

RESEARCH ON THE PRODUCTION, BEHAVIOUR AND EVOLUTION IN TERMS OF GROWTH AND DEVELOPMENT OF SOME SUCCULENT PLANTS, IN ORIGINAL SUPPORT STRUCTURES

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Abstract

At worldwide scale, the tendency concerning the indoor decoration with plants is to use some original and functional structures to support them. The design and achievement of the support prototype may have not only an aesthetic role, but also of fixing and providing an optimal substrate, with subsequent implications in plants' growth and development. The chosen support together with different materials such as: moss, peat, tree bark, fragments of twigs or roots with special forms, sand, gravel or other materials arranged in harmony with plant material, amplify the decorative effect of the final product. Selection and association of plants in such structures are essential. These should not be based only on aesthetic principles and the size of individuals, but also on the requirements of plants for environmental factors, very close to the plants' growth rate and development, so they preserve decorative aspect as much as possible. The aim of this research was to conceive and realize the support prototype and then to investigate the behaviour and evolution of some succulent indoor plants regarding their growth and development after installation on support.

Key words: succulent plants; concept; support; decorative.

INTRODUCTION

Succulent species are highly appreciated plants by flower lovers (Stead, 2016; Toma, 2009). They are important floral assortment through their special decorative potential and very varied propagation, culture and use possibilities (Baldwin, 2017; Change, 2012; Maggio, 2016). Equally, succulent plants are the subject of numerous researches with a very broad subject. Enrichment of the assortment with new species and varieties having special decorative potential is frequently considered in studies (Pino, 2005; Thulin, 2002). Also, many studies and researches used prototype supports for a large number of succulent species in combinations that have decorative impact and in the same time are functional in many variants of interior spaces (Harvey, 2016; Starr, 2016). Other research is focused on the possibilities of propagation, including in vitro propagation methods (Cabahug et al., 2016). Researches on the behaviour of succulent plants in different types of climate (Zeevaart, 1982; Kelaidis, 2008) or the taxonomy of

succulent plants (Gideon et al., 2017; Sandoval, 2017) are still modest.

The present research presents new and original supports prototype for succulent plants, which were then investigated indoors for their behaviour and development in time. Our work was based on many previous researches regarding the production and use of succulent plants in different crop varieties.

MATERIALS AND METHODS

I. Production of cuttings. Seventeen succulent plant species were selected to produce by cuttings the plant material necessary to cover different supports. The selected species were as follows: *Kalanchoe tomentosa* Baker, *Bryophyllum fedtschenkoi* Raym.-Hamet & H. Perrier, *Sedum nussbaumerianum* Bitter, *Sedum allantoides* Rose, *Sedum rubrotinctum* R.T. Clausen, *Sedum pallidum* var. *bithenicum* Gibson, *Sedum burrito* Walther, *Echeveria gibbiflora* DC, *Graptopetalum paraguayense* Walther, *Crassula perforata* var. *variegata* Thunb, *Aeonium arboreum* Webb & Berth., *Aeonium haworthii* Webb & Berth., *Cyanotis*

somalensis CB Clarke, *Senecio mandraliscae* Rowley, *Senecio kleiniiformis* Suess., *Mesembryanthemum crystalinum* L., *Corpuscularia taylorii* Schwantes.

For all these species were made top shoot cuttings with length between 4 and 8 cm, depending on the species (Bala, 2012; Selaru, 2006). Once made, the cuttings were left to dehydrate in plastic crates for 6 days (Figure 1).



Figure 1. Cuttings left to dehydrate

Before planting in the rooting substrate, the height and the number of leaves of the cuttings of each species was noted (Table 1).

Table 1. The cuttings features

No crt.	Species	Height (cm)	Leaves no.	No. of cuttings
1.	<i>Kalanchoe tomentosa</i>	6	7	10
2.	<i>Kalanchoe fedtschenkoi</i>	8	8	10
3.	<i>Senecio mandraliscae</i>	6	8	10
4.	<i>Senecio kleiniiformis</i>	8	8	10
5.	<i>Echeveria gbbiflora</i>	4	5	5
6.	<i>Crassula perforata</i> var. <i>variegata</i>	5	10	5
7.	<i>Graptopetalum paraguayense</i>	5	11	5
8.	<i>Mesembryanthemum crystalinum</i>	6	14	10
9.	<i>Corpuscularia taylorii</i>	7	6	10
10.	<i>Sedum nussbaumerianum</i>	5	14	15
11.	<i>Sedum allantooides</i>	5	25	10
12.	<i>Sedum rubrotinctum</i>	6	25	15
13.	<i>Sedum bithenicum</i>	4	15	10
14.	<i>Sedum burrito</i>	4	25	10
15.	<i>Cyanotis somalensis</i>	4	8	15
16.	<i>Aeonimum arboreum</i>	5	25	30
17.	<i>Aeonimum haworthii</i>	5	14	5
Total no. of cuttings			185	

