

Study of leaves structures that determine the resistance to dryness at succulent plants

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Abstract Succulent plants present some morpho-anatomical characteristics, that represent an indication concerning their biological behaviour (these being less pretentious concerning the water regime). The present work aims to highlight the biometrical values of anatomical structures that store the water (the mesophyll cells) or reduce the water losses (the cuticle thickness, the reduced number of stomata) and establish the connection between these and the water loss percentage on a determined period of time. The determinations were made on 8 species of succulent flower plants that belong to *Sedum* and *Senecio* genres.

Key words

succulents, mesophyll cells, cuticle, stomata, dryness

The water content at succulent plants varying between 80-95% [4, 5]. The leaves are specialised in storing water, for the majority of succulent flower plants[3] .

Willert Dieter, 1992, analyzing the water content to various species of succulent plants (40), discovered that the water percentage from leaves can vary between 77,9% and 93,3%. The specialized tissue is the mesophylle, this being formed of big parenchymatic cells, rich in hydrophilic colloids that retain water [1, 2].

In order to reduce the water losses, the succulent plants present some morpho-anatomical characteristics, such as the reduction of the foliar surface, the cuticle thickness, the reduced number of stomata [1, 2] .

The present work aims to distinguish the biometric characteristics of the leaves structures, that store the water (the mesophyll cells), or reduce the water losses (the cuticle thickness, the density of the stomata) and to establish a connection between these ones and the percentage of loss water in a determined period of time, for 8 species of succulent flower plants.

Material and Methods

The biological material used was represented by mature leaves belonging to the 8 species of succulent flower plants (*Sedum linearum*, *Sedum mexicanum*, *Sedum morganianum*, *Sedum pachyphyllum*, *Senecio jacobsenii*, *Senecio kleiniformis*, *Senecio pyramidatum*, *Senecio*

rowleyanus). The samples were gathered from the collection belonging to the discipline Floriculture, Faculty of Horticulture. In order to emphasize the structure of the leaves, at the level of the foliar limb, there were achieved tangential and transversal cut sections from the middle part of the leaf. The microscopic examination of devices was done at the Optech B4 microscope and the photos were achieved with a Cannon device.

The prominence of the dehydrating degree for the 8 species was achieved through the analysis of the water content from the body of plants before and after these one were subjected to water stress (through total removal of watering) for three weeks.

Results and Discussions

The biometrical values of different anatomical structures responsible for the storage, respectively the limitation of the water losses, are characteristic to the species.

Sedum linearum

Homogeneous mesophyll is form by round cells, which have approximately the same dimensions, 233,2 μm (length) respectively 184,9 μm (width)(fig.1).The thickness of the cuticle is 9,8 μm (fig.2).The density of stomata registered medium values of 31,80 stomata/ mm^2 (upper epidermis) and 37,64 stomata/ mm^2 (lower epidermis)(fig.3).

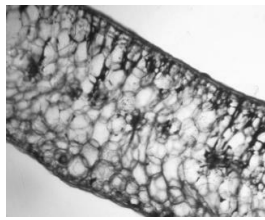


Fig. 1- mesophyll cells

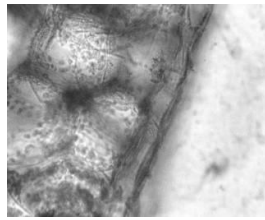


Fig. 2 - cuticle

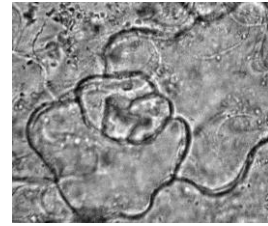


Fig. 3 - stomata

Sedum mexicanum

Homogeneous mesophyll is form by oval cells, which have the length of 285,5 μm and the width of 227,28 μm (fig.4). The thickness of the cuticle is 5,36 μm

(fig.5). The density of stomata registered medium values of 79,50 stomata/ mm^2 (upper epidermis) and 86,57 stomata/ mm^2 (lower epidermis)(fig.6).

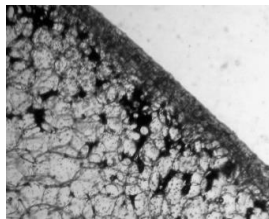


Fig. 4- mesophyll cells

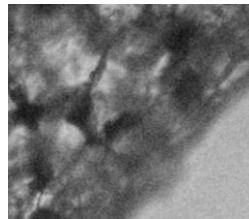


Fig. 5 - cuticle

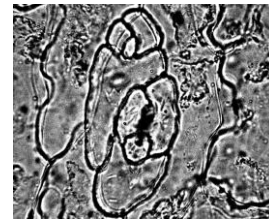


Fig. 6 - stomata

Sedum morganianum

Homogeneous mesophyll, formed of 2-3 rows of polygonal cells (with 6-7sides) with dimensions of 135,42 μm length and 90,15 μm width, peripherally arranged, followed by 5-6 rows of round cells (oval)

with dimensions of 360,1 μm length and 315,26 μm width(fig.7).The thickness of the cuticle is 4,5 μm (fig.8). The density of stomata registered medium values of 16,19 stomata/ mm^2 (upper epidermis) and 16,78 stomata/ mm^2 (lower epidermis)(fig.9).

