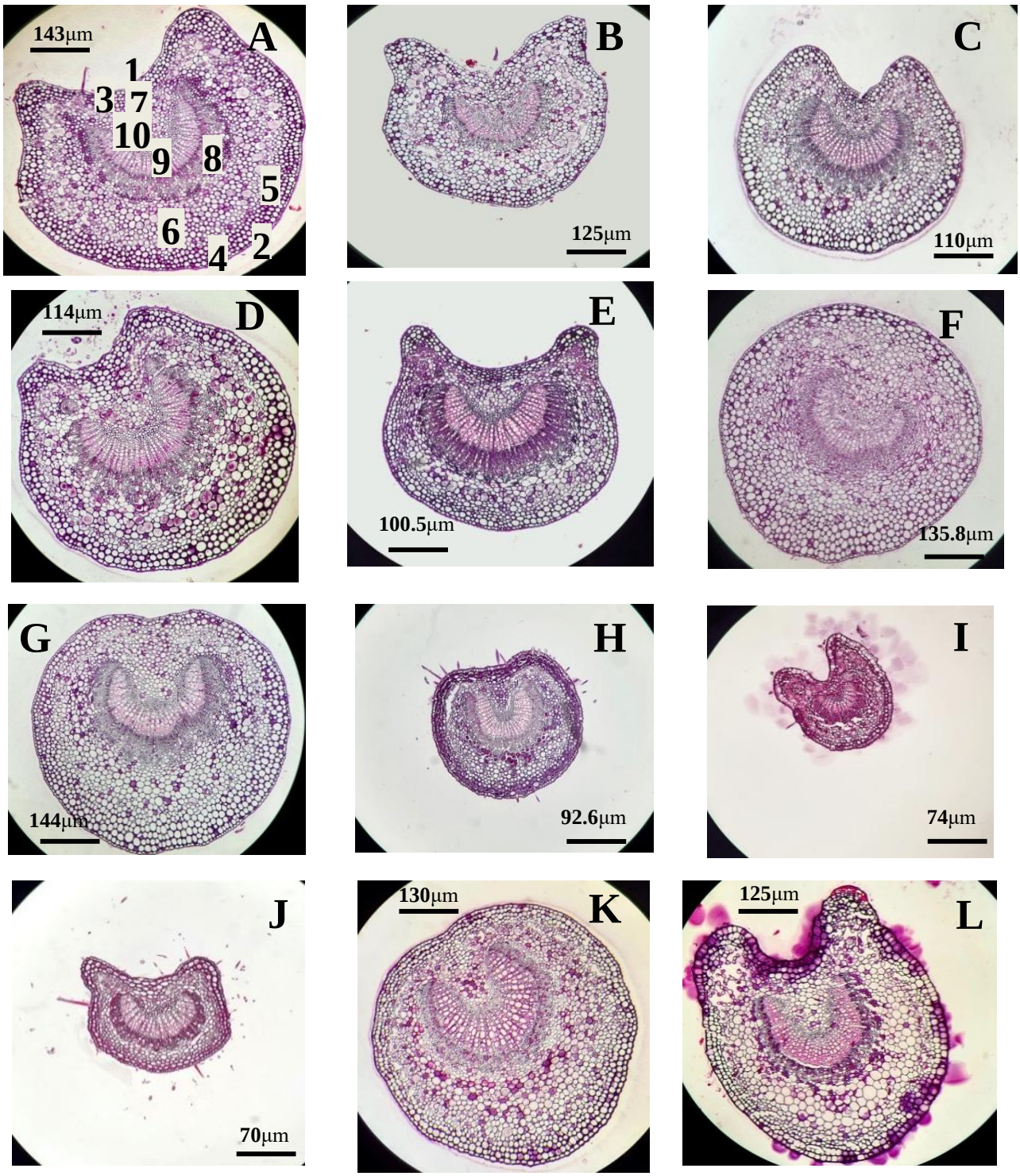

Figure 3. Petiole cross section. A. *P. cerasifera*, B. *P. domestica ssp.domestica*, C. *P. domestica* subsp. *syriaca*, D. *P. domestica* subsp. *insititia*, E. *P. domestica* subsp. *italica*, F. *P. armeniaca var. armenica*, G. *P. armeniaca* cv. *Saeede Meriame*, H. *P. microcarpa* var. *pubescens*, I. *P. microcarpa* var. *microcarpa*, J. *P. brachypetala*, K. *P. mahaleb*.L. *P. cerasus*. 1. Upper cuticle, 2. Lower cuticle, 3. Upper epidermis, 4. Lower epidermis, 5. Collenchyma, 6. Parenchyma, 7. Cortex, 8. Phloem, 9. Xylem, 10. Pith.