Five substrate variants (Figure 2) were used to root the cuttings of all species, as follows: V1 -

peat, V2 - sand, V3 - perlite, V4 - peat (50%) + sand (50%), V5 - peat (50%) + perlite (50%).



Figure 2. Substrates used for rooting the cuttings

Researches of various authors showed that the rooting time of the cuttings varies from a few days to a few weeks, depending on the species, the rooting substrate, climate or rooting stimulators applied (Cabahug et al., 2016; Cantor, 2016).

Eight weeks after planting, all the cuttings were rooted (Figure 3) and removed from the substrate.



Figure 3. Cuttings root 8 weeks after planting

The following observations and measurements were made: rooted cuttings height (cm), number of leaves, branches, branch length (cm), maximum root length (cm), number of main roots, length of main roots (cm), number of secondary roots, the length of the secondary roots (cm).

II. The growing of rooted cuttings in pots.

The eight-week-old rooted cuttings were planted individually in 5 cm pots (Figure 4). The substrate media used was consisted of celery soil, leaf soil, peat and sand in a ratio of 1: 1: 1/2: 1/3 plus chunks of 10% clay.

After planting, a set of observations and measurements were made: plant height, the number of leaves and shoots and the length of shoots (cm).



Figure 4. The aspect of plants after planting in pots

III. Designing and making structures with succulent plants. For several years, many publications and researches have been devoted to the creation and maintenance of different types of unconventional culture supports with succulent plants (Cammidge, 2019; Daigle, 2015). In this research we made and analyze three variants of such supports. First support was represented by a **large decorative sphere (diameter 20 cm)** made up of two sections of rigid wire (with a diameter of 5 mm) and covered in wire mesh (Figure 5).



Figure 5. Forming the large sphere

The inner walls of the sphere were lined with vegetable moss and the core filled with peat. Peat was chosen because is a very light substrate, thus maintaining a low weight to the sphere. Then the two sections were fixed to each other with wire, clamped around the equator, resulting in the large sphere. After joining, a ring and a decorative chain needed for hanging the sphere was attached. The working time for this prototype was two and a

half hours. A total of 187 cuttings of different succulent species were used to cover the sphere and the working time for planting was 6 hours (Table 2, Figure 6).



Figure 6. The planting on large sphere

Table 2. Species used for cover the large sphere

No. crt.	Species	No. of rooted cuttings
1.	<i>Kalanchoe tomentosa</i>	5
2.	<i>Kalanchoe fedtschenkoi</i>	15
3.	<i>Sedum nussbaumerianum</i>	10
4.	<i>Senecio mandraliscae</i>	12
5.	<i>Senecio kleiniiformis</i>	7
6.	<i>Echeveria gibbiflora</i>	2
7.	<i>Crassula perforate</i> var. <i>variegata</i>	13
8.	<i>Graptopetalum paraguayense</i>	3
9.	<i>Mesembryanthemum sp.</i>	12
10.	<i>Corpuscularia taylorii</i>	10
11.	<i>Sedum allantoides</i>	26
12.	<i>Sedum rubrotinctum</i>	4
13.	<i>Sedum bithenicum</i>	4
14.	<i>Cyanotis somalensis</i>	13
15.	<i>Aeonimum arboretum</i>	40
16.	<i>Aeonimum haworthii</i>	7
Total rooted cuttings: 187		

The second support was a **small decorative sphere (diameter 10 cm)**. The construction technique of the sphere was identical with that presented previously at the large sphere, the single difference being the size (10 cm diameter). In this case, before join together the sections these were covered first with succulent plants (Figure 7).



