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STUDY ON THE VEGETATIVE PROPAGATION OF SEVEN *SEDUM* L. SPECIES CULTIVATED OUTDOORS

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Abstract

In our study, in vivo propagation experiments of seven Sedum L. species were carried out to evaluate the effects of two factors (species, rooting substrate) on rooting of cuttings and plant acclimatisation. The biological material used was represented by cuttings of shoots belonging to 7 species of Sedum (Sedum aizoon, Sedum kamtschaticum, Sedum pallidum, Sedum spurium, Sedum rupestre, Sedum spectabile, Sedum sieboldii). Analysing the collected data, we found that, depending on the species, the rooted substrates influence in different ways the rooting process and the subsequent evolution of the plants.

Key words*: rooting medium, Sedum, species, vegetative propagation*

INTRODUCTION

Succulent plants are increasingly popular among plant collectors, home gardeners and professional landscapes for colorful leaves, sculptural shapes, simple care etc (Patel et al., 2016).

The *Sedum* genus is part of the *Crassulaceae* family of about 1,400 species grouped in 33 genera. Most species belonging to the *Sedum* genus originate in mountain regions of the subtropical and temperate zones in Europe, Central and Eastern Asia and North America. The species of the *Sedum* genus are rustic succulent plants with persistent leaves that have moderate, upright or revolving growth (Anton, 2009; Cullen and al., 2011).

There are also species that do not bear well the cold. These are grown in greenhouses or there are used as indoor decorative plants.

Their color changes dramatically with the seasons - in summer their flowers come in vibrant shades of pink and yellow, while in fall they are rich and earthy and in harshest climates, this tenacious plant continues to delight through the winter months as its flowerheads turn copper, then bronze (Horvath, 2014).

The sedum plants are grown outdoor in sunny areas, being used for decorating rocky gardens, curb-stones, contour lines and mosaics, or terraces and balconies (Jie et al., 2011).

Grown and globally distributed in all habitat types, sedums are used for more than just aesthetic purposes; they are also cultivated for their environmental benefits. More studies have been conducted investigating the use of the Sedum species for green-roofing systems (*S. acre, S. oryzifolium, S. kamtschaticum, S. reflexum, S. rupestre,* and *S. spurium*) in extreme conditions, highlighting their tolerance to cold and drought (Kim, 2010; Van Woert et al., 2005; Fazhi & Xiaomei, 2009). These green roofing systems aim to provide vegetation with added environmental benefits in an urban environment by enriching biodiversity using efficient and high-surviving plants (Li and Yeung, 2014).

These ornamental plants may be propagated in various ways, both sexually, via seeds, and vegetatively, through a number of methods, such as stem cuttings, leaf cuttings, and micropropagation (Jie L. et al., 2011). Appropriate propagation techniques are important to increase production rates and plant quality in the shortest time possible (Cabahug et al., 2018; Clark & Zheng, 2014). Some literature works have been made for this purpose, but most refer to succulent plants in general, and existing examples aimed

especially family, genus rather than a particular species (Cristescu et al., 2011).
In our study, in vivo propagation experiments of seven Sedum L. species were carried out to evaluate the effects of two factors (species, rooting substrate) on rooting of cuttings, and subsequent evolution of the plants.

MATERIALS AND METHODS

The experiment was established at the Floriculture Research Area, Faculty of Horticulture from Craiova (România), during the years 2016-2017.
The biological material used was represented by cuttings of shoots belonging to seven species of Sedum (*Sedum aizoon L.*, *Sedum kamtschaticum* Fisher, *Sedum pallidum* Bieb., *Sedum spurium L.*, *Sedum rupestre L.*, *Sedum spectabile* Boreau, *Sedum sieboldii* Sweet ex Hook.), which were considered as representatives sedums for outdoor growing in our country.
The cuttings were harvested from plants existing in the didactic field of the Floriculture discipline in April 2016. Length of the unrooted cuttings ranged from 3 to 5 cm but were uniform in size within species. Cuttings were stored overnight at 8 °C and propagated the next day on the greenhouse platforms. Ambient temperatures ranged from 20◦C–22◦C and relative humidity from 60%–80%.
In order to study the influence of the substrate on the rooting capacity of the cuttings, 15 cuttings of the seven *Sedum* species and three variants of the substrate were used: perlite (P), peat + pearlite (P + P) in a ratio of 1:1, sand (S), resulting 21 experimental variants. The experiment was laid out in a completely randomized design with three replications with five plants per replication. There was a total of forty-five plants per species.
The observations on the average number of roots, average length of roots, average height of the plants, leaves size, were recorded 45 days after the experiment was established. The evolution of the plants, after planting the rooted cuttings in pots, was determined by measuring the height at two moments (14, 45 days). We also determined the rooting percentage of the cuttings and the survival percentage of the plant one year after the experiment was established.
The data were submitted to variance analysis and the averages compared by Tukey test at 5% error probability ($p < 0.05$) in MINITAB 16 software.