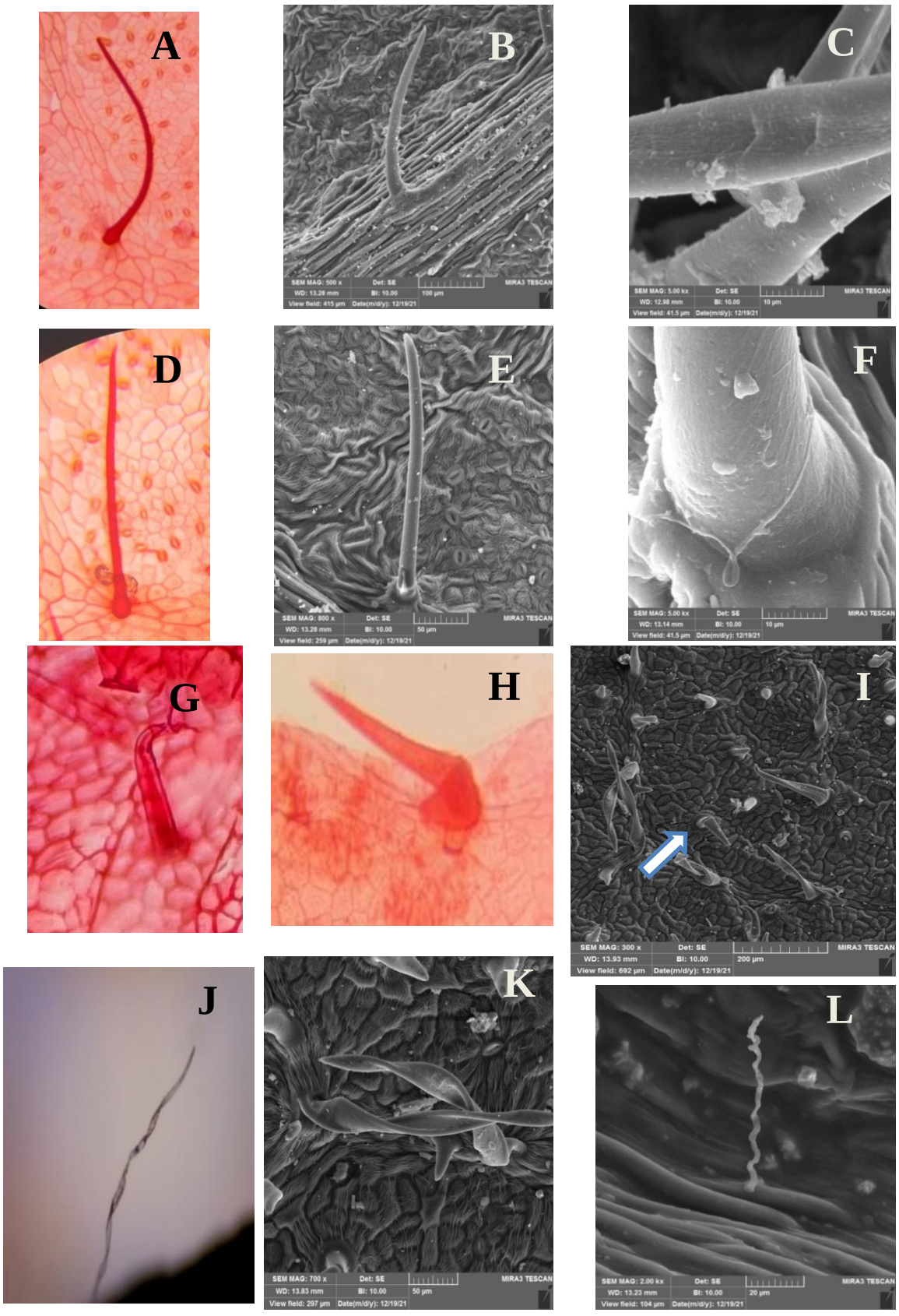

Figure 4. Types of trichomes present on the leaves of subgenera *Prunus* and *Cerasus*. A. LM (200 x), B. C. SEM (Acicular). D. LM (200 x), E. F. SEM (Strict). G. LM (200 x) (Hooked). H. LM (200 x), I. SEM (Appressed). J. LM (40 x), K. L. SEM (Spiral).