Figure 7. Forming and planting the small sphere

The working time for making this prototype was two hours. For the small sphere, we used 78 rooted cuttings belonging to 12 species, and the working time for planting was 4 hours (Table 3).

Table 3. Species used for the small sphere

No. crt.	Species	No. of rooted cuttings
1.	<i>Kalanchoe tomentosa</i>	3
2.	<i>Sedum nussbaumerianum</i>	6
3.	<i>Senecio mandraliscae</i>	10
4.	<i>Echeveria gibbiflora</i>	2
5.	<i>Crassula perforate var.variegata</i>	3
6.	<i>Graptopetalum paraguayense</i>	2
7.	<i>Corpuscularia taylorii</i>	5
8.	<i>Sedum alantoides</i>	7
9.	<i>Sedum rubrotinctum</i>	8
10.	<i>Cyanotis somalensis</i>	11
11.	<i>Aeonimum arboreum</i>	18
12.	<i>Aeonimum haworthii</i>	3
Total rooted cuttings: 78		

The third support was a **decorative photo frame with succulents**. For this support it was

used a wooden photo frame of 20 x 15 cm behind which was attached another wooden framework of 5 cm height and a wooden plywood, necessary to support the substrate. Also, a wire mesh was fixed in the space for photography. Over this it was supplemented with muscle and then peat was used as substrate (Figure 8).



Figure 8. The appearance of decorative photo frame

Before attaching the back plywood, a plastic foil was placed over the peat to protect it from moisture generated by the water used for watering.

The working time for making this prototype was one and a half hours. It was necessary a 33 cuttings of 14 species of succulent plants to cover the frame. The working time necessary for planting the support was 1 and a half hours (Table 4).

Table 4. Species used in the decorative photo frame

No crt.	Species	No. of rooted cuttings
1.	<i>Kalanchoe tomentosa</i>	3
2.	<i>Kalanchoe fedtschenkoi</i>	1
3.	<i>Sedum nussbaumerianum</i>	3
4.	<i>Senecio mandraliscae</i>	5
5.	<i>Echeveria gibbiflora</i>	1
6.	<i>Crassula perforate var.variegata</i>	3
7.	<i>Graptopetalum paraguayense</i>	1
8.	<i>Sedum alantoides</i>	1
9.	<i>Sedum rubrotinctum</i>	2
10.	<i>Sedum bithenicum</i>	1
11.	<i>Cyanotis somalensis</i>	2
12.	<i>Aeonimum arboreum</i>	3
13.	<i>Sedum burrito</i>	5
14.	<i>Aeonimum haworthii</i>	2
Total rooted cuttings: 33		

The height of the plants, the number of leaves, the number and length of shoots, the diameter of the plants and the moment of flowering were

determined to establish the degree of growth of the plants.

RESULTS AND DISCUSSIONS

I. Production of cuttings

The data shows that the percentage of rooting varied between 72.90% at variant V4, substrate peat (50%) + sand (50%) and 94.50% at variant V3, perlite.

The rooting quality varied with species substrate used (Table 5, Figures 9-10).

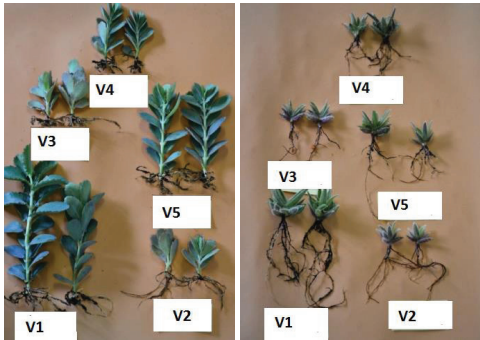


Figure 9. Differences between cuttings in terms of length and rooting at *Kalanchoe fedtschenkoi* (left side) and *Cyanotis somalensis* (right side)

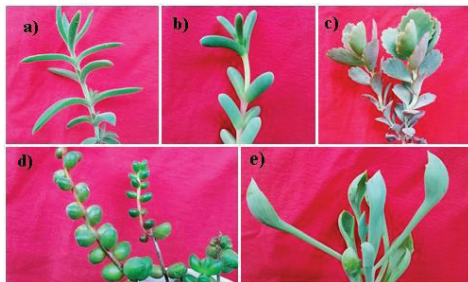


Figure 10. Species with indefinite growth: a) *Mesembryanthemum crystallinum*; b) *Corpuscularia taylorii*; c) *Kalanchoe fedtschenkoi*; d) *Sedum bithenicum*; e) *Senecio kleiniiformis*

From the 17 initial species, only the cuttings of *Aeonimum haworthii* did not rooted on any substrate tested.