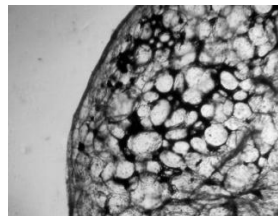


Fig. 7- mesophyll cells

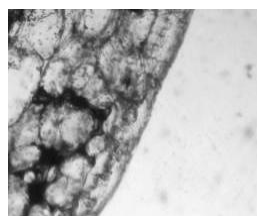


Fig. 8 - cuticle

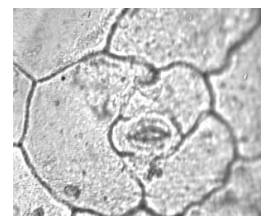


Fig. 9 - stomata

Sedum pachyphyllum

Homogeneous mesophyll is form by oval or round cells. The dimensions of mesophyll cells are 324,1 μm length and 225,57 μm width(fig10).The thickness of

the cuticle is 19,52 μm (fig.11).The density of stomata registered medium values of 5,88 stomata/ mm^2 (upper epidermis) and 7,21 stomata/ mm^2 pe (lower epidermis)(fig.12).

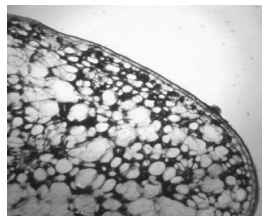


Fig. 10- mesophyll cells

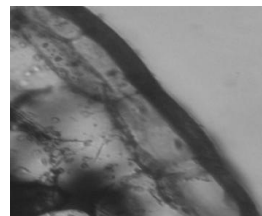


Fig. 11 - cuticle

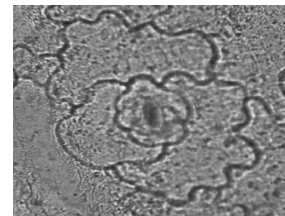


Fig. 12 - stomata

Senecio jacobsenii

Homogeneous mesophyll is form by oval cells with approximately the same dimensions, 207,4 μm length and 153 μm width (fig.13). The thickness of the

cuticle is 9,7 μm (fig.14). The density of stomata is 18,84 stomata/ mm^2 (upper epidermis) and 21,79 stomata/ mm^2 (lower epidermis)(fig.15).

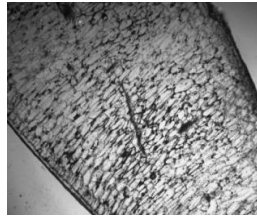


Fig. 13- mesophyll cells

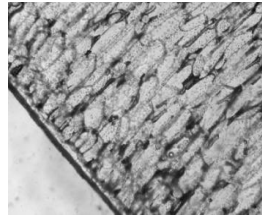


Fig. 14 - cuticle

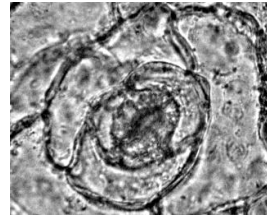


Fig. 15 – stomata

Senecio kleiniformis

The mesophyll is differentiated in palisade parenchyma (**pp**) and lacunar parenchyma (**lp**) - bifacial leaf reverse dorsiventral. Palisade parenchyma (under the lower epidermis) is composed of polygonal cells (5-6 rows) with a large number of chloroplasts, measuring 90,13 μm in length and 72,4 μm in width. Under the upper

epidermis we can find the lacunar parenchyma (3-4 rows) composed of oval or round cells of 315,25 μm in length and 225 μm (fig.16).

The thickness of the cuticle is 18,3 μm (fig.17). The density of stomata registered medium values of 7,06 stomata/ mm^2 (upper epidermis) and 29,4 stomata/ mm^2 (lower epidermis) (fig.18).

