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Structural Features of the Vegetative Organs of *Allium kysylkumi* Kamelin. Growing in the Conditions of Kyzylkum

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Abstract

The article presents the results of studies of the anatomical structure of the vegetative organs of *Allium kysylkumi* of the Amaryllidaceae family, which grows in the conditions of Kyzylkum (Kokchatau outlier mountain). The characteristic diagnostic features have been determined: the outer membrane of epidermal cells is well developed by the outer folded cuticle, cutinized and more thickened; leaves are amphistomatic; stomata are the most submerged, anomocytic type; isolateral-palisade type of leaf mesophyll; the conducting bundles are closed, collateral and are arranged in two rows, of which the upper side is represented only by small bundles, in the lower row, 3 large bundles alternate with one small bundle; peduncle and peduncle, parenchymal-beam type of structure; the epidermis is single-row, folded cuticle with more thickened and cutinized; the crustal parenchyma is thin-walled, round-oval, chlorophyll-bearing; the presence of lactic acid is in the cow parenchyma; the primary cortex is separated from the central cylinder by a ring of sclerenchyma; the central cylinder is extensive; closed collateral-type conductive bundles. In the vegetative organs of *Allium kysylkumi*, especially in the leaf, xeromorphic characters are pronounced, which indicates the fitness of this species in natural habitat. The revealed structural diagnostic signs of vegetative organs are species-specific, and show the adaptation of this species to its natural habitat, these micromorphological signs are taxonomic significance for distinguishing and identifying *Allium* species.

Keywords

Anatomy, Leaf, Stem, Peduncle, *Allium kysylkumi*, Navoi Region (Kyzylkum), Uzbekistan

1. Introduction

Allium L. is a widely distributed genus comprised of more than 800 species that occur mainly in seasonally dry regions in the Northern Hemisphere, including Europe, Asia and North America, and in South Africa [1] [2] [3] [4]. Central Asia is the main center of distribution and diversity of this genus, and it is rich in species of *Allium* [3] [5].

Based on morphological characters, the traditional taxonomic system placed *Allium* in the Liliaceae [6]. However, modern taxonomic treatments have placed the genus in the Alliaceae [7] [8] [9] [10] or in the Amaryllidaceae [11] based on morphological, anatomical, cytological and molecular data. Infrageneric classification of the genus *Allium* is problematic because of proliferation of synonyms and lack of good and consistent taxonomic characters, resulting in disagreements on which ones to use for taxon boundaries [12] [13]. Several characters have been used in taxonomic classification of *Allium*, and some of them have proved to be useful at the subgeneric and sectional levels. Vvedensky [14], Xu [12] and Stearn [1] divided the species of *Allium* from Russia, China and Europe into 10, 9 and 13 sections, respectively, based on morphological characters of the rhizome, bulb, leaf and flower. Hanelt *et al.* [8] divided the genus into six subgenera and 50 sections and Friesen *et al.* [3] and Nguyen *et al.* [15] into 15 subgenera and 56 sections using information on anatomy, cytogeography and DNA ITS sequences.

Morphological characters of leaf epidermal cells, *i.e.* shape of anticlinal walls and the distribution, density and type of stomata and trichomes, are of potential taxonomic significance and have been widely used for the classification of taxa in various plant families [16] [17] [18] [19] [20].

For example, in Lycoris (Amaryllidaceae), the shape of cells and distribution of stomata were used for species identification [21], and in Smilacina (Liliaceae) stomatal and other epidermal features can be used to distinguish species [22]. Krahulec [23], Tanker & Kurucu [24], Fritsch [25], Uysal [26], Choi & Oh [27] found that characters of leaf anatomy in *Allium* taxa as well as papillae, laticifers and vascular bundles were important characters in relation to taxonomy. Gregory [28] divided 22 species of sect. *Allium* into two distinct groups based on the number of stomata, height of guard cells and vascular bundles arrangement.

