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STRUCTURAL FEATURES OF THE ASSIMILATIVE ORGANS OF *SALSOLA PAULSENII* LITV. IN THE CONDITION OF THE SOUTH-WEST KYZYLKUM

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Abstract: Based on the study of the morpho-anatomical structure of the assimilative organs of *Salsola paulsenii* Litv., growing in the conditions of South-Western Kyzylkum, diagnostic and adaptive signs specific to it, were determined. The structure of the epidermis and mesophyll of cotyledons and leaves was analyzed. It was established that the mesophyll of the cotyledons of *S. paulsenii* belongs to the Kranz-centric (*Salsoloid*) type, as well as the presence of anomacytic and hemiparacytic types of stomata in the epidermis of the cotyledons. In the leaves of *Salsola* paulsenii, two different types of leaf mesophyll have been identified: Kranz-centric (*Salsoloid*) and Kranz-ventro-dorsal types, and in the leaf mesophyll the *Salsaloid* type explains that the peripheral vascular bundles are connected to the kranz cell. At the base of the leaf mesophyll there is a Kranz-ventro-dorsal structure. In the middle part and at the apex, the leaf mesophyll structure is Kranz-centric (*Salsoloid* type). In the leave epidermis of *S. paulsenii*, three types of stomata are established: anomacytic, hemiparacytic and paracytic; the anomacytic type of stomata is the most predominant. The presence of simple unicellular papillary trichomes is found from the middle part to the apex of the leaf. These identified diagnostic and adaptive anatomical signs in the mesophyll of cotyledons are dominated by xeromorphic signs, and in the mesophyll of leaves - halo-xeromorphic signs, which indicates the adaptation of this species to the conditions of South-Western Kyzylkum.

Key words: morphology, anatomy, cotyledon, leaf, *Salsola paulsenii*, Kyzylkum.

INTRODUCTION

In some species of the genus *Salsola* from the family Chenopodiaceae Vent. adaptation to arid living conditions is expressed in microphyllia, pubescence of leaves, centric type of leaf mesophyll in different modifications: scleromorphic and succulent (A. A. Butnik, 1975).

It has now been established that the leaf structure of xerophytes cannot be reduced to one type. In the Chenopodiaceae family, 4 structural and ecological groups of leaf types are distinguished, which have different, often opposing characteristics (Butnik, 1984; Duschanova, 2015).

Each leaf tissue has a specific role in the adaptive process of desert plants. The adaptive properties of the epidermis of *Climacoptera* species have not yet been studied and information about its structure is fragmentary. Meanwhile, the structural features of the epidermis in combination with the type of mesophyll determine the path of adaptation to thermo-helioxeric conditions (Butnik, 1984, Duschanova, 2015).

Classical signs of the epidermis of xerophytes are pubescence, a thick cuticle and waxy coating, thickening of the outer cell wall, small cells, and submerged stomata (Korovin, 1958; Oppenheimer, 1960; Stocker, 1960; Seddon, 1974).

The leaf epidermis of succulent xerophytes, including of the family Chenopodiaceae, is often large-celled, with a thick or thin cuticle, which performs the function of water storage (Sundberg, 1986; Butnik, Timchenko, 1987).

The important role of the epidermis is due to its versatility. The processes of respiration, photosynthesis, and transpiration are carried out through the epidermis, and it provides protection from unfavorable conditions.

Butnik A.A., Duschanova G.M., Yusupova D.M. et al. (2017) were identified the structure of the leaves 93 species of the family. Chenopodiaceae from different regions of Central Asia, mainly Kyzylkum, of the presence of Kranz-syndrome was studied. The size of Kranz-cells in 41 species was determined and conducted signs ranging, distingush isolated group of species (63.8% of the total) with the parameters of 21-30 microns. Kranz-types of leaves predominate in the species *Salsoloideae* (89%), reflecting its higher evolutionary level. In he leaves of species in Chenopodiaceae in Central Asia dominated by succulent adaptation strategy (65% of the total number of species), in connection with the general background of saline deserts.

The type of mesophyll is specific location assimilation, conductive, sponge or water-bearing tissue relative to the across plane of the organ and each other. Carolin R.C., Jacobs S., Vesk M. (1975) made the first classification of types of mesophyll Chenopodiaceae. Nonkranz-types: Axyroid; Corispermoid; Austrobassioid (close to Corispermoid, but containing water-bearing tissue); Neokochioid (with peripheral vascular bundles); Sympegmoid (similar to Neokochioid, but peripheral banales separated from chlorenchimya). Kranz-types: Atriplicoid, Kochioid, Salsoloid, Kranz-Suaedoid vary by location Kranz-cells in relation to the vascular bundles.

At present Kranz-cells are studied by molecular biology in Russia, Germany, America, in connection with the type of metabolism, taxonomy and phylogeny of the family Chenopodiaceae (Pyankov, Kuzmin, Ku et al, 1998; Voznesenskaya, Franceschi, Artyusheva, 2003; Kadereit, Borsch, Weising, 2003; Akhani, Ghasemkhani, 2007; Freitag, Kadereit). Our study of Kranz-cells connected with ecology plants.

