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Effects of Different Cutting Types, Rooting media, IBA Doses and Waiting Times on Propagation of Native White Stonecrop (*Sedum album* L.)*

Farklı Çelik Tipleri, Köklendirme ortamları, IBA Dozları ve Bekleme Sürelerinin Çoban Kavurgası Bitkisinin (*Sedum album* L.) Çoğaltılması Üzerine Etkileri*

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Abstract: This study was conducted to reveal the effects of different media, cutting types, IBA doses and different waiting times on the cutting propagation of *Sedum album* L. species, which naturally spreads in the flora of Kırşehir, Türkiye. After the cuttings were prepared, the first group was planted immediately, and the second group was planted after waiting for 3-d. Peat + perlite (3:1) and sand media were used as rooting medium in the experiment. Cuttings were prepared as terminal, leaf, leafy stem and stem cuttings and treated with 0, 50 mg l^{-1} and 100 mg l^{-1} doses of IBA before planting. Results showed that the peat + perlite (3:1) environment exhibited better performance than the sand environment and gave higher values in all investigated parameters. While rooting occurred in all cutting types in the peat + perlite medium, rooting was occurred only in the terminal cuttings in the sand environment. 100% rooting was occurred in the peat + perlite medium in terminal cuttings, it was 98.12% in the sand environment. The effects of planting time and IBA doses on investigated parameters were statistically insignificant (P> 0.05).

Keywords: *Sedum album* L., succulent, propagation, IBA, rooting medium

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Öz: Bu çalışma, Kırşehir ili florasında doğal olarak yayılış gösteren *Sedum album* L. türünün çelikle çoğaltılması üzerine farklı ortamların, çelik tiplerinin, IBA dozlarının ve farklı bekleme sürelerinin etkilerini ortaya koymak amacıyla yapılmıştır. Çelikler hazırlandıktan sonra ilk grup hemen dikilmiş, ikinci grup ise 3 gün bekletildikten sonra dikilmiştir. Denemede köklendirme ortamı olarak torf + perlit (3:1) ve kum ortamları kullanılmıştır. Çelikler terminal, yaprak, yapraklı gövde ve gövde çelikleri olarak hazırlanmış ve dikimden önce IBA'nın 0, 50 mg l^{-1} ve 100 mg l^{-1} dozları ile muamele edilmiştir. Sonuçlar torf + perlit (3:1) ortamının kum ortamına göre daha iyi performans sergilediğini ve incelenen tüm parametrelerde daha yüksek değerler verdiğini göstermiştir. Torf + perlit ortamında tüm çelik tiplerinde köklenme meydana gelirken, kum ortamında sadece terminal çeliklerde köklenme meydana gelmiştir. Terminal çeliklerde torf + perlit ortamında %100 köklenme gerçekleşirken, kum ortamında bu oran %98.12 olmuştur. Dikim zamanı ve IBA dozlarının incelenen parametreler üzerine etkisi istatistiksel olarak önemsiz bulunmuştur (P>0.05).

Anahtar Kelimeler: *Sedum album* L., sukkulent, çoğaltma, IBA, köklendirme ortamı

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INTRODUCTION

Succulents, which have an important place among ornamental plants, are known and used by mankind since ancient times. The superior adaptability of cactus and succulent species let to the use of these plants as outdoor and indoor ornamental plants. These plants, which are quite durable, can continue their lives without any damage in severe drought and irregular irrigation conditions. For this reason, its cultivation and maintenance is much easier than other plants. Nowadays, succulents have started to take place as alternative green field plants in landscape areas due to their beautiful appearance and low water demand (Cabahug et al., 2018).