RESULTS AND DISCUSSIONS

Because of the high market demand for succulents, the need to use appropriate propagation techniques for particular genus or species is deemed necessary (Cabahug et al., 2018). The success of propagating succulents is unpredictable, and the choice of substrate is one of the factors that decides on final effect of ornamental sedums cultivation, influencing the environment in which the root system is developing (Jackson et al., 2005).
The behaviour of the sedum cuttings in the rooting process was observed depending on the used substrate between the 2016 and 2017 period. The data collected shows that the percentage of the rooting of cuttings recorded maximum values (100%) in all the *Sedum* species analysed in all the tested substrates.
The average number of roots recorded maximum values in peat + pearlite substrate in *S. spurium* (65,4 roots), *S. spectabile* (43,4 roots) and *S. sieboldii* (40,3 roots). In the perlite substrate, the highest values correspond to the species *S. aizoon* (121,3 roots) and *S. pallidum* (58,9 roots), and in the sand substrate they correspond to *S. kamtschiaticum* species (83,9 roots) and *S. rupestre* (67,3 roots).
Analysing the average value obtained from each substrate, the lowest number of roots was recorded in the P + P substrate (57,6 roots) and the highest number of roots corresponds to the perlite substrate (60,3 roots) (Table 1).
Analysing the influence of the substrate on the average length of the roots, it was found that the 7 Sedum species reacted differently from this point of view. In the P substrate, the highest values correspond to the *S. aizoon* cuttings. The highest values of root lengths in P+P substrate were recorded in *S. pallidum* and *Sedum spectabile*. In the case of the S substrate, the average root length had maximum values for *S. kamtschaticum, S. spurium, S. rupestre* and *S. sieboldii*.
The average values obtained on each substrate indicate that the best results on the root sizes

were obtained in the S and P substrates and the lowest in the P + P substrate (Table 2).

Regarding the average height of the plants after two weeks from the beginning of the experiment (22.04.2017), the highest values were obtained in the P + P substrate for most species*: S. aizoon* (7,0 cm), *S. kamtschaticum* (6,1 cm), *S. spurium* (5.98 cm), *S. pallidum* (5,7 cm) and *S. rupestre* (7,3 cm). The exceptions were *S. spectabile* and *S. sieboldii* which recorded higher values of the average height of plants rooted in sand. The lowest values of this parameter correspond to the perlite substrate for all the analysed species.

Analysing the average plant height after two and a half months since the experiment was established (02.07.2016), there are significant differences depending on the substrate. The highest values correspond to the P + P substrate for most species: *S. aizoon* (21,0 cm), *S. kamtschaticum* (38,9 cm), *S. spurium* (30.3 cm), *S. pallidum* (33,9 cm), *S. rupestre* (39.0 cm), *Sedum spectabile* (19,2 cm) with the exception of the *S. sieboldii* species which recorded the highest values in the sand (9,18 cm). The lowest values were recorded in the perlite substrate: *S. aizoon* (21,0 cm), *S. spurium* (30,3 cm), *S. pallidum* (33,9 cm), *S. rupestre* (39,0 cm), *S. spectabile* (19,3 cm), *S. sieboldii* (Table 3; Figure 1).

Two types of sedum are known in terms of the appearance of leaves, i.e. with cylindrical leaves and with flat leaves. As a result, the average width of the leaves varies within the range of 0,1 cm in *S. pallidum* and 2,93-3,53 cm in *S. spectabile*.

Regarding the average length of leaves varies within the range of 1,3-1,7 cm in *S. pallidum* and 5,1-5,6 cm in *S. spectabile*. Depending on the substrate used for rooting the cuttings, the highest values were obtained in the P + P substrate in the *S. spectabile*, *S. pallidum* and *S. sieboldii* species. For *S. aizoon*, *S. spurium* and *S. kamtschaticum*, the highest values of the average leaf length correspond to the rooted cuttings in sand and for *S. rupestre* the highest value corresponds to the cuttings rooted in perlite (Figure 2).