A special feature of Kranz species is the presence Kranz-cells. The anatomists have noted a long her presence in the leaves it calling the cubic form cells. Discovery H.P. Kortschak et al. (1965) and M.D. Hach, C.R. Slack (1966), and special way of the primary carboxylation called C_4 – dicarboxylic acids cycle, led to the rapid development of biochemical and anatomical studies. G. Kadereit et al. (2003) for the analysis of molecular structure Amaranthaceae and Chenopodiaceae leaves identified 7 groups with 17 types of mesophyll, calling them at described species (Atriplex halimus-type, etc.). Freitag H., Stichler W. (2002) was first described new types of mesophyll: Bienertia and Bocszczowia, which palisade cell is functionally divided into kranz-part and palisade-part without partitions.

Studying the structure of the leaf species in specific regions for the presence of Kranz-syndrome is a necessary element of ecological monitoring in connection aridization growing climate and reduction of water resources. Increase in the number of species with Kranz anatomy-leaves are considered as an indicator of intensified xerophilous habitat (Stowe, Teeri, 1978; Toderich et al, 2006).

Butnik A.A., Duschanova G.M., Yusupova D.M. et al. (2017) described 13 types of mesophyll and 4 modifications in plants of the Kyzylkum desert. Considered such detailing necessary and consider it as a design modification. Chloroplasts are contained in the aquiferous parenchyma, as in spongy tissue, but there are fewer of them, they provide the transition to CAM-type photosynthesis. A significant number of Kranz-types were found in the leaves of Salsoloideae (89.1%), including highly specialized *Salsoloid* types (according to Kadereit et al., 2006) have *Salsola arbuscula*, *S. richteri, S. paulsenii* and less (30-7%) in the subfamily Chenopodioideae. This indicates the formation of most species of Chenopodioideae of the southwestern Kyzylkum in an arid climate and the appropriation of the historical youth and native flora of Central Asia (Kamelin, 1973).

In species of the genus *Salsola*, studies were carried out to determine the type of leaf mesophyll and ecological type.

In the Kyzylkum desert, 4 non-fender types with two modifications are described, and 9 fender types with a third modification are described. The presence of Kranz cells increases the possibility of forming leaf morphotypes that expand their adaptive response. Kranz types are predominant in the subfamily Salsoloideae (89%) compared to the subfamily Salsoloideae, subfamily Chenopodioidae (35%), which reflects their evolutionary level.

Kranz cells of Chenopodiaceae have different heights. The largest among the species (*Atriplix* and *Suaeda*). The width of the cells varies significantly, resulting in their shape varying from rectangular to cubic. By ranking the index of their sizes, we can distinguish a group of species with a cell height and width of 21-30 microns. The variability of Kranz type cells in one species has a small range, which indicates their genetic stability. Within familial variability in size, Kranz cells are higher. Differences in the size and thickness of the Kranz cell membranes and their location in the leaves indicate different times of their formation.

Osmanali B.B., Akhtaeva N.Z., Veselova P.V. and others (2020) studied the anatomical features of some species of the genus *Salsola*: *Salsola arbuscula* Pall., *S. tragus* L., *S. paulsenii* Litv. It was noted that the leaf blades of the studied species belong to the salsoloid type. The leaf mesophyll is centric. In the aquiferous parenchyma, the presence of calcium oxalate drusen in *S. tragus* and *S. paulsenii*. The common features of the organization in the studied species are the similarity in the succulent structure of the leaf blade, which determines the large-cellularity of the aquiferous parenchyma and the round shape of the cells in the three studied species of the genus *Salsola*.

The genus *Salsola* L. is the largest genus of the family Chenopodiaceae in the flora of Kazakhstan, numbering 33 species. Its representatives typically grow in saline habitats in desert areas. Species of this genus are widely used in traditional medicine against many diseases due to the content of various biologically active compounds such as phenolic compounds, alkaloids, flavonoids, saponins, vitamins, carotenoids, etc. (Aminova et al., 2016).

The halophytic succulent character of the representatives of the genus is due to their ability to accumulate water in the form of sap in the above-ground parts during the rainy season. This allows them to survive for quite a long time without external moisture. Moisture accumulates mainly in the stems or leaves. In the first case, the plants are called stem succulents, and in the second, leaf succulents.

According to the anatomical and physiological classification of halophytes (Taisumov et al., 2014), species of the genus *Salsola* belong to the group true halophytes (euhalophytes), which are characterized as the most salt-tolerant plants, accumulating significant concentrations of crystals and calcium oxalate druse in their leaves.

The anatomical structure of the leaves of succulent plants, particularly *Salsola*, is significantly different from the structure of a typical leaf. The leaves of leafy succulent plants are especially succulent (succulent); the leaves are thick, fleshy, often cylindrical, light-colored, and more or less transparent. This is partly due to the abundance of cell sap and the poverty of chlorophyll, and partly to the small size of the intercellular spaces. The thickness of the leaves is mainly due to the increase in mesophyll cells, which become large and round. The inner cells become poor in chlorophyll, very light in color and turn into almost true water tissue, surrounded by palisade tissue. In this case, the palisade fabric reaches a strong development. Individual cells become taller and often undergo transverse division. In many species we find a waxy coating, which gives them a bluish, dull color (Warming, 1902).

V. Kh. Tutayuk (1980), presenting the general diagram of the anatomical structure of *Salsola dendroides* Pall., indicates that the outside of the leaf is covered with epidermis, the cells of which are stretched across the length of the leaf. There is a hypodermis, which everywhere underlies the epidermis, interrupted under the stomata. The stomata lie on flush with the surface without being immersed in the fabric. The hypodermis here plays the role of water-bearing parenchyma. Chlorenchyma is two-layered: the cells of the outer layer are oblong, the cells of the inner layer are in the form of a tetrahedron, stretched in the tangential direction and shaped like a brick. They have fewer chloroplasts. The arrangement of chlorenchyma cells is one layer across the other, which enhances mechanical strength and holds together the succulent tissues of the leaf. The entire central part of the sheet is occupied large-celled water-bearing parenchyma, in the middle of which there is one vascular bundles. The lateral small bundles are tightly adjacent to the chlorenchyma.