We have studied the anatomical structure of the *Allium suworowii* leaf in different ecological conditions: the Jizzakh region and in the Tashkent Botanical Garden of the Academy of Sciences of the Republic of Uzbekistan and identified diagnostic signs of the leaf, also identified a different combination of xeromorphic and mesomorphic characters, which ensure adaptation to habitat conditions [29].

Thus, various authors have concluded that leaf epidermal anatomy can provide a significant tool for resolution of the taxonomic confusion of *Allium* species. In this regard, the identification of morphological, structural diagnostic characters of representatives of the genus Allium in natural conditions, the

substantiation of their adaptive features are of great scientific and practical importance.

2. Materials and Methods

The objects of study are *Allium kysylkumi* Kamelin. a perennial herbaceous plant species of the genus *Allium* L. Family Amaryllidaceae (**Figure 1**). *Allium kysylkumi* bulbs 1 - 4 attached to an oblique or ascending rhizome, oblong-conical and oblong-ovate, with reddish-brown reticular membranes. Arrow or peduncle 15 - 30 cm in height. Leaves 3 - 5, narrowly linear, 0.5 - 2.5 mm wide, slightly grooved, often bent, rough along the edge. The cover is shortly pointed, 1.5 - 2 times shorter than the umbrella, remaining. Umbel is tuberous or almost hemispherical, relatively few-flowered. Pedicels are unequal, 2 times shorter or slightly longer than the perianth, without bracts at the base. The perianth is narrowly bell-shaped; leaflets purple with a darker vein, extended, pointed or obtuse, outer 6 - 8 mm in length, linear-lanceolate or lanceolate, equal. Filaments of stamens are 2 times shorter than the perianth, half fused together and with the perianth, whole, outer triangular-subulate, inner almost 3 times wider than outer, triangular; anthers are yellow. The column does not protrude from the perianth. Ovary at the apex with cartilaginous denticles forming a crown surrounding the base of the column. Blooms in May. It grows on clay and rubble slopes of low mountains at an altitude of 400 - 700 m. It is endemic to Uzbekistan (Kyzylkum: Kokcha outlier mountain) [30].

The research was carried out in natural conditions. Simultaneously with the morphological description, the leaf, peduncle and peduncle were fixed in 70% ethanol for anatomical study. The epidermis was studied on paradermal and cross sections. Cross sections of the leaf are made through the middle, the stem and peduncle through the base. Hand-prepared preparations were stained with methylene blue, followed by gluing in glycerol-gelatin [31]. Descriptions of the main tissues and cells are given according to K. Esau [32], NS Kiseleva [33], epidermis according to S.F. Zakharevich [34] carried out using light microscopy. Micrographs were taken with a computer microphoto attachment with a *Canon* A123 digital camera under a *Motic B*1-220*A*-3 microscope.

3. Results and Discussion

Leaves of *Allium kysylkumi*, 3 - 5, narrow-linear, 0.5 - 2.5 mm wide, slightly grooved, often curved, rough along the edge.

3.1. The Anatomical Structure of the Leaf

Under light microscopy, signs of cells of the epidermis and stomatal apparatus were constantly found both on the adaxial and abaxial surfaces of the lobes in the central part of each leaf. That is, within the species, the shape of epidermal cells was the same on the adaxial and abaxial sides of the leaf. In the paradermal section, the outline of the epidermis is represented by highly elongated cells with

Figure 1. Appearance of *Allium kysylkumi* in the flowering phase.

straight anticlinal walls; epidermal cells are numerous on the abaxial side than on the adaxial side. The cells of the adaxial epidermis are larger than the abaxial ones.

Leaves are amphistomatic. The stomata are located transversely to the longitudinal axis of the leaf. The shape of the stomata is round-oval, numerous on the abaxial side than on the adaxial side. The stomata guard cells on both sides of the leaf are almost the same length. The stomata are the most submerged, of the anomocytic type (Figure 2, Figure 3).