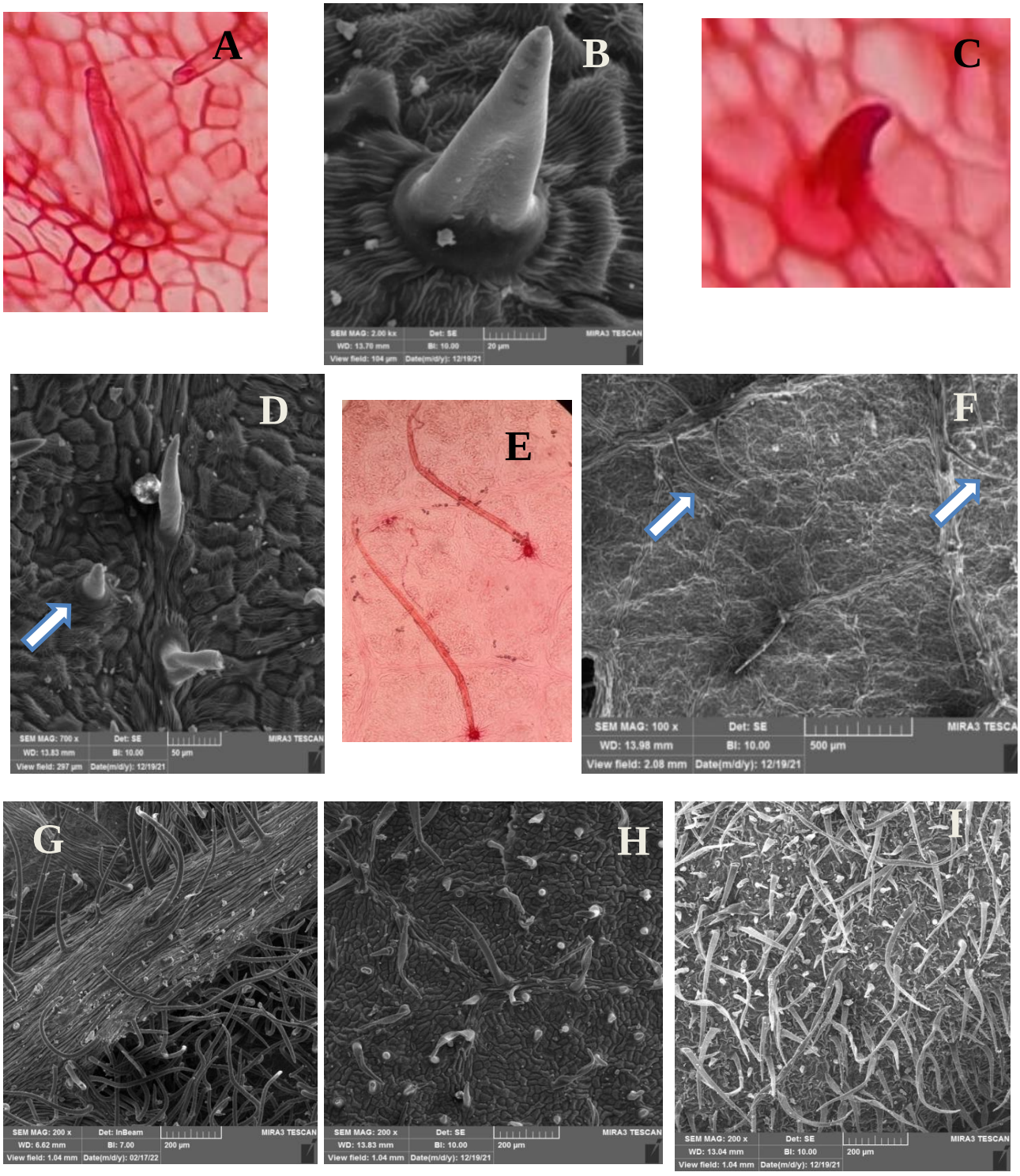

Figure 5. Types of trichomes present on the leaves of subgenera *Prunus* and *Cerasus*. A. LM (200 x), B. SEM (Subulate). C. LM (200 x), D. SEM (Papillae). E. LM (40 x), F. SEM (Pilose). G. H. I. SEM (densely present of trichomes on the blade base of leaf, *P. microcarpa* var. *pubescens* and *P. brachypetala*) respectively.

Table (1.). Quantitative characters of cells and tissues measurements in blade cross section of subgenera *Prunus* and *Cerasus* (µm).

Taxon	Statistic	Blade (lamina) thickness	Upper cuticle thickness	Lower cuticle thickness	Upper epidermis cells length	Lower epidermis cells length	Upper epidermis cells width	Lower epidermis cells width
P. cerasifera	Mean	122.41	2.96	2.47	18.65	10.05	26.86	11.84
	Min	93.33	1.05	1.47	8.21	5.94	7.92	5.45
	Max	167.54	5.81	4.32	33.79	25.56	48.95	27.15
P. domestica	Mean	129.51	2.41	1.86	23.96	10.91	28.78	15.31
subsp.	Min	92.25	1.32	0.73	11.24	5.94	10.65	4.73
domestica	Max	194.64	4.13	3.44	49.35	17.44	60.28	39.93
P. domestica	Mean	140.15	2.70	1.65	20.23	9.38	28.81	15.28
subsp. *syriaca*	Min	112.40	1.76	0.93	7.92	4.76	8.29	6.52
	Max	183.14	4.18	2.65	40.74	22.24	63.14	41.77
P. domestica	Mean	189.28	2.75	2.11	25.19	11.05	28.97	20.06
subsp. *insititia*	Min	133.81	1.87	1.41	7.21	3.18	9.83	8.04