The influence of the substrate on the rooting percentage of the cuttings was observed in four of the seven *Sedum* species; the other species recorded 100% rooting percentage of the cuttings (*S. aizoon, S. kamtschaticum S. sieboldii*).

S. spurium and *S. rupestre* recorded the best results in this respect in the perlite substrate (100%), and 60% rooting percentage for both species was recorded in the other two substrates. *S. pallidum* recorded the best results of the rooting percentage of the cuttings in P and P+P substrates (80%), and 60% in the S substrate. *S. spectabile* obtained the best results in this respect in the sand and peat + perlite substrates (100%) and 80% in the perlite substrate.

After analysing the survival percentage of the plant one year after the experiment was established, it was observed that the cuttings in the perlite substrate obtained the best results for most of the analysed species, the values ranging between 48% (*Sedum pallidum*) and 100% (*S. aizoon*, *S. kamtschaticum*, *S. spurium*, *S. rupestre*) (table 4). The survival rate was 100% in the cuttings of *Sedum aizoon, S. kamtschaticum* and *S. rupestre* rooted in the P+P mixture. Only *S. kamtschaticum* recorded the 100% survival rate for the cuttings from all the three substrates.

The lowest survival percentages correspond to the sand substrate for *S. aizoon*, *S. spurium* and *S. rupestre* species, and the lowest values for *S. spectabile* and *S. pallidum* were obtained in the peat + perlite substrate.

It is worth mentioning that the *S. Sieboldii* cuttings rooted in the S and P+P substrates did not survive the cold winter temperatures, and the cuttings rooted in the perlite substrate survived in a proportion of 80%. The best results in this regard correspond to the species *S. kamtschaticum* whose survival rate was 100% for all the analysed variants (Table 4).

Table 1. Effect of the rooting substrates on the number of roots (cm)

Treatments	Sedum aizoon	Sedum kamtschiaticum	Sedum pallidum	Sedum spurium	Sedum rupestre	Sedum spectabile	Sedum sieboldii	Mean
P	121,3a	52,3c	58,9a	56,2a	58ab	40,1a	35,2a	60,3
P+P	102,2b	70,5b	31,2b	65,4a	50,4b	43,4a	40,3a	57,6
S	86,7c	83,9a	52a	41b	67,3a	42,2a	37,4a	58,7

Means comparison were done using Tukey's test ($p<0,05$). For each variable lowercase letters indicate comparison among treatments and uppercase ones comparison among species.

Table 2. Effect of the rooting media on the average length of the roots (cm)

Treatments	Sedum aizoon	Sedum kamtschiaticum	Sedum pallidum	Sedum spurium	Sedum rupestre	Sedum spectabile	Sedum sieboldii	Mean
P	22,9a	15,63a	5,67a	6,03ab	4,93ab	6,8a	4,06a	9,43
P+P	14,97b	9,93a	8a	3,73b	4b	8,17a	4a	7,54
S	18,87ab	18,07a	6,83a	7,37a	7,5a	6,53a	5,1a	10,04

Means comparison were done using Tukey's test ($p<0,05$). For each variable lowercase letters indicate comparison among treatments and uppercase ones comparison among species.

Table 3. Effect of the rooting medium on the mean height of plants (cm) at the end of experiment

Treatments	Sedum aizoon	Sedum kamtschiaticum	Sedum pallidum	Sedum spurium	Sedum rupestre	Sedum spectabile	Sedum sieboldii	Mean
P	12,82a	21,52b	17,78b	17,94b	24,28b	15,6a	7,44a	16,71
P+P	21,02a	38,9a	30,32a	33,86a	39,02a	19,22a	8,88a	27,32
S	14,66a	21,26b	25,22ab	32,28a	33,04a	15,76a	9,18a	21,63

Means comparison were done using Tukey's test ($p<0,05$). For each variable lowercase letters indicate comparison among treatments and uppercase ones comparison among species.