According to K.Sh. Tozhibaev, N.Yu. Beshko, Kh.F. Shomurodov (2020) presents in the cadastre of the flora of Uzbekistan - species of the genus *Salsola*, common in the Bukhara region, including in the Amaranthaceae group, and also provides data for each plant species, data on life form, ecology, distribution, economic importance, environmental status.

H. Akhani, G. Edwards, E.H. Roalson (2007) was the first to provide a comprehensive phylogenetic analysis of tribe Salsoleae s.l. (Salsoloideae: Chenopodiaceae) is presented based on maximum parsimony and maximum likelihood analysis of nuclear ribosomal internal transcribed spacer and chloroplast psbB-psbH DNA sequences.

M.M. Il‘in (1936) assigned the *S. paulsenii* species growing in South-western Kyzylkum conditions to the section Kali (Adans) Ulbrich in the USSR flora, and later V.P. Bochantsev (1969) by included in the section *Salsola* Botsch.

The *Salsola* section contains only annual species. They lack real pubescence; their leaves are without a hump at the base, but with a cartilaginous point at the apex; flowers solitary (sometimes 3); anther appendages dense, small, smooth; the seeds are horizontal or sometimes vertical with a dry pericarp (Bochantsev, 1969).

H. Ahani, G. Edwards, E.H. Roalson (2007) was the first to study a comprehensive phylogenetic analysis and the obtained results of this species, *S. paulsenii* from the genus *Salsola*, renamed *Kali paulsenii* (Lit.) Akhani & EH Roalson, belonging to the genus *Kali* Mill. Their research work is aimed at an in-depth study of the composition and quantitative parameters of leaves, ecology and the evolution of its offspring.

Based on information from the above-mentioned literary sources, the anatomical structure of the cotyledon and leaves of the species *Salsola paulsenii*, growing in the conditions of South-western Kyzylkum, has been partially studied; the identified diagnostic and adaptive characteristics show the relevance and scientific novelty of our research.

MATERIALS AND METHODS

Salsola paulsenii is bushy-branched from the base, 10-40 cm tall, rough with dense, short spines or smooth, yellowish-green, often with reddish stems. Stem leaves are alternate, linear, long, semi-rolled, widened at the base, drawn into a hard spine at the apex, do not fall off when dry, or fall off; The bracts are somewhat wider and shorter than the stem ones, but longer than the bracts, only at the top of the inflorescence they are approximately equal to them. The bracts are pointed, like the bracts, deflected from the stem. The tepals are drawn into a pointed point and, when fruiting above the wings, are collected in a column. Anthers without appendages. Stigmas are thread-like, equal to or longer than the style. The seeds are horizontal. Blossoms and bears fruit in June-September (Bochantsev, 1953).

Lives on sandy soils and sands. Grows in the regions Tashkent, Namangan, Fergana, Bukhara, Kashkadarya and Surkhandarya; and Kara-Kalpak Autonomous Soviet Socialist Republic. General distribution. Central Asia, southeast of the European part of the USSR, Caucasus, Dzungaria, Kashgaria (Bochantsev, 1941).

S. paulsenii Litv. species is distributed in the Caucasus, Central Asia, in the saline and sandy soils of the European part of Russia (Akzhigitova, 1982), in Tashkent, Namangan, Fergana, Bukhara, Kashkadarya and Surkhandarya regions of Uzbekistan, as well as in the sandy and sandy soils of the Republic of Karakalpakstan.

The research was carried out in 2022-2023 in South-western Kyzylkum in the Bukhara region. The species *Salsola paulsenii* was collected from saline sandy, sandy-gravel soils, and herbarium specimens and fixing materials were prepared. Species *Salsola paulsenii* identified by taxonomist N.Yu. Beshko (1.05.2023).

Salsola paulsenii Litv. distributed in saline and sandy soils of the Caucasus, Central Asia, and the European part of Russia (Akzhigitova, 1982). In sandy and gravelly soils of Tashkent, Namangan, Fergana, Bukhara, Kashkadarya and Surkhandarya regions of Uzbekistan, as well as on gravelly soils of the Republic of Karakalpakstan.

According to Khasanov F.O., Shomurodov Kh.F., Kadyrov G (2011), the area of the Kyzylkum desert is 300,000 km^2. It consists mainly of sandy plains and rocky mountains. I.P. Gerasimov and P.N. Chikhachev (1964-1967) divided the territory of Kyzylkum according to its geological structure into four regions: 1. Northern Kyzylkum. 2. Central Kyzylkum. 3. South-Eastern Kyzylkum. 4. South-Western Kyzyl Kum (Esonov X.K., 2023). Todjibaev K.Sh., Beshko N.Yu., Popov V.A. (2016) argued in the botanical-geographical zoning scheme of Uzbekistan that Southwestern Kyzylkum is included in the Turan Province and consists of the Kyzylkum district (Kyzylkum and Kyzylkum regions of the remnants of the mountains) and the Bukhara district (Lower Zarafshan and Karshi-Karnabchol regions). South-Western Kyzylkum consists of sandy, gypsum, salt, gravel, rocky, clayey deserts, wastelands and anthropogenically developed areas. There are also lakes, basins, and remains of mountains and hills. This region borders the Karshi-Karnab and Sundukli deserts in the east, the Amu Darya in the west, the Bukhara and Karakol oases in the south, and the Kulyuktag ridge in the north. There is not a single surface watercourse throughout the entire territory (with the exception of the drying up Jonadarya), but there are rich reserves of pressurized underground fresh water. The soil is grey-brown, saline, gypsum, sand and gravel (Li, 1973; An, Gringof, Konovalov, 1978; Momotov, 1978; Akzhigitova, 1982). *S. paulsenii* is a psammophyte plant growing on saline sandy soils in South-western Kyzylkum.