	Max	270.79	3.66	3.50	54.04	28.41	47.63	59.32
P. domestica	Mean	163.92	2.91	1.80	22.36	8.06	27.17	12.26
subsp. *italica*	Min	131.72	1.97	0.93	13.71	5.38	14.30	7.72
	Max	226.08	5.01	2.43	33.28	14.30	46.78	24.49
P. armeniaca	Mean	162.46	2.20	2.36	37.00	14.96	36.01	16.01
var. *armeniaca*	Min	93.64	1.47	1.51	13.12	6.39	8.78	4.18
	Max	262.38	4.11	3.66	77.51	26.35	76.71	45.85
P. armeniaca	Mean	162.76	1.90	2.00	29.47	16.09	38.25	18.07
cv. Saeede	Min	113.72	1.00	1.16	12.73	9.02	12.18	5.57
Meriame	Max	224.93	2.80	3.63	55.44	30.12	75.54	49.58
P. microcarpa	Mean	203.92	2.87	2.30	22.56	12.07	36.65	14.70
var. *pubescens*	Min	134.11	1.76	1.32	8.40	6.17	10.55	7.70
	Max	311.08	4.45	3.63	47.35	21.34	87.78	27.77
P. microcarpa	Mean	217.25	4.99	3.32	29.73	17.77	24.19	16.46
var.	Min	169.67	2.05	1.87	17.87	10.11	10.22	8.50
microcarpa	Max	269.18	12.59	6.77	45.30	30.25	37.18	34.12
P. brachypetala	Mean	116.34	2.36	2.00	12.62	8.60	17.57	11.55
	Min	81.62	1.28	1.35	6.11	5.60	6.95	5.31
	Max	148.00	4.19	2.67	19.33	13.35	38.64	33.22
P. mahaleb	Mean	176.02	2.34	1.80	14.71	10.10	24.47	16.93
	Min	134.37	1.19	1.25	7.70	5.94	8.86	6.60
	Max	320.41	4.87	3.32	23.52	16.55	50.07	34.67
P. cerasus	Mean	192.34	3.14	2.37	28.76	12.55	48.79	20.01
	Min	155.61	1.65	1.61	13.60	7.47	16.41	7.70
	Max	242.45	5.04	3.09	58.45	21.30	101.20	39.65