Table 4. The influence of the substrate on the rooting percentage of the *Sedum* cuttings (22.07.2016) and the survival percentage of the plant one year after the experiment was established (31.03.2017)

Species	the rooting percentage after planting			the survival percentage		
	P	P+P	S	P	P+P	S
Sedum aizoon	100	100	100	100	100	80
Sedum kamtschiaticum	100	100	100	100	100	100
Sedum pallidum	80	80	60	48	32	36
Sedum spurium	100	60	60	100	36	24
Sedum rupestre	100	60	60	100	100	48
Sedum spectabile	80	100	100	80	40	60
Sedum sieboldii	100	100	100	80	-	-

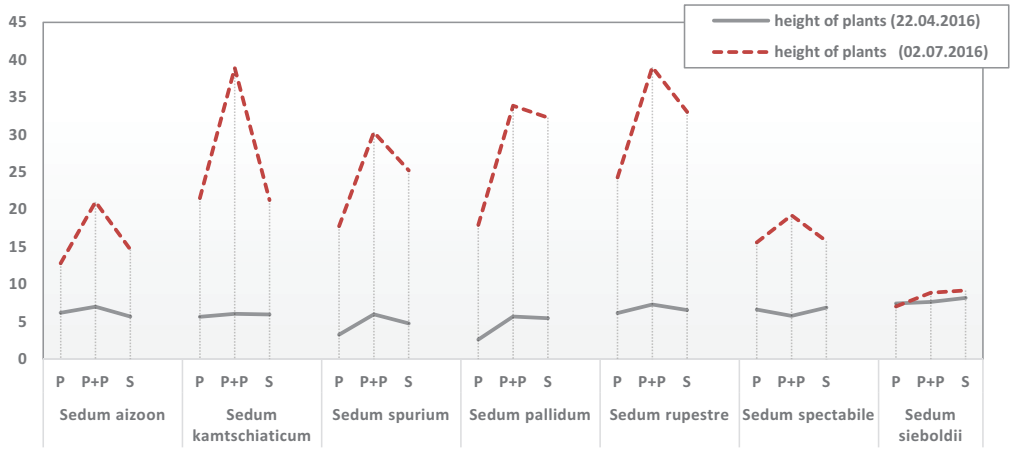

Figure 1 The average height of plants (cm) depending on the substrate type

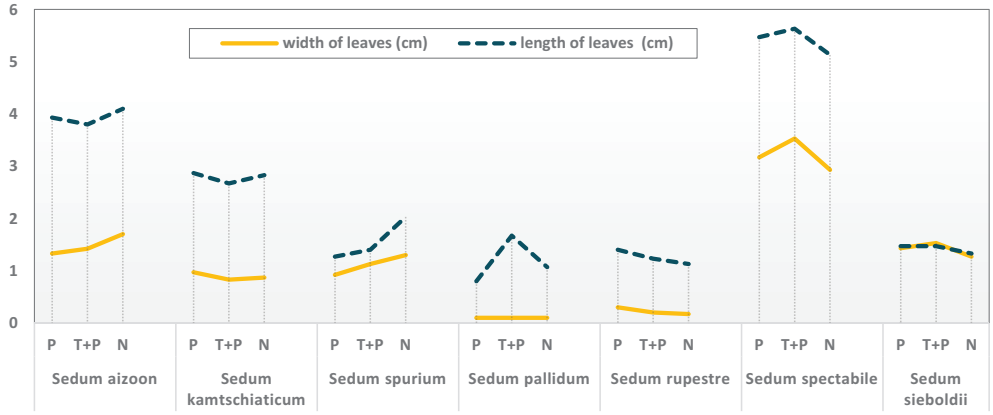

Figure 2 The average size of the leaves (cm) depending on the substrate type

CONCLUSIONS

The result shows that the highest number of roots corresponds to the perlite substrate and the lowest number of roots was recorded in the P + P substrate. The average values obtained on each substrate indicate that the best results on the root sizes were obtained in the P and S substrates and the lowest in the P + P substrate.

Depending on the substrate, there were significant differences in the vegetative growth of the plants, and the substrate with the highest values was P + P for all species. The lowest values were recorded in the P substrate.

Analyzing the plant survival percentage one year after the establishment of the experiment, the best results were obtained at the cuttings in the P substrate for all the analyzed species, with values ranging from 48% to 100%.

It is worth mentioning that the *S. sieboldii* cuttings rooted in the sand and peat + perlite substrates did not survive the cold winter temperatures, and the cuttings rooted in the perlite substrate survived in a proportion of 80%. The best results in this regard correspond to the species *S. kamtschaticum* whose survival rate was 100% for all the analyzed variants.

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