Fig. - 1. General view of *Salsola paulsenii* in the conditions of Kyzylkum.

The study of the morphological and anatomical structure of the assimilating organs of *Salsola paulsenii*, growing in natural conditions, was carried out on the basis of generally accepted methods (Fig. -1). The plant was fixed in 70% ethyl alcohol to study the anatomical structure of the vegetative organs of the plant, as well as a morphological description of the leaf and cotyledons. The epidermis of leaves and cotyledons was studied using paradermal and cross sections. Transverse sections from the leaves (from tip to base) were made using ordinary blades. The finished sections were stained with methylene blue and temporarily fixed with glycerol. Pictures of transverse and paradermal sections were taken on a microscope KSO-5001-1 and S/N – EC 2209876 with magnifications 7x4; 7x20; 7x40; 10x4; 10x10 and 10x40. Tissues and cells of assimilative organs of plants are described according to the method of K. Esau (1969), N.S. Kiseleva (1971), A.A. Butnik et al. (2015), epidermis - S.F. Zakharevich (1954), types of leaf rollers M.A. Baranova (1981).

RESULTS AND DISCUSSION

When studying the assimilating organs of *S. paulsenii* by morphological state, it was found that the cotyledons are succulent, sessile, linear, ring-shaped, semicircular, 1-1.2 cm long, 4-5 mm wideEpidermis is monostichous (single row), consisting of large round isodiametrical cells with straight-line contours and a thick outer wall. The observations of Inamdar *et al.* (1977), and Butnik and Timchenko (1987) were confirmed about the presence of different types of stomata on a single leaf.In a paradermal section of the cotyledon of *Salsola paulsenii*, the epidermal cells are straight and polygonal in projection. The number of epidermal cells in the cotyledons is 945.06±1.08 per 1 mm2. The cotyledons have an amphistomatic structure, the length of the oval stomata is 18.7±0.15 µm, the width is 10.73±0.10 µm. It has been established that the number of stomata in cotyledons is 236.87±1.96 per 1 mm2, and the connecting cells in them have almost the same length. Stomata are submerged (4.15±0.038 µm) in the epidermal cell of the cotyledon. In the epidermis of cotyledons, 2 different types of stomata were found, of which the predominance and large number of stomata of the anomacytic type (82.8%) and a small number of stomata of the hemiparacytic type (17.2%) were determined (Fig. – 2, a).

The Kranz-centric (*Salsoloid*) type of cotyledon mesophyll of the species *S. paulsenii* has been established. In the mesophyll of cotyledons there are palisade parenchyma, water-bearing cells and vascular bundles; it has been established that photosynthesis C_4-type occurs in columnar and fringe cells. In mesophyll of the Kranz-centric (*Salsoloid*) type, the cotyledon has a ring-shaped structure; in the central part of the cotyledon there is 1 main vascular bundle and water-bearing parenchyma cells (Fig. – 2, b-d).

