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STUDY CONCERNING THE BEHAVIOUR TO WATER STRESS OF SOME SUCCULENT FLOWER PLANTS

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KEY WORDS: *succulent plants, water stress, wilting*

ABSTRACT

The analysis of the initial water content from leaves to twenty species of succulent flower plants indicated values between 91.53% and 98.24%. After being subjected to total water stress it was stated that theose twenty species standed a period between nine and seventeen weeks, the permanent wilting intervening when the water content from leaves decreased with 4.29% until 19,.9%, according to the species. The establishment of some correlations between the water percentage lost and the biometric values of foliar structures that contain and reduce the water losses (the cells of the mesophyll, the thickness of the cuticle and stomata density) shows the combined effect of foliar structures in the limits of water losses and implicitly to drought resistance.

INTRODUCTION

The knowledge of the way of behaviour of flower plants in the conditions of application of water stress can represent among the theoretical and practical importance, representing a criteria that must be taken into account in establishing the water that is necessary but also in the association of different species in different flower combinations.

Succulent plants coming from regions with draughty climate bear long periods of draught and those which have their origin in regions with temperate climate from North hemispheres *(Sedum sp.)* have enough water reserves in order to remain alive a longer time, without being watered (Schulte 1989, Van Woert et al. 2005).

The water content from the succulent plants registers high values, between 90-94% (Wickens 1998, Barrera 2009), or even more 95% (Capon 2010), varying according to species, organs, tissue (Willert 1992, Sayed 1998).

The high dimensions of the mesophyll cells and the presence to this level of some substances osmotic active, that increase the capacity of retaining water make that to the level of leaves cumulate the highest water quantity (Esser 2004, Mauseth 2009).

Retaining water is favoured by other structure features of leaves as the cuticle thickness and the low density of stomata (Willert 1992). The analysis of these foliar structures, relieve an interdependence between those that retain water, respectively those who limit the water losses (Cristescu et al. 2009).

The observations made followed the identification of water content from leaves for those twenty species under study with the periodic monitoring of water losses,

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identification of percentage of lost water, which induces the permanent wilting and the period of time upon which this phenomenon is installed. As well there were established correlations between the water losses and the biometric values of different foliar structures (dimension of mesophyll cells, the cuticle thickness and stomata density).

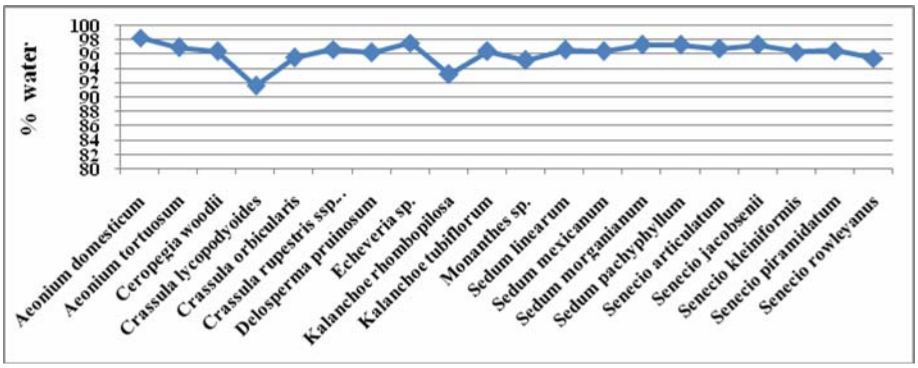
MATERIAL AND METHOD

In order to analyze the water content there were sampled the leaves from mature plants belonging to the twenty species of succulent plants studied: *Aeonium domesticum*, *Aeonium tortuosum*, *Ceropegia woodii, Crassula rupestris ssp marnieriana, Crassula orbicularis, Crassula lycopodyoides, Delosperma pruinosum, Echeveria sp.„ Kalanchoe rhombopilosa, Kalanchoe tubiflorum, Monanthes sp*, *Sedum linearum , Sedum mexicanum, Sedum morganianum, Sedum pachyphyllum*, *Senecio articulatum, Senecio jacobsenii, Senecio piramidatum,, Senecio kleiniformis, Senecio rowleyanus*. The analysis of water content from leaves was made with the help of the analytical balance Kem, before and after the application of the water stress, from the apparition of the first signs of fading for some species until the final fading of the last species. After total removal of watering, determinations were made in stages, at determined time intervals. (at 3, 5, 7, 9, 11, 13, 15, and 17 weeks).