Continue Table (1.).

Taxon	Statistic	Palisade cell Length	Palisade cell width	Palisade cell 2 Length	Palisade cell 2 width	Spongy cell Length	Spongy cell width	Spongy thickness	Blade angle
P. cerasifera	Mean	17.34	10.53	13.61	4.94	10.56	6.21	64.86	88
	Min	6.92	4.61	7.22	3.98	5.94	3.45	48.17	
	Max	27.20	21.31	20.17	5.94	18.38	11.24	90.14	
P. domestica	Mean	17.09	6.92	12.73	4.72	8.74	6.77	64.35	107
subsp.	Min	10.11	4.61	9.74	2.66	4.76	3.34	41.03	
domestica	Max	26.22	10.32	17.82	6.20	14.01	10.52	79.86	
P. domestica	Mean	20.90	6.76	14.36	5.85	12.35	7.74	83.01	133
subsp. *syriaca*	Min	7.70	4.50	9.57	3.98	4.50	5.45	61.82	
	Max	35.93	9.78	20.99	10.52	23.54	11.41	102.82	
P. domestica	Mean	42.40	8.22	20.27	6.07	17.85	7.82	115.99	91
subsp.	Min	16.79	4.30	13.56	4.28	9.54	5.05	74.80	
insititia	Max	62.35	12.95	32.29	7.74	27.48	11.36	174.95	
P. domestica	Mean	18.94	4.94	13.85	5.37	10.59	6.30	49.70	136
subsp. *italica*	Min	12.11	2.97	8.65	3.80	6.53	4.79	29.49	
	Max	31.18	8.25	18.50	7.51	16.34	8.56	63.77	
P. armeniaca	Mean	24.44	6.34	15.16	5.06	10.62	7.74	87.61	174
var.	Min	8.52	3.54	9.67	3.61	5.05	3.78	45.73	
armeniaca	Max	48.29	9.53	21.52	6.77	21.72	13.21	141.36	
P. armeniaca	Mean	20.40	6.88	12.25	4.50	9.89	6.49	85.43	170
cv. Saeede	Min	10.99	5.01	7.35	3.20	4.76	4.13	51.44	
Meriame	Max	34.31	10.84	24.37	6.72	17.04	9.62	114.53	
P. microcarpa	Mean	22.03	7.93	17.40	5.96	14.08	7.45	130.09	122
var.	Min	13.01	4.76	9.79	4.28	7.88	4.76	78.14	
pubescens	Max	37.88	10.33	25.17	7.44	27.36	11.47	184.44	
P. microcarpa	Mean	22.33	6.82	15.08	5.82	12.65	7.53	102.94	100
var.	Min	16.73	3.80	9.67	3.61	7.81	4.20	77.12	
microcarpa	Max	36.73	10.71	22.39	8.83	18.29	11.09	157.26	
P.	Mean	27.07	8.08	20.44	6.20	11.87	6.84	34.63	137
brachypetala	Min	20.31	5.63	15.99	4.64	7.18	4.79	25.65	
	Max	39.07	10.57	23.37	8.40	16.73	8.83	49.13	
P. mahaleb	Mean	29.37	6.02	21.15	5.77	10.33	6.03	70.49	129
	Min	17.53	4.18	9.23	3.59	5.60	4.18	46.56	
	Max	42.64	8.52	27.86	8.04	16.68	7.88	96.71	
P. cerasus	Mean	39.50	8.13	17.53	8.56	13.33	7.19	100.26	100
	Min	15.85	5.45	10.62	5.63	6.08	4.76	65.25	
	Max	56.54	12.18	21.90	12.60	19.29	10.86	159.90	

Table 2. Quantitative characters of cells and tissues measurements in midrib cross section of subgenera *Prunus* and *Cerasus* (µm).