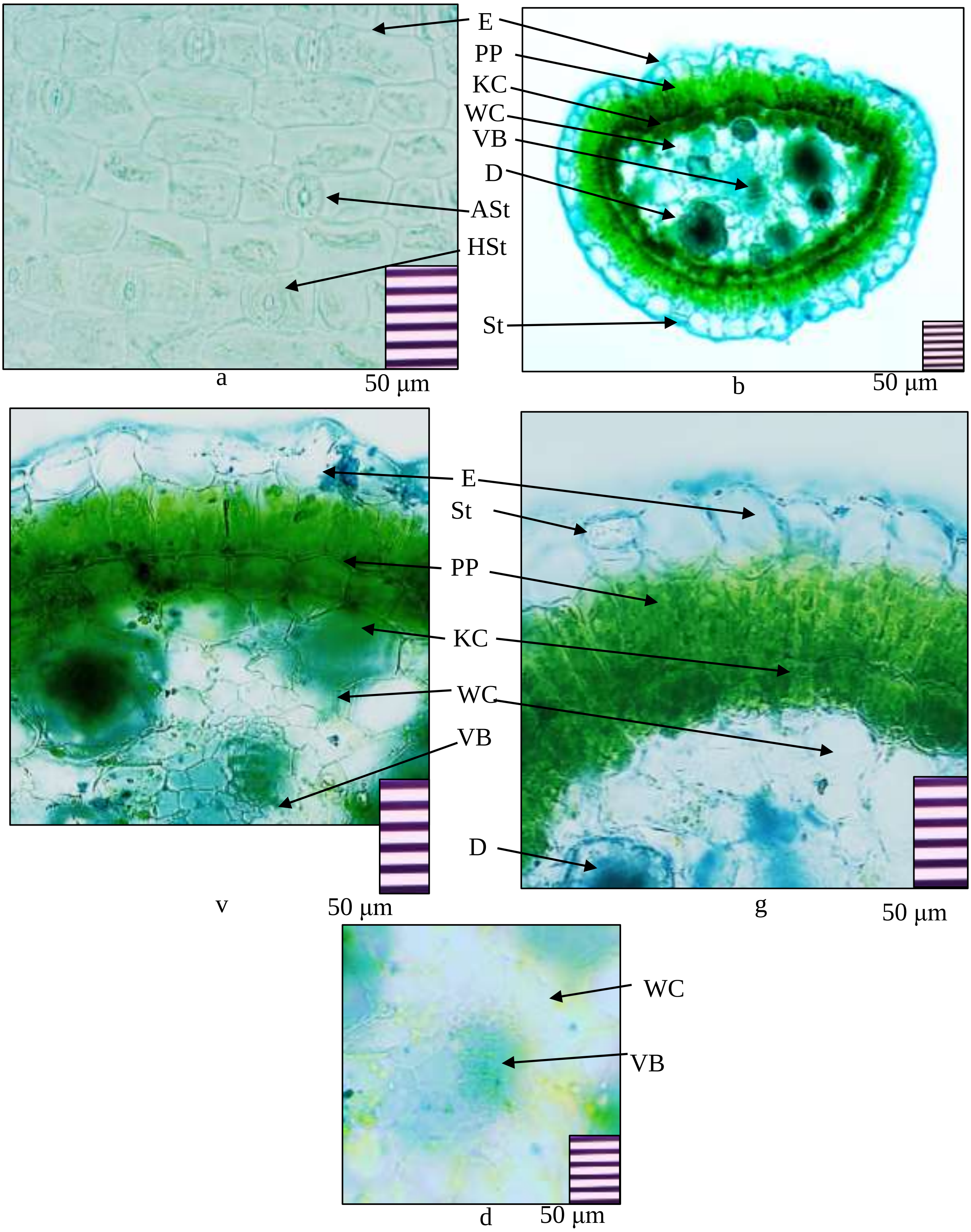

Figure - 2. Anatomical structure epidermis and of the cotyledon of *Salsola paulsenii* in cross section: a-epidermis, stomata: anomacytic and hemiparacytic type; b-g - epidermis, stomata, palisade parenchyma, kranz, water-bearing cells, vascular bundles and druses, d - palisade parenchyma and water-bearing cells;. **Conditional symbols**: ASt – anomocytic stoma, D – drusen, E – epidermis, HS – hemiparacytic stoma, KC – kranz cell, PP – palisade parenchyma, S– stoma, VB– vascular bundles , WC – water-bearing cells.

The epidermal cells are a series of round-oval cells with a height of 22.15± 0.13 µm and consist of a thin-walled cuticle (2.39 ± 0.056 µm) compared to the leaf. The palisade parenchyma of the 1st row of elongated cells, 34.94±0.28 µm long and 10.73±0.10 µm wide, is located between the epidermis and Kranz cells and has a small number of chlorophyll grains compared to Kranz cells (Fig. – 2, a-g).

The diameter of Kranz cells is 16.11 ± 0.14 µm, and more chlorophyll grains are found than in palisade cells. The lateral (peripheral) vascular bundles are adjacent to the fender cell and are located between the fender and water-bearing cells (Fig. – 2, b-g).

Water-bearing cells are thin-walled, round, oval, isodermic cells with a diameter of 131.87 ± 0.75 µm. The thickness of the water-bearing cells of the mesophyll of the cotyledons is 178 microns and accounts for 53.4%. In the mesophyll of the cotyledon there are 6-7 rows of water-bearing cells, among which a large amount of calcium oxalate drusen was found (Fig. – 2, b-d).

The main vascular bundles are of a closed collateral type, consisting of phloem and xylem, the number of xylems in the main vascular bundles is 5-6, its diameter is 3.23±0.039 µm. The vascular bundles are relatively lignified; mechanical tissue, sclerenchyma, is well developed in them. These vascular bundles are located between the water-bearing cells of the mesophyll of the cotyledons (Fig. – 2, table).

The leaves of *S. paulsenii* are succulent, sessile, linear, ring-shaped, semicircular, 1.8-2 cm long, 2-3 mm wide, 1-1.5 mm thick, extending from the base to 1/3 the length of the leaf, with long unicellular papillary trichomes, located alternately on the stem. During the generative period, it was found that the leaves on the main stem dry out or fall off (Fig. – 4, a).

Epidermal cells in paradermal sections of *S. paulsenii* leaves are straight, the projection is multifaceted, its height is 30.35 ± 0.35 µm. The epidermal cells contained numerous simple unicellular papillary trichomes, the length of which was 36.7 ± 0.45 µm; in arid conditions, these trichomes perform the function of low water evaporation and protection (Pic. – 3, b).