II. The growing of rooted cuttings in pots.

The results obtained by the rooted cuttings of the 16 succulent plant species, after planting in pots, showed a different reaction in their growth (Table 6-7). At planting time, the average height of plants was 5.23 cm and after

nine months this achieve a value of 17.98 cm (Figure 11).

Table 5. Cuttings roots characteristics on different substrate

Species	Var.	Length of roots (cm)	No. of primary roots	No. of secondary roots
<i>Kalanchoe tomentosa</i>	V1	7.00	9.0	12.0
	V2	3.75	13.5	11.5
	V3	3.20	21.0	27.5
	V4	2.75	10.0	-
	V5	2.50	9.5	-
<i>Senecio kleiniiformis</i>	V1	11.00	5.5	19.0
	V2	-	-	-
	V3	3.50	6.0	15.0
	V4	5.50	5.0	7.0
	V5	9.00	6.0	12.5
<i>Kalanchoe fedtschenkoi</i>	V1	11.25	10.0	8.0
	V2	10.75	7.5	35.0
	V3	6.75	7.0	27.5
	V4	7.75	9.5	17.5
	V5	9.00	10.5	10.5
<i>Sedum nussbaumerianum</i>	V1	2.50	2.5	3.5
	V2	3.00	5.0	6.5
	V3	2.75	5.0	8.0
	V4	-	-	-
	V5	2.50	3.5	-
<i>Cyanotis somalensis</i>	V1	17.00	10.5	5.0
	V2	13.25	3.5	3.5
	V3	14.50	2.5	4.5
	V4	12.25	5.5	6.0
	V5	11.75	7	4.0
<i>Senecio mandraliscae</i>	V1	-	-	-
	V2	2.00	2.0	-
	V3	4.50	2.5	6.5
	V4	2.00	2.5	3.0
	V5	0.85	3.0	3.0
<i>Sedum rubrotinctum</i>	V1	4.25	1.0	3.0
	V2	5.25	8.5	14.5
	V3	3.25	5.5	9.0
	V4	3.00	3.5	10.0
	V5	4.75	7.0	13.0
<i>Aeonimum arboreum</i>	V1	2.75	2.5	2.0
	V2	4.00	6.5	7.5
	V3	2.50	5.0	2.5
	V4	3.25	5.5	3.0
	V5	3.25	5.0	5.0
<i>Mesembryanthemum crystallinum</i>	V1	3.25	2.5	-
	V2	6.75	7.0	6.5
	V3	12.00	4.5	6.5
	V4	2.25	2.0	-
	V5	12.00	6.5	5.0
<i>Graptopetalum paraguayense</i>	V1	4.50	7.0	5.0
	V2	3.50	7.0	-
	V3	2.00	8.0	-
	V4	2.20	5.0	-
	V5	3.50	6.0	-
<i>Sedum bithenicum</i>	V1	11.00	2.5	-
	V2	6.40	2.5	-
	V3	6.00	3.0	2.0
	V4	8.75	3.0	2.5
	V5	10.50	3.5	3.0
<i>Sedum burrito</i>	V1	4.50	0.5	-
	V2	4.25	1.0	-
	V3	4.75	1.0	-
	V4	3.75	1.0	-
	V5	3.50	2.0	-
<i>Crassula perforata variegata</i>	V1	6.00	3.0	-
	V2	4.50	4.0	-
	V3	5.50	3.0	-
	V4	4.00	5.0	-
	V5	5.00	2.0	-
<i>Echeveria gibbiflora</i>	V1	10.00	4.0	-
	V2	3.50	3.0	-
	V3	3.50	1.0	-
	V4	11.00	4.0	-
	V5	-	-	-
<i>Corpuscularia taylorii</i>	V1	11.50	5.0	-
	V2	11.00	5.0	-
	V3	9.50	5.0	-
	V4	-	-	-
	V5	23.50	6.5	-
<i>Sedum allantoides</i>	V1	2.50	3.0	-
	V2	7.25	8.5	-
	V3	8.25	4.5	-
	V4	-	-	-
	V5	-	-	-



Figure 11. The aspect of plants at planting (a) and after nine months (b)

In nine months, five species - *Kalanchoe fedtschenkoi*, *Senecio kleiniiformis*, *Mesembryanthemum crystallinum*, *Corpuscularia taylorii* and *Sedum bithenicum* reached considerable heights of 20-45 cm (Figure 10).