Taxon	Statistic	Upper cuticle	Lower cuticle	Upper epidermis	Lower epidermis	Collenchyma thickness	Parenchyma thickness	Cortex thickness	Phloem thickness	Xylem thickness	Pith thickness
P. cerasifera	Mean	2.4	3.12	24.02	22.98	34.1	230.77	303.91	72.62	146.64	53.96
	Min	1.15	1.32	14.2	12.46	21.5	137.17	161.02	46.21	104.45	26
	Max	4.01	6.44	37.36	34.53	47.29	315.57	376.38	96.5	194.16	81.29
P. domestica subsp. *domestica*	Mean	1.85	2.37	15.12	13.07	37.64	153.69	163.45	48.1	83.42	38.71
	Min	1.05	1.05	7.68	7.95	16.68	96.4	101.56	35.62	60.52	22.72
	Max	3.48	4.82	23.28	20.61	52.31	200.25	200.17	66.02	103.11	62.48
P. domestica subsp. *syriaca*	Mean	2.96	2.97	12.79	10.72	42	183.23	118.03	81.37	107.8	30.55
	Min	1.31	1.91	5.91	4.76	23.4	117.48	56.79	41.55	58.86	13.5
	Max	6.01	4.76	18.94	20.06	82.74	319.69	190.3	123.04	148.7	59.08
P. domestica subsp. *insititia*	Mean	2.03	3.71	17.79	18.61	60.82	262.82	176.2	92.49	168.54	64.26
	Min	1	1.48	7.68	9.62	34.91	168.66	81.57	45.76	115.58	36.11
	Max	3.82	8.22	26.61	29.89	95.74	398.27	244.17	150.21	274.84	97.58
P. domestica subsp. *italica*	Mean	2.65	2.83	13.23	8.51	35.2	167.08	140.8	53.91	97.83	30.13
	Min	1.48	1.55	6.77	3.98	18.45	92.21	95.97	34.02	39.25	14.46
	Max	4.61	5.93	19.92	16.15	48.79	229.46	191.06	84.17	136.05	51.09
P. armeniaca var. *armeniaca*	Mean	1.82	2.6	20.27	13.7	92.09	244.08	368.93	78.45	129.4	64.58
	Min	1.15	1.1	7.88	8.88	61.03	194.9	242.49	25.28	86.58	26.69
	Max	3.61	4.93	40.52	24.35	133.1	303.2	478.39	136.07	176.22	105.74
P. armeniaca cv. Saeede Mariame	Mean	1.9	2.22	16.46	10.79	82.84	239.3	317.66	87.35	154.28	61.77
	Min	0.93	0.96	7.56	6.39	38.67	153	173.6	37.2	98.86	37.75
	Max	3.13	5.33	29.82	19.38	108.46	304.19	447.47	128.36	200.76	90.03
P. microcarpa var. *pubescens*	Mean	2.2	2.33	14.93	11.24	25.07	110.66	84.76	45.91	72.1	32.84
	Min	0.88	1.55	6.68	4.13	13.47	67.47	51.73	29.09	30.52	16.38
	Max	3.59	4.18	24.35	23.89	47.7	171.3	121.83	73.94	102.8	72.21
P. microcarpa var. *microcarpa*	Mean	1.96	2.86	17.52	14.97	19.66	93.65	52.88	34.95	61.16	26.78
	Min	1.25	1.8	9.22	10.37	5.97	71.73	33.62	22.57	24.41	14.26
	Max	2.8	5.28	28.33	22.94	32.16	129.47	78.44	47.28	98	50.12
P. brachypetala	Mean	1.98	1.79	14.29	11.95	19.93	60.93	46.54	22.73	54.16	17.09
	Min	1.16	0.98	6.42	7.18	13.04	40.11	22.26	13.98	21.62	9.67
	Max	3.38	2.69	25.42	18.5	30.07	99.2	76.03	37.56	95.62	29.44
P. mahaleb	Mean	3.9	3.08	13.25	10.9	37.14	174.35	194.63	62.1	146.01	39.3
	Min	1.71	1.65	5.85	6.17	26.16	83.76	118.82	40.41	94.46	16.91
	Max	7.99	5.8	21.63	15.73	50.62	229.93	289.11	77.33	193.39	71.13
P. cerasus	Mean	2.48	1.69	23.7	17.24	31.97	195.35	179.77	64.85	121.36	47.81
	Min	1.15	1.04	12.33	6.17	24.22	121.09	113.8	48	85.67	32.49
	Max	4.5	2.56	33.67	31.86	43	317.3	236.08	84.97	152.04	67.43