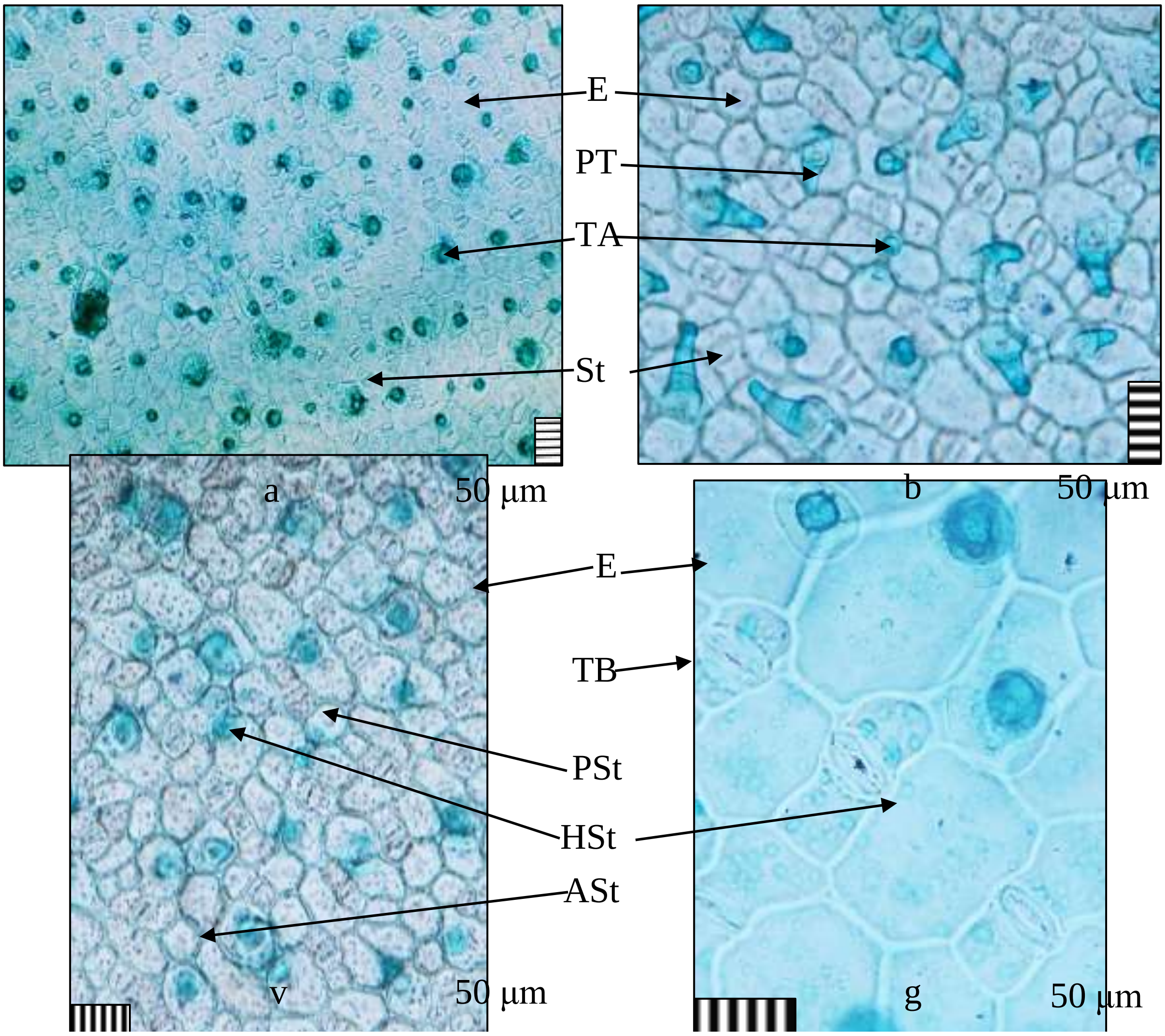

Figure - 3. Anatomical structure of the epidermis of leaves of the species *Salsola paulsenii* in paradermal section: a-g – epidermis, leaf stomata and the base of trichomes; b - papillary trichomes in the epidermis; v - anomacytic, hemiparacytic and paracytic leaf stomata in the leaf epidermis. **Conditional characters:** ASt – anomacytic stomata, HSt – hemiparacytic stomata, E - epidermis, PSt- paracytic stomata, PT - papillary trichomes, St – stomata, TB - trichome base.

The leaves of *S. paulsenii* have an amphistomatic structure. The shape of the leaf stomata is round-oval, length 22.64±0.21 µm, width 17.5±0.09 µm, the connecting cells of the stomata are almost the same length and are not submerged in the epidermal cells. In the leaf epidermis, 3 different types of stomata were identified, the predominance and abundance of stomata of the anomacytic type - 52.6% and a small amount of the hemiparacytic type - 31.6% and the paracytic type - 15.5% (Fig. -3, table).

The study of the anatomical structure of the leaf mesophyll of the species *S. paulsenii* was carried out by making transverse serial sections of the leaf and 2 different types of leaf mesophyll were identified. From the base to the middle part of the leaf mesophyll, the Kranz-ventro-dorsal type was determined, and from the tip to the middle part of the leaf, the Kranz-centric (*Salsoloid*) type of leaf mesophyll was determined. It has been established that in the identified leaf mesophylls, C_4-type photosynthesis is carried out in columnar and crown cells.

The Kranz-ventro-dorsal type of leaf mesophyll in the lower (abaxial) part of the leaf has a number of palisade parenchyma, kranz cell and peripheral vascular bundles, and in the upper (adaxial) part of the leaf there are water-bearing cells and 3 main vascular bundles (Fig. -4, a: 1-3).

The *Salsoloid* type is the most common. It is characterized by one row palisade parenchyma and kranz cells located along the entire circumference of the leaf. Peripheral vascular bundles are adjacent to the kranz cells. The main vascular bundle is located in the center of the leaf among the water-bearing cells. Hypodermal cells present or absent (*Salsola orientalis*, *S. aperta, S. paulsenii, S. richteri*) (Butniket al., 2017).