Biometric values of different foliar structures, such as the dimensions of the mesophyll cells, the thickness of the cuticle and stomata density were determined before the plants be subjected to water stress, with the help of the optic microscope with the ocular micrometer. The phenomenon of wilting was visually analyzed, for the decorative aspect, and the irreversibility of wilting was analyzed with the help of some plants witness. Correlations were achieved with the help of the statistics Excel programme.

RESULTS AND DISCUSSION

The analysis of the initial content of water from leaves (before the application of water stress) to the twenty species of succulent flower plants indicated high values between 91,53% for *Crassula lycopodyoides* end 98.24% for *Aeonium domesticum* (graph 1).

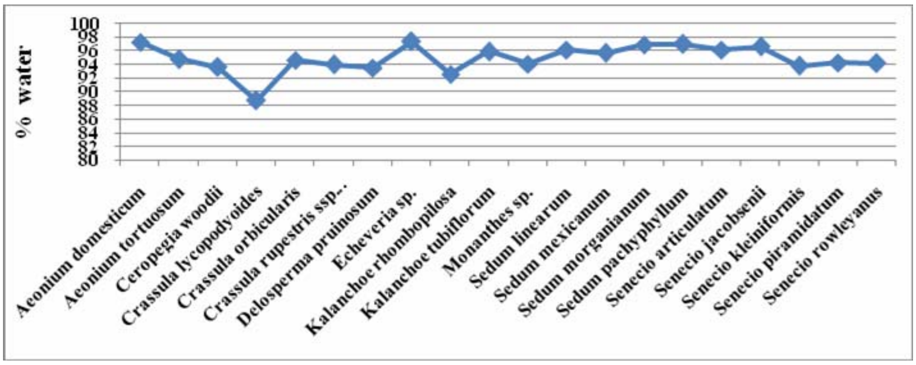


Graph 1. The initial water content (%) in leaves

After three weeks (stage I) from total removal of watering, the percentage of lost water from plants was between 0,19% (*Echeveria sp.*) and 2,99% (*Aeonium tortuosum)* (graph 2).

Reported to genera, the smallest values registered to the species **Sedum** values between 0,32% for *Sedum pachyphyllum* and 0,74% la *Sedum mexicanum*), followed by ***Kalanchoe*** (5% for *Kalanchoe tubiflorum* and 0,56% for *Kalanchoe rhombopilosa)*, ***Senecio*** (values between 0,71 % for *Senecio jacobsenii* and 2,54 % for *Senecio kleiniformis*), ***Aeonium*** (2,1% for *Aeonium domesticum* and 2,61% for *Aeonium tortuosum*) and ***Crassula*** (with values between 2,82% for *Crassula lycopodyoides* and 2,70% for *Crassula rupestris ssp marnieriana*). Intermediate values presented the species *Monanthes sp.* (1,02%), *Delosperma pruinosum* (2,74%) and *Ceropegia woodii* (2,78%).