Table 3. Quantitative characters of cells and tissues measurements in petiole cross section of subgenera *Prunus* and *Cerasus* (µm).

Taxon	Statistic	Upper cuticle	Lower cuticle	Upper epidermis	Lower epidermis	Collenchyma thickness	Parenchyma thickness	Cortex thickness	Phloem thickness	Xylem thickness	Pith thickness
P. cerasifera	Mean	2.97	4.53	35.34	36.78	68.72	389.73	383.47	63.58	150.6	40.32
	Min	1.28	2.67	14.59	17.7	29.29	278.58	295.01	41.5	66.81	16.38
	Max	9.11	8.01	52.17	58.03	99.54	507.98	461.96	94.82	239.45	56.76
P. domestica subsp. *domestica*	Mean	2.22	2.84	16.8	9.63	52.53	258.02	171.87	47.54	88.06	40.25
	Min	1.25	1.48	8.27	5.08	24.1	148.47	105.19	24.62	41.74	23.07
	Max	3.94	4.73	26.64	15.06	89.32	321.44	242.85	63.89	130.58	62.65
P. domestica subsp. *syriaca*	Mean	2.88	3.29	10.42	9.11	63.9	241.11	223.8	77.88	113.64	48.73
	Min	1.16	1.64	3.59	5.57	40.74	131.74	125.74	45.58	68.15	23.54
	Max	4.33	6.16	17.05	14.61	93.12	331.32	392.94	112.96	164.55	74.81
P. domestica subsp. *insititia*	Mean	2.33	4.43	10.06	20.21	114.92	410.59	304.24	83.25	215.03	59.34
	Min	1.35	2.59	3.54	7.77	66.92	288.84	214.65	44.11	119.29	31.09
	Max	4.59	8.06	19.86	37.41	180.17	548.51	438	137.45	321.8	87.33
P. domestica subsp. *italica*	Mean	2.92	3.38	9.22	11.24	65.97	232.34	189.96	61.45	108.59	38.66
	Min	1.76	1.55	4.2	6.93	43.58	149.2	102.53	35.31	46.98	15.68
	Max	4.72	8.78	16.13	18.48	99.36	265.85	257.28	84.84	169.01	65.42
P. armeniaca var. *armeniaca*	Mean	2.41	2.73	11.05	13.08	177.47	298.36	454.18	96.59	166.56	81.6
	Min	1.16	1.91	5.91	6.89	142.44	213.98	324.79	63.14	82.57	33.38
	Max	6.91	6.68	18.07	25.73	232.19	382.12	594.99	129.7	236.31	118.09
P. armeniaca cv. Saeede Mariame	Mean	2.06	3.61	10.79	10.25	104	370.02	430.52	97.53	155.23	55.44
	Min	1.04	2.05	4.18	6.5	79.2	179.62	258.56	50.33	105.66	24.84
	Max	3.77	8.07	20.98	15.46	127.52	481.85	575.87	147.7	223.07	79.83
P. microcarpa var. *pubescens*	Mean	2.72	2.4	18.87	11.29	36.04	135.54	151.14	53.62	89.09	36.63
	Min	1.62	1.28	9.02	6.89	13.27	70.67	63.54	34.98	48.08	17.17
	Max	4.79	3.71	32.02	21.13	81.71	231.16	254.32	79.03	140.63	57.35
P. microcarpa var. *microcarpa*	Mean	2.4	2.59	19.6	13.55	34	126.66	98.1	40.18	59.67	31.29
	Min	1.64	1.47	11.83	9.52	17.82	88.79	23.49	22.76	35.81	13.28
	Max	3.74	3.82	29.89	21.39	43.37	177.4	187.46	53.48	85.75	43.3
P. brachypetala	Mean	1.83	1.68	10.96	11.17	42.12	95.88	133.13	33.29	81.68	34.73
	Min	1.15	1.31	4.52	3.98	28.39	57.47	71.73	20.23	25.94	16.64
	Max	3.02	2.46	17.82	19.32	57.09	155.06	180.22	56.15	145.11	55.1
P. mahaleb	Mean	4.65	3.74	14.63	19.92	75.73	300.84	447.79	65.69	173.72	39.69
	Min	2.56	1.87	7.7	11.04	49.34	179.22	322.46	35.8	77.36	18.88
	Max	7.98	8.47	24.22	30.41	112.77	428.67	539.92	92.15	228.7	64.68
P. cerasus	Mean	2.55	2.6	30.25	30.83	53.24	302.67	273.63	66.05	138.51	60.75
	Min	1.1	1.35	11.1	12.97	39.1	204.9	143.39	50.21	59.15	22.64
	Max	7.27	4.32	51.56	45.42	79.39	417.7	421.95	85.6	194.53	169.7