Anatomical description of the cross section of *Salsola arbuscula*, which is included in the section *Arbuscula*, is almost identical to the one given as a characteristic of the section in the article "Problems of Botany of Southern Siberia and Mongolia" Z. Wen and M. Zhang (2015). However, it should be noted that the species characteristics that make up the taxon section differ. This is due to different anatomical types of leaves. Thus, in *Salsola arbuscula* and *S. richteri* has *Salsoloid* type leaves, *S. arbusculiformis* has *Sympegmoid* leaves, *S. euruphylla* has leaves flat-leaved *Salsoloid* type (Pyankov et al., 1997; Voznesenskaya et al., 2003, 2013; Wen, Zhang, 2015; Butnik et al., 2017).

In the mesophyll of a leaf of the Kranz-centric (*Salsoloid*) type, the leaf has a ring-shaped structure, in the central part of the leaf there is 1 main vascular bundles and water-bearing cells (Fig. – 4, a: 4-6). Also, in the Kranz-centric (*Salsoloid*) type of leaf mesophyll, the lateral (peripheral) vascular bundles are located along the perimeter of the water-bearing tissue, in contact with the kranz cell, followed by a row of palisade parenchyma cells (Fig– 4, 1-3).

The height of the epidermal cell is 30.35±0.35 µm, the height of the thin-walled cuticle is 6.24±0.10 µm. Adaxial cells of the epidermis are larger and arranged in a row than abaxial cells. Between the adaxial and abaxial cells of the epidermis there are palisade parechyma, Kranz, water-bearing cells and vascular bundles. The palisade parenchyma of the 1st row of elongated cells with chlorophyll granules had a length of 31.41±0.21 µm, a width of 6.34±0.098 µm, and a palisade index of 4.95 µm. Palisade parenchyma cells are located between the adaxial epidermis and Kranz cells (Fig. – 4, table).

The diameter of the edge cells was 16.65±0.15 µm. Kranz cells contain more chlorophyll grains than palisade cells. The main vascular bundles of the leaf are of the closed collateral type and consist of phloem and xylem. The main vascular bundle has 10-11 xylem, its diameter is 6.23±0.10 µm. The vascular bundles are relatively lignified, the mechanical tissue - sclerenchyma - is well developed. It has been established that these vascular bundles are located between the water-bearing cells of the leaf mesophyll.