The cross section of the *Allium kysylkumi* leaf has a flat outline with some dorsal ribs. The leaf mesophyll on the transverse section of the isolateral-palisade type, which is represented by palisade, spongy cells and vascular bundles. The epidermis is represented by one row of oval-shaped cells (Figure 2, Figure 3).

The outer membrane of epidermis cells is well developed by the outer folded cuticle, cutinized and more thickened (Figure 2, Figure 3).

The palisade parenchyma consists of two rows, long cylindrical and elongated cells. The spongy parenchyma consists of 7 - 8 rows of small cells. Palisade and spongy parenchyma are chlorophyll-bearing. Between the palisade cells, there are numerous small lacteals. Around the lacteals there are large, rounds, 5 - 6 cells of the sheath (Figure 3).

The spongy parenchyma consists of rounded cells with large intercellular spaces, and in the middle part of the leaf, the intercellular spaces merge, forming small cavities. Conducting bundles are arranged in two rows, of which the upper side is represented only by small bundles. In the bottom row, 3 large bundles alternate with one small bundle. The conducting bundles are closed, collateral, numerous, consisting of phloem and xylem (Figure 3).

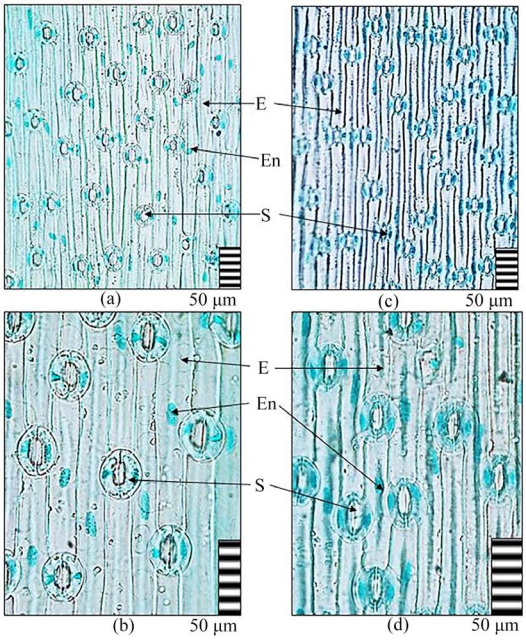

Figure 2. Anatomical structure of the epidermis of the *Allium kysylkumi* leaf: (a)-(b) adaxial epidermis; (c)-(d) abaxial epidermis. Legend: S—stomata, E—epidermis, En—epidermal nucleus. **Magnification** –50 micron.

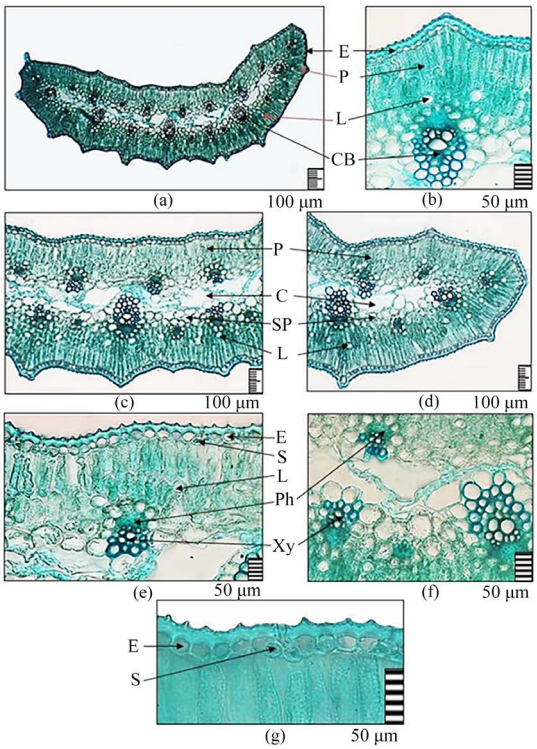

Figure 3. Anatomical structure of the *Allium kysylkumi* leaf: (a) general view of the leaf mesophyll; (b)-(c)-(d) epidermis, palisade parenchyma, conducting bundles and lactic acid; (e)-(f) detail of the middle and extreme part of the leaf mesophyll and vascular bundles; (g) submerged stomata. Legend: SP—spongy parenchyma, Xy—xylem, L—lacteals, P—Palisade parenchyma, C—cavity, CB—conducting bundles, S—stomata, Ph—phloem, E—epidermis. **Magnification** –50 - 100 micron.