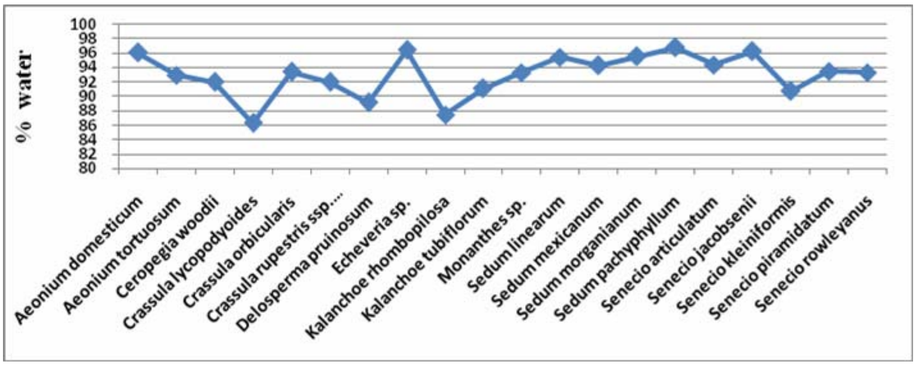
After three weeks from stopping the watering, at the level of the foliar device appeared the first morphological modifications, that at the majority of the species consisted of a change of leaves texture (more soft leaves). At *Senecio articulatum, Senecio kleiniformis, Senecio piramidatum* the modifications are more obvious, displaying through a soft crimping of leaves. They did not present signs of wilting *Echeveria sp., Monanthes sp., Sedum morganianum, Sedum pachyphyllum* and the species of the genus *Aeonium*.



Graph 2. The water content (%) - stage I

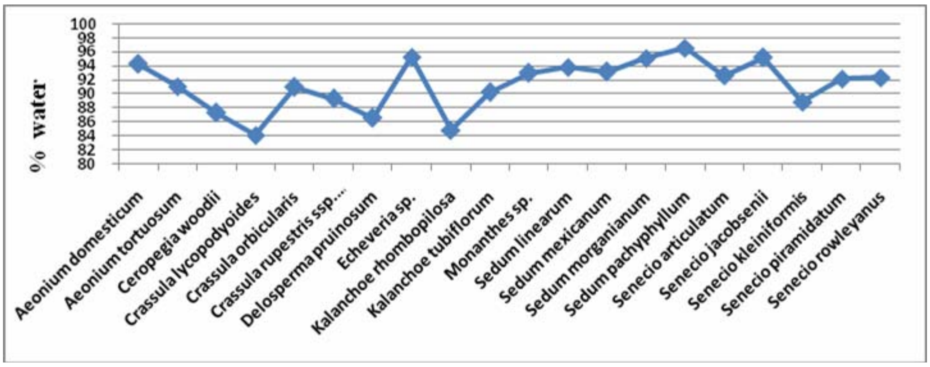
Determinations performed in second stage relieved to some species bigger differences concerning the percentage of lost water. In this stage, the highest percentage of lost water presented the species of the genus *Kalanchoe* (5,10% *Kalanchoe rhombopilosa* respectively 4,80% *Kalanchoe tubiflorum*) and *Delosperma pruinosum* 4,37% (for those species registering the biggest differences in comparison with the previous period), and the smallest *Sedum pachyphyllum* (0,18%), *Senecio jacobsenii* (0,40%), followed by *Monanthes sp.* (0,75%), *Senecio piramidatum* (0,80 %) and *Echeveria sp.* (0,92%) (graph 3). For the other species the values were closed to those from the first stage.

The wilting phenomenon could be observed in this moment for the majority of species, more pronounced for *Crassula rupestris ssp. marnieriana, Kalanchoe rhombopilosa, Kalanchoe tubiflorum, Delosperma pruinosum, Senecio articulatum, Senecio kleiniformis Senecio rowleyanus*. The affected species were *Aeonium domesticum, Echeveria sp. Sedum morganianum, Sedum pachyphyllum, Monanthes, Senecio jacobsenii.* For all species, the wilting phenomenon is reversible on this stage.