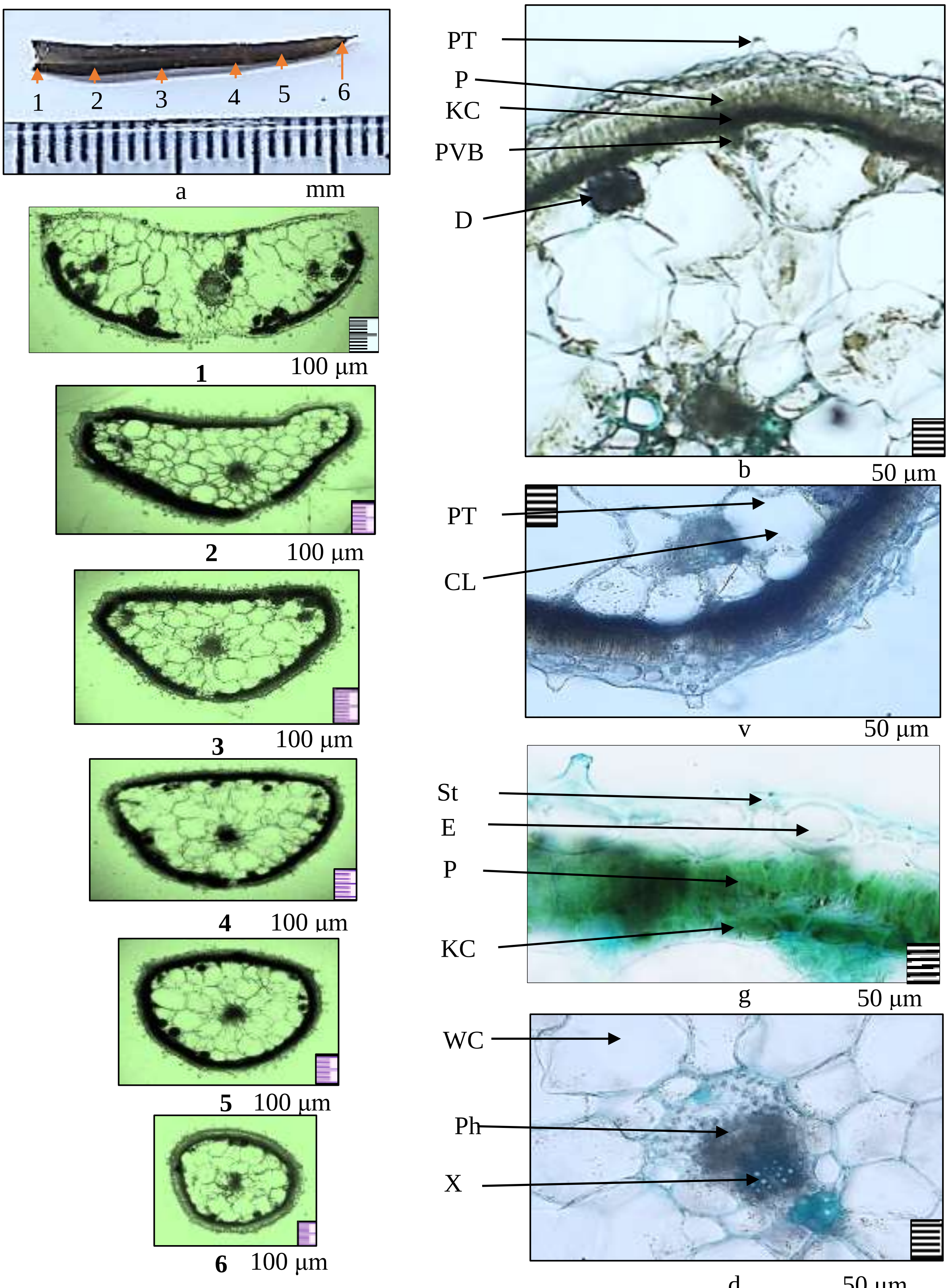

Figure - 4. Anatomical structure of the mesophyll leaf of *Salsola paulsenii* in cross section: a - general view of ring-shaped leaf; b – detail of leaf mesophyll; v - papillary trichomes, epidermis and collenchyma in the rib-like part of the leaf; g - stomata, palisade parenchyma, epidermis and kranz cells, d - water-bearing cell and vascular bundles. **Conventional signs**: CL - collenchyma, D - drusen, E - epidermis, KH - kranz cells, PVB - peripheral vascular bundles, Ph – phloem, P – palisade parenchyma, PT - papillary trichomes, St - stomata, X – xylem, WC - water-bearing cell.

Also, 24-27 lateral (peripheral) vascular bundles are attached to the kranz-cell and are located between the kranz and water-bearing cells. Water-bearing cells consisted of 6-7 rows of thin-walled, round, oval, isodermic cells, their thickness was 626±2.53 µm, and their diameter was 82.25±0.47 µm. The thickness of the water-bearing cells in the leaf mesophyll is 93.815±0.037 µm, which is 78.3% and occupies the main part of the leaf. Also, the presence of a large number of calcium oxalate drusen in the water-bearing cells of the peripheral part of the leaf mesophyll was found (Fig. – 4, tab.).

Table

Quantitative parameters of the assimilating organ of *Salsola paulsenii* species (n=30)

Indicator		**Assimilating organ**	
		cotyledon	leaf
Mesophyll thickness, µm			
Epidermis, µm **:**			
height		**22,15±0,13**	30,35±0,36
thick. outside walls		2,39±0,056	**6,24±0,10**
Number of epidermis 1 mm^2		945,06±1,08	557,08±1,22
Stomata, µm **:**			
Length		18,7±0,15	22,64±0,21
Width		10,73±0,10	**17,5±0,09**
Number of stomata 1 mm2		**236,87±1,96**	**146,9±1,84**
Stomatal density		4,15±0,038	**5,59±0,02**
Anomocytic types		82,8 %	52,6 %
Paracytic types		17,2 %	31,6 %
Hemiparacytic types		–	15,5 %
Trichome, µm Length		–	**36,7±0,45**
Palisade parenchyma, µm:	Height	**39,9±0,28**	31,41±0,21
	Width	**10,73±0,10**	6,34±0,098
	Palisade index	3,72	**4,95**
Water-bearing cell, µm:	thickness of layer	**131,87±0,75**	93,815±0,037
	% of d-list	53,4	**78,3**
	diameter	**31,5±0,18**	82,25±0,47
	row number	6-7	6-7
Diameter of the Kranz, µm		**16,11±0,14**	**16,65± 0,15**
Number of peripheral vascular bundles on a cross section		13-14	**24-27**
Number of vessels in the main vascular bundles		5-6	**10-11**
Diameter of vessels		**3,23±0,039**	6,23±0,10

Based on a comparative biometric analysis of quantitative indicators of the anatomical features of the assimilating organs of *Salsola paulsenii*, the following predominant anatomical features were identified.

The cotyledons of this species are dominated by the following anatomical features: small, numerous epidermal cells; most numerous stomata; thin mesophyll; small and numerous water-bearing parenchyma; high and elongated palisade parenchyma and palisade index; small and few vessels in the vascular bundles are xeromorphic features.

The leaf of this species is dominated by the following anatomical features: large, few epidermal cells; a few stomates; thick leaf mesophyll; large and numerous water-bearing parenchyma; tall and elongated palisade parenchyma and palisade index; large and numerous vessels in vascular bundles are halo-xeromorphic features.

Briefly, diagnostic structural and adaptive features were determined based on the study of the anatomical structure of the assimilating organs of *Salsola paulsenii* plants growing in the conditions of South-Western Kyzylkum. The mesophyll cotyledon of *Salsola paulsenii* has Kranz-centric (*Salsoloid*), and in the leaf mesophyll there are Kranz-centric (*Salsoloid*) and Kranz-ventro-dorsal types of mesophyll, correct linearity and versatility of the cell wall of the epidermis, the presence in the epidermis of a large number of simple unicellular papillary trichomes; Amphistomatic type of cotyledons and leaves, presence of anomacytic and hemiparacytic type of stomata in the epidermis of leaves and cotyledons of anomacytic, hemiparacytic and paracytic type of stomata, closed collateral type of vascular bundle in the mesophyll of the cotyledon and leaf. Calcium oxalate drusen were identified in water-bearing leaf mesophyll cells. The predominance of xeromorphic characters in the mesophyll of the cotyledon of *Salsola paulsenii*, as well as halo-xeromorphic characters in the mesophyll of leaves indicates its good adaptation to the conditions of South-Western Kyzylkum.

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