Consequently, these succulent plant species, with indefinite growth, were considered inappropriate for use in such decorative systems (sphere and photo frame).

Table 6. Height of potted plants (cm)

Species	<i>h</i> at planting	<i>h</i> after nine months
<i>Kalanchoe tomentosa</i>	5.50	14.45
<i>Kalanchoe fedtschenkoi</i>	13.25	44.50
<i>Sedum nussbaumerianum</i>	6.60	12.75
<i>Senecio mandraliscae</i>	3.90	15.00
<i>Senecio kleiniiformis</i>	9.25	20.50
<i>Echeveria gibbiflora</i>	3.50	10.50
<i>Crassula perforata</i> var. <i>variegata</i>	2.75	13.50
<i>Graptopetalum paraguayense</i>	3.50	19.00
<i>Mesembryanthemum crystallinum</i>	5.95	39.50
<i>Corpuscularia taylorii</i>	4.70	21.50
<i>Sedum alantoides</i>	3.25	13.50
<i>Sedum rubrotinctum</i>	7.50	18.50
<i>Sedum bithenicum</i>	5.25	21.50
<i>Cyanotis somalensis</i>	3.00	5.25
<i>Aeonimum arboreum</i>	4.07	11.25
<i>Sedum burrito</i>	1.75	10.25

After nine months of growing in pots, most of the succulent plants branched and considerably increased the number of leaves (Table 7). The most thickest and compacted plants were *Sedum alantoides*, *Sedum rubrotinctum* and *Cyanotis somalensis*.

Table 7. Plants measurements after nine months

Species	Leaves no.		No. of branch.		Length of branch (cm)	
	at planting	after 9 months	at planting	after 9 months	at planting	after 9 months
<i>Kalanchoe tomentosa</i>	8.5	34.5	-	4.0	-	4.1
<i>Kalanchoe fedtschenkoi</i>	16.5	36.5	-	2.5	-	10.0
<i>Sedum nussbaumerianum</i>	16.5	41.5	-	2.5	-	3.8
<i>Senecio mandraliscae</i>	5.5	29.0	-	0.5	-	4.0
<i>Senecio kleiniiformis</i>	13.5	41.0	-	3.5	-	6.3
<i>Echeveria gibbiflora</i>	5.0	20.5	-	0.5	-	2.0
<i>Crassula perforata</i> var. <i>variegata</i>	14.0	45.0	-	1.5	-	4.0
<i>Graptopetalum paraguayense</i>	9.5	44.0	-	1.0	-	9.2
<i>Mesembryanthemum crystallinum</i>	14.5	98.0	3	55.0	1	23.5
<i>Corpuscularia Taylorii</i>	6.0	19.5	-	6.5	-	1.5
<i>Sedum alantoides</i>	15.5	70.5	-	6.5	-	6.5
<i>Sedum rubrotinctum</i>	21.5	88.0	4	13.5	2	6.6
<i>Sedum bithenicum</i>	18.5	93.0	3	5.5	1.8	4.9
<i>Cyanotis somalensis</i>	9.0	78.5	5	10.5	2	4.8
<i>Aeonimum arboreum</i>	15.0	98.0	1	3.0	1	4.5
<i>Sedum burrito</i>	19.5	73.5	-	1.5	-	1.1

Regarding the viability of plants after nine months after planting, it was established that only 7% from the total plants were lost (Table 8).