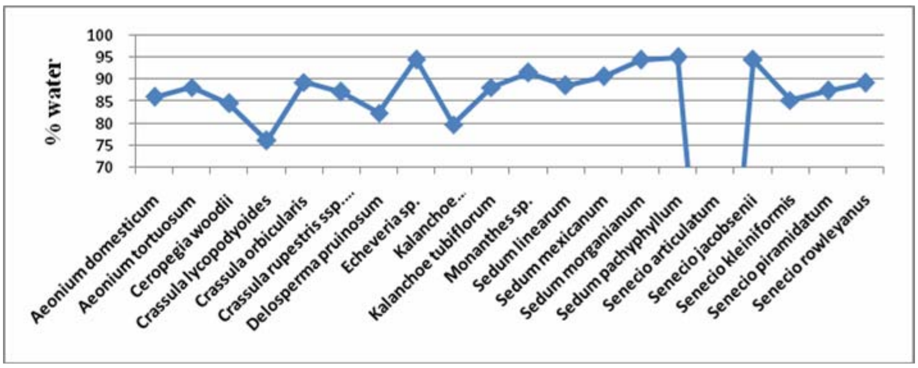
Graph 3. The water content (%) - stage II

In IIIrd stage the differences registered were between 0,23% for *Sedum pachyphyllum* and 2,65% for *Kalanchoe rhombopilosa*, for the majority of the species the values being in the limits closed to those from previous stages (graph 4). The wilting phenomenon is reversible for all species..



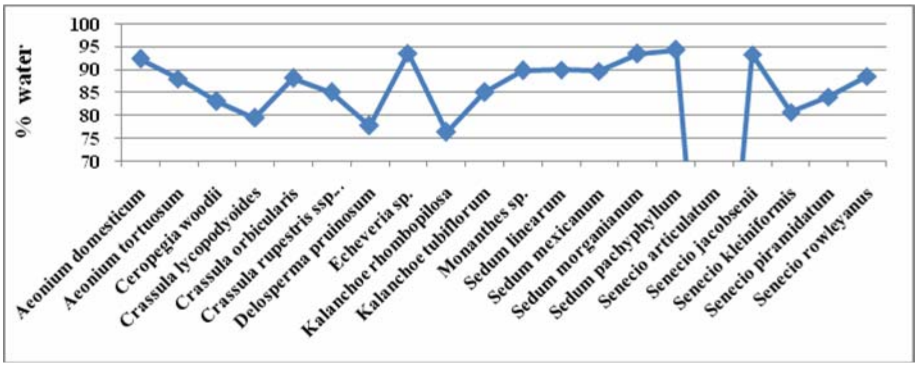
Graph 4. The water content (%) – stage III

After 9 weeks of water stress (stage IV) wilting is permanent for *Senecio articulatum* (graph 5)



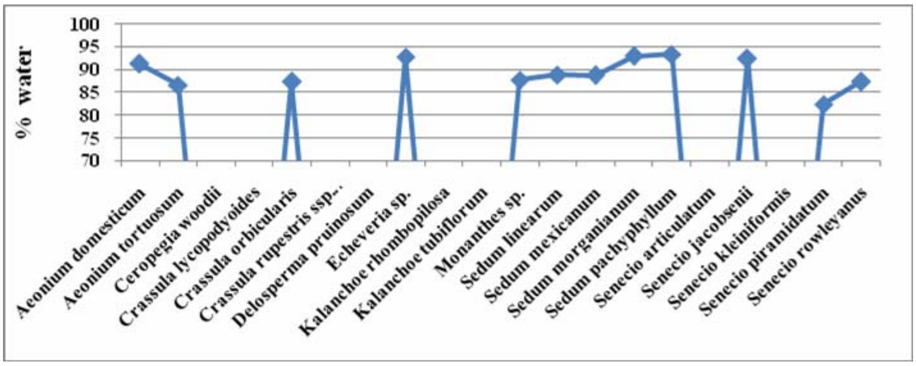
Graph 5. The water content (%) - stage IV

In Vth stage the values of the percentage of dehydrating are between 0,85% for *Senecio jacobsenii* and 4,59% for *Delosperma pruinosum*. In this stage not any other species was affected by permanent wilting (graph 6).