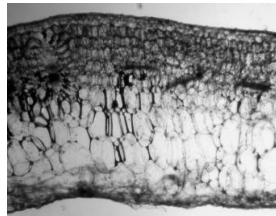


Fig. 16- mesophyll cells

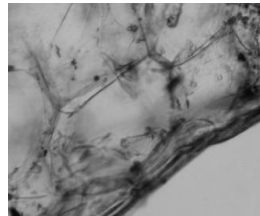


Fig. 17 - cuticle

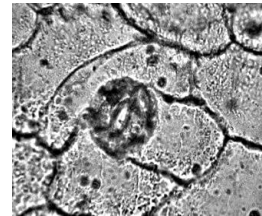


Fig. 18 - stomata

Senecio piramidatum

Equifacial leaf, both under the upper epidermis and the lower is found the palisade parenchyma (**pp**) form by 2-3 rows, composed of elongated cells, and measuring 93,25 μm in length and 45 μm in width. Lacunar parenchyma (**lp**) is composed of big cells, and

measuring 495,11 μm in length and 433,7 μm in width (fig. 19).

The thickness of the cuticle is 6,32 μm (fig.20).The density of stomata registered medium values of 12,36 stomata/ mm^2 (upper epidermis), respectively 13,10 stomata/ mm^2 (lower epidermis) (fig.21).

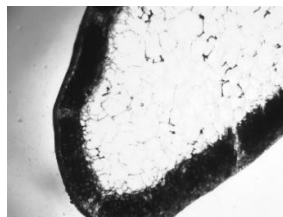


Fig. 19 - mesophyll cells

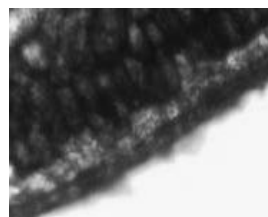


Fig. 20 - cuticle

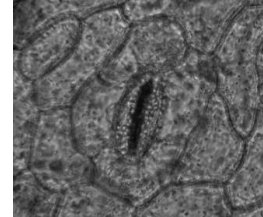


Fig. 21 – stomata

Senecio rowleyanus

Homogeneous mesophyll, the cells dimensions increases from the periphery (1) to the center (2) from 180,7 μm in length respectively 183,29 μm in width to 360,43 μm in length and 315,5 μm in width

(fig.22).The thickness of the cuticle is 17,5 μm (fig.23).The density of stomata is 22,96 stomate/ mm^2 (upper epidermis) 26,5 stomate/ mm^2 (lower epidermis) (fig.24).

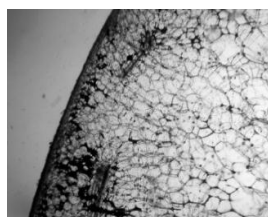


Fig. 22 – mesophyll cells

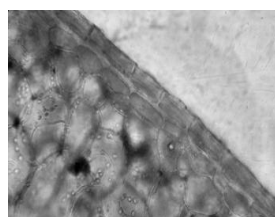


Fig. 23 – cuticle

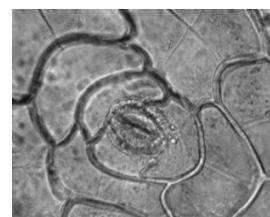


Fig. 24 – stomata

Table 1

The biometrical values for anatomical structures responsible for the storage water (mesophyll cells) or limitation of the water losses (thickness of the cuticle, density of the stomata)

Biometrical values Species	The dimensions of mesophyll cells $\bar{x} \pm s_x$ (μm)		The thickness of the cuticle $\bar{x} \pm s_x$ (μm)	The density of the stomata $\bar{x} \pm s_x$ (stomata/ mm^2)	
	length	Width		upper epidermis	lower epidermis
<i>Sedum linearum</i>	233.2 \pm 0,89	184.9 \pm 1,03	9.8 \pm 2,12	31,80 \pm 4,94	37,64 \pm 4,94
<i>Sedum mexicanum</i>	285.5 \pm 1,15	227.78 \pm 1,30	5.36 \pm 1,75	71,50 \pm 8,42	86,57 \pm 4,82
<i>Sedum morganianum</i>	360.1 \pm 2,10	315.26 \pm 1,89	4.5 \pm 2,12	16,19 \pm 0,94	16,78 \pm 1,01
<i>Sedum pachyphyllum</i>	324.1 \pm 0,89	225.57 \pm 1,05	19.5 \pm 3,06	5,88 \pm 0,97	7,21 \pm 1,28
<i>Senecio jacobsenii</i>	207.4 \pm 1,25	153 \pm 1,44	9.7 \pm 2,88	18,84 \pm 4,59	21,79 \pm 2,82
<i>Senecio kleiniformis</i>	l.p 315.55 \pm 1,05	l.p 225 \pm 0,87	18.3 \pm 3,15	7,06 \pm 2,47	29,44 \pm 4,77
	p.p 90,13 \pm 1,02	p.p 70,4 \pm 1,16			
<i>Senecio pyramidatum</i>	l.p 495.11 \pm 0,54	l.p 433.7 \pm 0,95	6.32 \pm 1,65	12,36 \pm 1,01	13,10 \pm 0,82
	p.p 93,25 \pm 0,92	p.p 45 \pm 1,10			
<i>Senecio rowleyanus</i>	(1) 180,7 \pm 1,8	(1) 183,29 \pm 1,63	17.5 \pm 2,83	22,96 \pm 4,29	26,50 \pm 3,06
	(2) 360.43 \pm 2,01	(2) 315.5 \pm 1,05			