Table 8. Plants viability in potted culture

Species	Initial no.	No. after nine months	% of viability
<i>Kalanchoe tomentosa</i>	10	10	100
<i>Kalanchoe fedtschenkoi</i>	10	10	100
<i>Sedum nussbaumerianum</i>	12	12	100
<i>Senecio mandraliscae</i>	7	5	71
<i>Senecio kleiniiformis</i>	7	7	100
<i>Echeveria gibbiflora</i>	4	4	100
<i>Crassula perforata</i> var. <i>variegata</i>	5	5	100
<i>Graptopetalum paraguayense</i>	5	5	100
<i>Mesembryanthemum crystallinum</i>	10	10	100
<i>Corpuscularia taylorii</i>	8	3	37
<i>Sedum alantoides</i>	6	2	33
<i>Sedum rubrotinctum</i>	15	15	100
<i>Sedum bithenicum</i>	10	10	100
<i>Cyanotis somalensis</i>	14	14	100
<i>Aeonimum arboreum</i>	26	26	100
<i>Sedum burrito</i>	8	8	100

In several months after planting, five of sixteen species flowered (Figure 12).

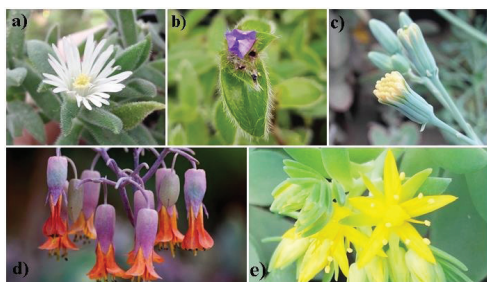


Figure 12. Flower details at: a) *Mesembryanthemum crystalinum*; b) *Cyanotis somalensis*; c) *Senecio kleiniiformis*; d) *Kalanchoe fedtschenkoi*; e) *Aeonimum arboreum*

The length of the flower stems varied between 3.5cm at *Aeonimum arboreum* and 45cm at *Senecio kleiniiformis* (Table 9).

Table 9. The variation in the quality of the floral elements and the flowering time

Species	Height of stem flower (cm)	No. of flower stems	No. of flowers/stem	Color of flowers	Time of flowering
<i>Senecio kleiniiformis</i>	45	1	10	yellow	XI
<i>Mesembryanthemum crystalinum</i>	-	-	1	white	X
<i>Kalanchoe fedtschenkoi</i>	10	1	10	orange	XII
<i>Aeonimum arboreum</i>	3.5	5.5	11	yellow	XII
<i>Cyanotis somalensis</i>	-	-	3.5	violet	I

Two of the species, *Mesembryanthemum crystalinum* and *Cyanotis somalensis*, bloom directly on shoots, consequently they do not have flower stems. The number of stems per plant ranged from 1 to 5-6 flower stems/plant. The number of flowers on a stem varies from one single flower and reaches up to 11 flowers. The colour of the flowers was: white, yellow, orange and purple. For most of the species, flowers do not smell, except *Senecio kleiniiformis*, whose odour is strong and unpleasant. The flowering period was between October and January.

III. Designing and making structures with succulent plants. Results of studies on the **large decorative sphere (diameter 20 cm)** showed that after planting, the viability of the

cuttings of the 16 species had a percent of 88.7%. Losses of cuttings were noted at *Senecio kleiniiformis*, *Mesembryanthemum crystalinum* and *Corpuscularia taylorii*, the last one, with the most severe losing (100%).

In this system, the association of plants proved to be approximately successful, since only two of the species - *Kalanchoe tomentosa* and *Crassula perforata variegata*, were partially covered by the rest of the species (Figures 13-14).



Figure 13. Initial form of the large decorative sphere



Figure 14. The large decorative sphere after one year. Leaf decay and loss was also observed in the case of the species: *Aeonimum arboretum*,

Sedum rubrotinctum, *Graptopetalum paraguayense*, *Sedum alantoides* and *Echeveria gibbiflora*.

In December, some of the species, such as *Kalanchoe fedtschenkoi*, *Aeonimum arboretum* and *Mesembryanthemum crystalinum* have blossomed.

Data results in the case of the **small decorative sphere (diameter 10 cm)**, the cuttings survived better than previously structure. For this sphere of smaller size covered with 12 species, the viability of cuttings had a percent of 93.5% (Figures 15-16).



Figure 15. Initial form of the small decorative sphere



Figure 16. The small decorative sphere after one year

Only the cuttings of *Corpuscularia taylorii* were entirely lost, therefore we considered that the

association of plants in this system was successful. Plants developed harmoniously, without invading each other. Still, similar with the plants of large sphere, the plants of smaller sphere presented leaf decay and loss at *Aeonimum arboretum*, *Sedum rubrotinctum*, *Graptopetalum paraguayense* and *Sedum allantoides* (Figure 17).