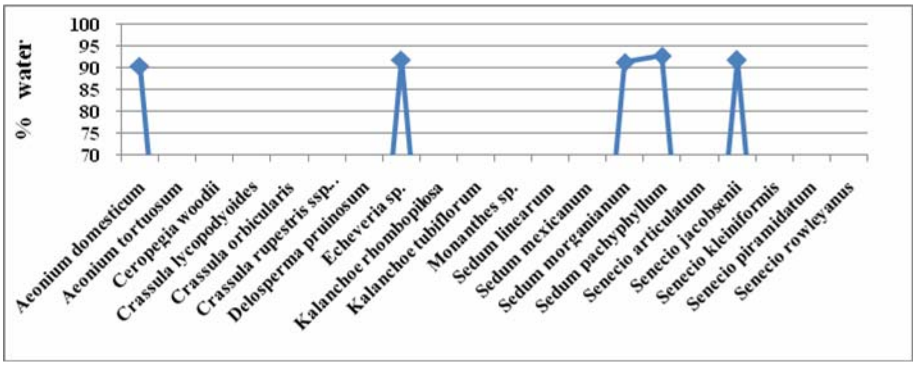
Graph 6. The water content (%) - stage V

Starting with 13th week (stage VI), wilting is permanent for other 6 species (*Ceropegia woodii, Crassula lycopodyoides, Crassula rupestris ssp marnieriana, Delosperma pruinosum, Kalanchoe rhombopilosa, Kalanchoe tubiflorum* and *Senecio kleiniformis*). In this stage the percentage of lost water from leaves being between 0,7% for *Sedum morganianum* and 2,22% for *Monanthes sp* (graph 7).

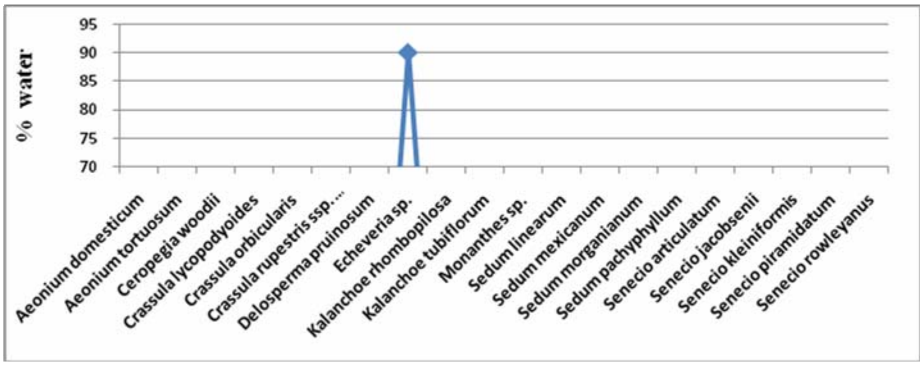


Graph 7. The water content (%) – stage VI

Starting with 15th week (stage VII), just five of all species under study has been resisting to water stress, after 17 weeks (stage VIII) the most repellent being *Echeveria sp.* (graph 8,9).



Graph 8. The water content (%) - stage VII



Graph 9. The water content (%) - stage VIII

Data from table 1 indicates for each species what is the water percentage that the species studied may lose in a period of time, then the wilting becomes irreversible.

From the determinations made it was stated that wilting is determined by water losses between 4,29% (*Senecio articulatum)* until 19,9% to (*Delosperma pruinosum*) values under those indicated in literature for heliophile plants *(*Toma, 1998 states that in the case of heliophile species temporary wilting manifests when plants lose 20-30% from total water)

According to total quantity lost which determines the permanent wilting, those 20 species of succulent plants can be grouped in plants that can suffer losses under 5% (*Sedum pachyphyllum, Senecio articulatum),* losses between 5% and 10% *(Aeonium domesticum, Crassula orbicularis, Echeveria sp, Monanthes sp., Sedum morganianum, Senecio jacobsenii, Senecio rowleyanus),* losses between 10% and 15% *(Aeonium tortuosum, Ceropegia woodii, Crassula lycopodyoides,Crassula rupestris ssp marnieriana, Kalanchoe tubiflorum, Senecio piramidatum),* losses over 15% *(Delosperma pruinosum, Kalanchoe rhombopilosa, Senecio kleiniformis).*

Table 1.