To all species under analysis, the initial percentage of water from leaves was big, being comprised between 95,38% to *Senecio rowleyanus* and 97,29% to *Sedum mexicanum*, respectively *Senecio jacobsenii* (fig. 25).

After three weeks from the total removal of waterings, the percentage of water loss varied between 0.32% (*Sedum pachyphyllum*) and 2.54% (*Senecio kleiniformis*) (fig. 25).

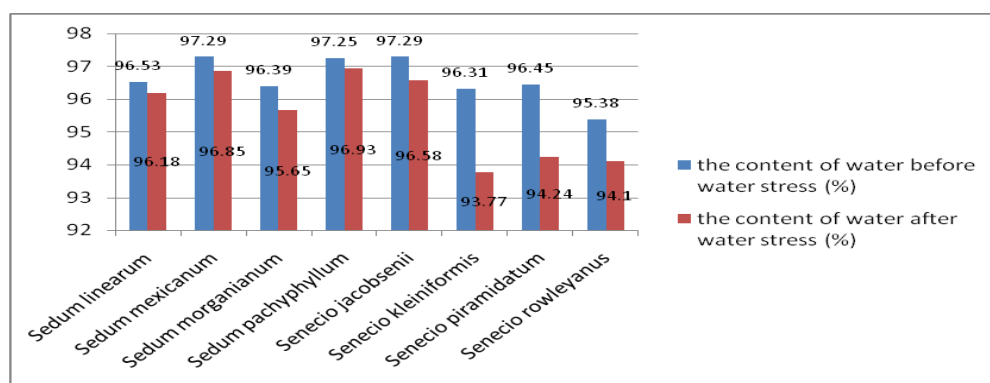


Fig. 25 – The content of water from leaves, before and after the application of the water stress

For the species of **Sedum** genus the small percentage of lost water through transpiration (varying between 0.32% for *Sedum pachyphyllum* and 0.74% to *Sedum mexicanum*) is caused by the big dimensions of the mesophyll cells, capable to store a big quantity of water, but also reduced stomata densities (to *Sedum morganianum* and *Sedum pachyphyllum*) and the cuticle thickness (*Sedum pachyphyllum*), that limits the water losses.

The big dimensions of the mesophyll cells, the thick cuticle and the reduced density of the stomata caused at *Sedum pachyphyllum* the small percent of lost water.

For the species of **Senecio** genus, the percentage of lost water through transpiration was bigger in comparison with the species of the *Sedum* genus, varying between 0.71% to *Senecio jacobsenii* and 2.54% to *Senecio kleiniformis*.

The bigger percentage of lost water can be explained through the differentiation of the mesophyll in palisade parenchyma and lacunar parenchyma, to *Senecio kleiniformis* and *Senecio pyramidatum* (case when only the mesophyll cells that enter in the structure of the lacunar parenchyma are specialized in storing water, the other having a leading role photosynthetic assimilator), or through the different dimensions of the mesophyll cells, to *Senecio rowleyanus* (smaller cells to periphery, bigger cells towards centre), which, as well decrease the capacity of storage and retaining the water in leaves.

Conclusions

All the species under analysis have in their leaves a big quantity of water, varying between 95.38% to *Senecio rowleyanus* and 97.29% to *Sedum mexicanum*, respectively *Senecio jacobsenii*.

Dependent on the species and the characteristics of anatomical structures of the foliar limb that store water or reduce the water losses, the percentage of lost water in three weeks from stopping the watering was small, varying between 0.32% (*Sedum pachyphyllum*) and 2.54 % (*Senecio kleiniformis*).

From the data analyzed we observe that those particularities of structure, that leads the resistance to dryness, varies in accordance with the species. Therefore, some species store and retain the water because of the big dimensions of the mesophyll cells (*Sedum morganianum*, *Sedum pachyphyllum*), and others limit the water losses through the cuticle thickness (*Sedum pachyphyllum*, *Senecio kleiniformis*, *Senecio rowleyanus*) or the decrease of the stomata density (majority of the species studied).

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