Table 4. Leaf trichome length and number of trichomes/ mm^2.

Taxon	Statistic	Length (mm)		Number/ mm^2	
		Adaxial	Abaxial	Adaxial	Abaxial
P. cerasifera	Mean	0.04	0.85	7.35	4.7
	Min	0.03	0.26	2	2
	Max	0.06	1.26	14	8
P. domestica	Mean	0.13	0.35	1.45	2.11
subsp. *domestica*	Min	0.05	0.18	0	0
	Max	0.26	0.47	3	3
P. domestica	Mean	0.13	0.33	1.65	4.3
subsp. *syriaca*	Min	0.05	0.1	0	0
	Max	0.35	0.43	3	9
P. domestica	Mean	0.19	0.35	1.4	4.55
subsp. *insititia*	Min	0.09	0.13	0	2
	Max	0.33	0.6	3	8
P. domestica	Mean	0.44	0.25	1.2	4.14
subsp. *italica*	Min	0.22	0.09	1	2
	Max	0.88	0.40	3	6
P. armeniaca	Mean	0.17	0.4	2.86	1.29
var. *armeniaca*	Min	0.04	0.12	1	0
	Max	0.34	0.79	6	3
P. armeniaca cv.	Mean	0.19	0.16	1.45	3.75
Saeede Mariame	Min	0.08	0.01	0	1
	Max	0.45	0.52	3	8
P. microcarpa	Mean	0.11	0.18	67.15	89.65
var. *pubescens*	Min	0.02	0.04	49	65
	Max	0.27	0.37	86	110
P. microcarpa	Mean	----	0.03	----	0.15
var. *microcarpa*	Min	----	0	----	0
	Max	----	0.24	----	1
P. brachypetala	Mean	0.38	0.53	211	260.5
	Min	0.04	0.12	198	230
	Max	0.92	0.78	220	288
P. mahaleb	Mean	----	0.69	----	2.55
	Min	----	0.39	----	1
	Max	----	1.07	----	5
P. cerasus	Mean	----	0.88	----	1.45
	Min	----	0.51	----	0
	Max	----	0.88	----	1.45

CONFLICT OF INTEREST

The authors declare that they have no conflicts of interest.

DECLARATION OF FUND

The authors declare that they have not received a fund.

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