3.2. The Anatomical Structure of the Stem

Stem on a transverse cut of an oval shape, a parenchymal-beam type structure. The epidermis is represented by one row of cells, serrated. The outer membrane of epidermal cells is well developed by the outer cuticle, cutinized and more thickened. The cuticle is slightly wavy. Under the epidermis there is a 4 - 5 row thin-walled, round-oval, chlorophyll-bearing cortex parenchyma. Large and numerous lacteals are located between the cells of the cortex parenchyma. Around the -lacteals there are large, rounded 5 - 6 cells of the sheath. The primary cortex is separated from the central cylinder by a ring of sclerenchyma. The thickness of this ring and the degree of lignification of the cells in some respect reflect the evolutionary advancement of the species. Sclerenchyma is thick-walled, annular, and consists of 8 - 10 rows of cells. Under the cortex parenchyma and above the sclerenchyma there are small annular conductive bundles (Figure 4). The central cylinder is extensive, the parenchymal cells are thin-walled, large, rounded-oval. Among the sclerenchymal and parenchymal cells of the central cylinder, there are large, numerous conducting bundles, which are localized in an annular shape. The vascular bundles are closed collateral type, have very large and small vessels, phloem and xylem. Among the parenchymal cells of the central cylinder, there are hydrocytic cells (Figure 4).

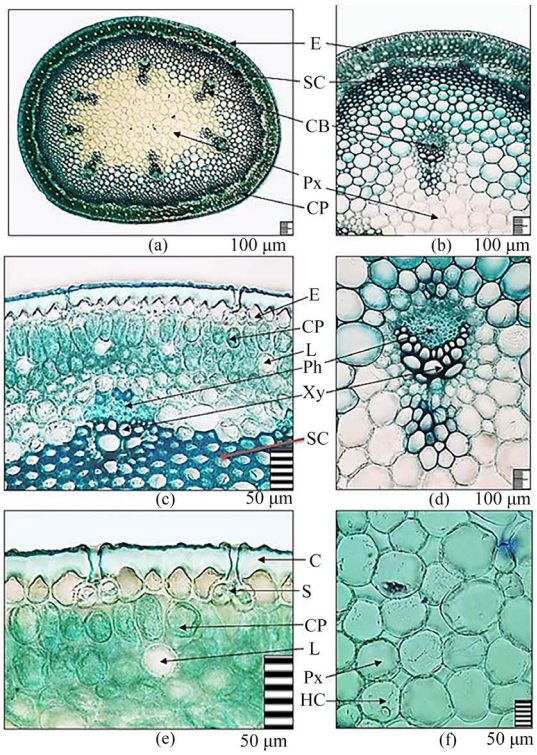

Figure 4. Anatomical structure of the stem *Allium kysylkumi*: (a) general view of the stem; (b) detail of the stem; (c) epidermis; cortex parenchyma and lacteals; (d) conducting beam; (e) submerged stomata and lacteals; (f) core. Legend: HC—hydrocytic cells, C—cuticle, CP—cortex parenchyma, Xy—xylem, L—lacteals, CB—conducting bundles, Px—parenchyma, SC—sclerenchyma, S—stomata, Ph—phloem, E—epidermis. **Magnification** –50 - 100 micron.