Figure 17. Leaf loss at sphere system: a) *Aeonimum arboretum*; b) *Sedum alantoides* and *Sedum rubrotinctum*; c) *Graptopetalum paraguayense*; d) *Echeveria gibbiflora*

The only species that developed flowers in this system was *Aeonimum arboretum*, in December. The observations made in the case of the **decorative photo frame with succulents**, indicated an excellent survival of the cuttings. All the 14 species cuttings rooted and developed without any lost (Figures 18-19). Consequently, the association of plants in this system was considered successful. During one year, plants developed harmoniously, without invading each other.



Figure 18. Initial form of the decorative photo frame



Figure 19. The decorative photo frame after one year

The species that developed flowers were *Aeonimum arboreum* and *Kalanchoe fedtschenkoi*. The leaf decomposition was noted at five species: *Sedum alantoides*, *Sedum rubrotinctum*, *Sedum bithenicum*, *Graptopetalum paraguayense* and *Kalanchoe fedtschenkoi* (Figure 20).

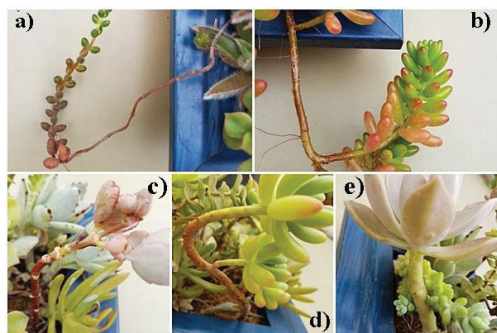


Figure 20. Leaf loss at the photo frame system: a) *Sedum bithenicum*; b) *Sedum rubrotinctum*; c) *Kalanchoe fedtschenkoi*; d) *Sedum allantoides*; e) *Graptopetalum paraguayense*

CONCLUSIONS

I. Production of cuttings. Data of this experiment showed slightly variation between species and substrate used for rooting. The best rooting results obtained for the cuttings of 16 species were on two substrates: perlite (94.5%) and peat+perlite (89%). The substrates

with smaller rooting percent were: sand - 86%, peat 81% and peat+sand - 72.9%. One of the species (*Aeonimum haworthii*) failed to root on all five tested substrates.

II. The growing of rooted cuttings in pots.

Regarding the evolution of the selected species, it was found that not all the 16 species selected originally are suitable for planting in structures. This occurs because *Kalanchoe fedtschenkoi*, *Senecio kleiniiformis*, *Mesembryanthemum crystalinum*, *Corpuscularia taylorii* and *Sedum bithenicum* had a faster growth rate, reaching in a relatively short period of time 20 cm height or more. Therefore, these species exceed, invading and compete the other plants and finally changing the shape and the harmony of plant association of the structures.

A percent of 31.25% from the tested species initiated and developed flowers.

After nine months of planting, the cuttings viability was of 92.9%.

III. Designing and making structures with succulent plants.

The design and construction of sphere-type structures is recommended to be done in two sections, which can be easily fill and assembled. Also, such systems must be made of durable materials, wire and wire mesh, in order to maintain the spherical shape. Regarding the realization of the structure of the photo frame, it was noted that the wood used as material for sustain the substrate and plants, did not deteriorate over time. Anyway, it is recommended to protect structure on the outside at the time of spraying water.

The percentage of viability of the non-rooted cuttings planted in the three decorative structures was different: 88.7% at the large decorative sphere, 93.5% at the small decorative sphere and 100% at decorative photo frame. The species *Corpuscularia taylorii* recorded a plant loss of 100% for both types of spheres. Another two species, *Senecio kleiniiformis* and *Mesembryanthemum crystalinum* were lost in the case of large sphere.

Regarding the evolution of the species used in sphere-type systems, it was noted that five species, *Mesembryanthemum crystalinum*, *Sedum bithenicum*, *Sedum rubrotinctum*, *Sedum alantoides* and *Graptopetalum paraguayense*, require a guidance of shoots among the wire at

the moment where they exceed the spherical contour of the structure. The development of the species in the decorative photo frame was remarked to be much faster at *Sedum alantoides*, *Sedum rubrotinctum* and *Sedum bithenicum*. So, we recommend to plant these species at the base of the structure, so that the subsequent growths did not cover and compete the other species.

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