The percentage of water lost to cause permanet wilting

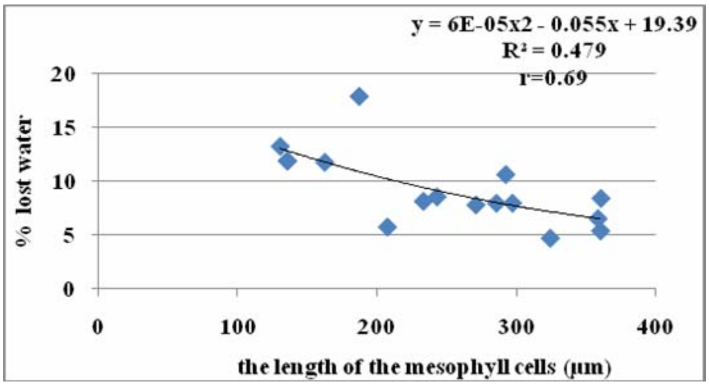
Species	The percentage of lost water to cause permanent wilting	The period (weeks)
Aeonium domesticum	7,99%	15
Aeonium tortuosum	10,65%	13
Ceropegia woodii	13,57%	13
Crassula lycopodyoides	13,27%	13
Crassula orbicularis	8,58%	13
Crassula rupestris ssp. marnieriana	11,92%	13
Delosperma pruinosum	19,09%	13
Echeveria sp.	6,55%	17
Kalanchoe rhombopilosa	17,92%	13
Kalanchoe tubiflorum	11,79%	13
Monanthes sp.	7,82%	15
Sedum linearum	8,16%	13
Sedum mexicanum	7,98%	13
Sedum morganianum	5,41%	15
Sedum pachyphyllum	4,73%	15
Senecio articulatum	4,29%	9
Senecio jacobsenii	5,77%	15
Senecio kleiniformis	16,13%	13
Senecio piramidatum	14,61%	13
Senecio rowleyanus	8,43%	13

The results of the observations concerning the biometrical values of foliar structures for these twenty species are presented in the work *„Study of the structural particularities of leaves in succulent flower plants "*(Cristescu et al. 2009).

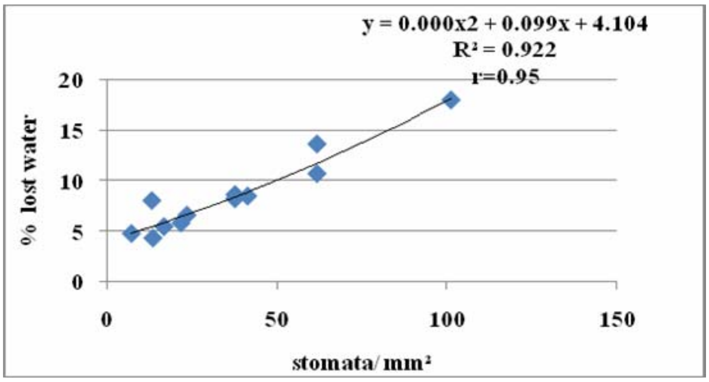
Therefore, for the dimensions of the mesophyll cells are between 135,67µm (L)/108,6 µm (w) for *Crassula rupestris ssp. marnieriana* and 495,11 µm (L)/433,7 µm (w) for *Senecio piramidatum,* the density of stomata (inferior epidermis) is between 7,21 st/mm^2 *Sedum pachyphyllum* and 101,29 st/mm^2 for *Kalanchoe rhombopilosa*, and the cuticle thickness varies from 2,71µm for *Senecio articulatum* and 19,52µm for *Sedum pachyphyllum.*. Establishing some correlations between these and the percentage of water lost during the whole period of water stress stated the followings:

- negative significant correlation between the percentage of water lost and the dimension of the mesophyll cells (L) for fifteen species (*Aeonium domesticum, Aeonium tortuosum, Crassula lycopodyoides, Crassula orbicularis, Crassula rupestris, ssp marnieriana, Echeveria sp., Kalanchoe rhombopilosa, Kalanchoe tubiflorum, Monanthes sp, Sedum linearum, Sedum mexicanum, Sedum morganianum, Sedum pachyphyllum, Senecio jacobsenii, Senecio rowleyanus)* (graph 10).
- positive significant correlation between the density of stomata and the percentage of the water lost for twelve species under study (*Aeonium domesticum, Aeonium tortuosum, Ceropegia woodii, Crassula orbicularis, Echeveria sp., Kalanchoe rhombopilosa, Sedum linearum, Sedum morganianum, Sedum pachyphyllum, Senecio articulatum, Senecio jacobsenii, Senecio rowleyanus)*(graph 11).

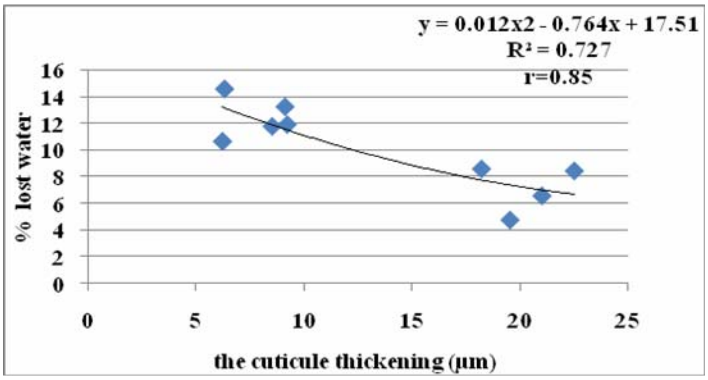
- negative significant correlation between the cuticle thickness and the percentage of lost water for nine of the species (*Aeonium domesticum, Crassula lycopodyoides, Crassula orbicularis, Crassula rupestris ssp. marnieriana, Echeveria sp, Kalanchoe tubiflorum, Sedum pachyphyllum, Senecio piramidatum, Senecio rowleyanus)*(graph 12).



Graph 10. The corelation between water lost and the mesophyll cells dimensions



Graph 11. The correlation between water lost and stomata density



Graph 12. The correlation between water lost and cuticle thickening

For the strongest five species (*Aeonium domesticum, Echeveria sp, Sedum morganianum, Sedum pachyphyllum* şi *Senecio jacobsenii*) the establishment of some correlations between the percentage of lost water and the dimensions of the mesophyll cells, the density of stomata and for *Aeonium domesticum, Echeveria sp*. and *Sedum pachyphyllum* and for the cuticle thickness, it states the effect combined of these structures on the capacity of containing water.

CONCLUSIONS

For the twenty species taken under study, the permanent wilting installed when the total water content from leaves decreased with 4,29% (Senecio articulatum) until 19,9% (*Delosperma pruinosum*). From the analysis made on determined periods of time, we observe that the water losses are constant for some species (*Monanthes sp, Sedum mexicanum, Senecio jacobsenii)* or fluctuate all along different stages *(Delosperma pruinosum, Kalanchoe rhombopilosa, Kalanchoe tubiflorum, Senecio jacobsenii).*

From the twenty species taken under study the least resistant was *Senecio articulatum* where the permanent wilting intalled after nine weeks from stopping waterings.

With the exception of five species that lasted fifteen weeks (and *Echeveria sp.* seventeen weeks), for the rest of the species the permanent wilting installed at thirteen weeks.

For the most resistant five species (*Aeonium domesticum, Echeveria sp, Sedum morganianum, Sedum pachyphyllum* şi *Senecio jacobsenii*), the percentage of lost water from one stage to another maintained under the value of 1% (exception *Aeonium domesticum)*, and the water content from leaves did not decrease to 90%.

The establishment of some correlations between the percentage of water lost and the structure features of leaves shows the role in the limits of water losses, respectively the resistance to drought.

Taking into consideration the period of resistance to drought, we can state that between the 19 species of succulent plants we can accomplish different types of decorative combinations, taking into account the aesthetic aspect.

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