3.3. The Anatomical Structure of the Pedicel

Pedicel on the cross section is rounded, structure of the parenchymal-bundle type. The epidermis is represented by one row of cells, rounded. The outer epidermal cells are thin-walled. Under the epidermis there is a 4 - 5 row, rounded-oval, small and thick-walled cortex parenchyma. The central cylinder contains 6 conductive bundles (Figure 5).

The vascular bundles are not cleared and consist of phloem and xylem. Vessels are small, thick-walled, 2 - 4 in number. Most of the pedicel is occupied by the cortex and parenchymal cells (Figure 5).

The anatomical structure of the vegetative organs of *Allium kysylkumi*, growing in the conditions of Kyzylkum, was studied and the following diagnostic features were revealed: in the leaf, the outline of the epidermis is represented by highly elongated cells with straight anticlinal walls; the outer membrane of epidermal cells is well developed by the outer folded cuticle, cutinized and more thickened; leaves are amphistomatic; stomata are the most submerged, anomocytic type; leaf shape is flat, contour with some dorsal ribs; isolateral-palisade type of leaf mesophyll structure; palisade parenchyma is two-rowed, has long cylindrical and elongated cells; spongy parenchyma consists of rounded cells with large intercellular spaces; in the middle part of the leaf the intercellular spaces merge, forming small cavities; the conducting bundles are closed, collateral and are arranged in two rows, of which the upper side is represented only by small bundles, in the lower row 3 large bundles alternate with one small bundle; stem-parenchymal-beam type of structure; the epidermis is single-row, serrated; the outer cuticle of epidermal cells is cutinized, more thickened and slightly wavy; the cortex parenchyma is thin-walled, round-oval, chlorophyll-bearing; there are large and numerous lactates in the cow parenchyma; the primary cortex is separated from the central cylinder by a ring of sclerenchyma; the central cylinder is extensive; parenchymal cells are thin-walled, large, rounded-oval; closed collateral-type conductive bundles; peduncle parenchymal-beam type of structure; the epidermis is single-row and thin-walled; the cortex parenchyma is round-oval, small and thick-walled; the conducting bundles are not cleared, closed collateral type (Figures 2-5).

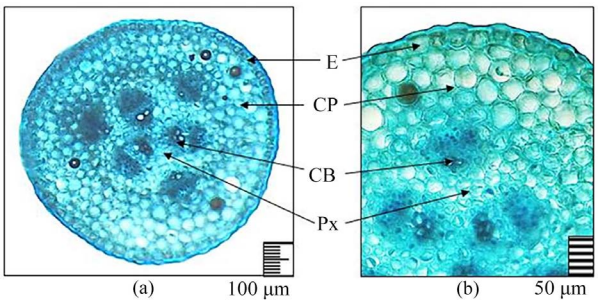

Figure 5. Anatomical structure of the pedicel of *Allium kysylkumi*: (a) general view of the peduncle; (b) detail. Legend: CP—cortex parenchyma, CB—conductive bundles, Px—parenchyma, E—epidermis. **Magnification** –50 - 100 micron.

Based on the identification of the anatomical features of the vegetative organs of *Allium kysylkumi*, the following xeromorphic features were identified: the isolateral-palisade type of leaf mesophyll; outer folded cuticle of epidermal cells is cutinized, more thickened; palisade parenchyma with long cylindrical and elongated cells; numerous, most submerged stomata; there are numerous small milkmen; small epidermal, spongy and parenchymal cells; multi-row sclerenchymal cells.

4. Conclusion

Thus, the anatomical structure of the vegetative organs of *Allium kysylkumi*, growing in the conditions of Kyzylkum (Kokchatau outlier mountain), was studied and diagnostic signs were determined. In the vegetative organs of *Allium kysylkumi*, especially in the leaf, xeromorphic characters are clearly expressed, which indicates the fitness of this species in natural habitat. The revealed structural diagnostic signs of vegetative organs are species-specific, and show the adaptation of this species to its natural habitat, these signs can be used for taxonomy.

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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