Sedum is a large genus of flowering plants in the *Crassulaceae* family. Sedums are commonly known as stone drops. Sedums, which mainly spread naturally in the Northern Hemisphere, are naturally found in Africa and South America in the southern hemisphere. *Sedum* is a plant native to Europe, Asia, Africa and the Americas. When the whole family is examined, it is reported that it consists of a total of 1410 species and 305 subspecies, as well as 33 genera and 23 hybrid genera. The genus *Sedum* is the largest genus in the *Crassulaceae* family with 428 species (Thiede and Eggli, 2007; Manda et al., 2019). Sedums are in different forms, from annuals and creeping plants to shrubs. Their leaves store water. Generally, five-petaled flowers form, while 4 or 6-petal formations are observed. Typically, petals have twice as many stamens (Thiede and Eggli, 2007). Turkey has an extremely rich and wide range of *Sedum* species. Among the reasons why *Sedum* species diversity is so high, the topographic structure of our country plays an important role. These topographic features include deep and discrete valleys, rocky slopes and height differences. There are 34 species and 44 taxa in total in the flora of Türkiye. 7 of these species are endemic (Alpınar, 2012).

Sedum album L. was plant material of current study. This species is a flowering plant of the *Sedum* genus of the *Crassulaceae* family. It is naturally present in the northern temperate regions of the Earth, growing in crevices, rocky and stony slopes. *S. album*, which is a long day plant and grows vegetatively most of the year, blooms white in summer. The densely leafy creeping stems are short and cluster on the ground. At the time of flowering in July and August, the stems are elongated, getting wider and branching to give new shoots. Although the colors of these shoots vary according to the drought, they are usually pinkish-brown. The leaves are succulent and almost cylindrical in shape, blunt and rounded, with a lobed arrangement on the stem. The flowers are loosely structured, multi-flowered, in the form of cyme at the end of the branch or stem. The flowers have 5 white petals. The calyx consists of 5 fused sepals. Stamens are 10 pieces. The female organ is divided into carpels and 5 pistils (Chamberlain, 1972). *S. album* is an evergreen, highly resistant to climatic conditions (cold, arid etc.), perennial, dense and herbaceous plant. This species, which can be easily reproduced, develops and spreads very quickly and easily, is an economical plant material sought for landscaping applications in recent years due to its contentment. *S. album* has creep stolons. That is why it is located in rocky, stony and sloping areas. It covers ground quikly. Recently, this plant has been used in refuges, parks and gardens, and roof gardens, with its wide and short stems, leaf shapes, small white flowers on a thin flower stalk (Arslan, 2020). The species that can be easily propagated vegetatively by cuttings and separation method. Root formation begins where their stems come into contact with the soil. For this reason, they can spread easily by covering an entire area.

This study was conducted to determine the effects of different media (sand and peat + perlite), cutting types (terminal, leaf, leafy stem and stem), waiting times (immediately and planting after 3-d waiting), and IBA doses (0, 50, 100 mg l^{-1}) on propagation of *Sedum album* L. cuttings, which naturally present on stony and rocky slopes at Kervansaray Mountain flora in Kırşehir.

MATERIAL AND METHOD

In this study, *S. album* L. (White Stonecrop) species, which naturally spreads on the Kervansaray Mountain located within the borders of Kırşehir province, in Turkey, was used as plant material. The cuttings were taken in 2019 and trials were established, and since they were under controlled conditions, the study was planned for a single year. The cuttings were prepared in the laboratory of Kırşehir Ahi Evran University Faculty of Agriculture, Department of Horticulture. Propagation works were done in the unheated greenhouses of Kırşehir Ahi Evran University, Faculty of Agriculture, Department of Horticulture. Two

different rooting media (peat + perlite (3:1) and sand) were used. IBA (Indole Butyric Acid) was applied for the rooting of cuttings.

The cuttings were collected at the end of July. Cuttings were taken in the form of shoots using scissors sterilized in 70% ethanol. When taking the cuttings, the plant was cut from the bottom of the stem and the mother plant was not damaged. The collected cuttings were brought to the laboratory by placing them in styrofoam boxes with moist newspaper lined inside. The cuttings brought were prepared in four different ways as leaf, stem, leafy stem and terminal cutting. Information on the preparation of cutting is given below in detail;

For obtaining terminal cuttings, the cuttings were cut from the non-flowering shoots of the mother plant, about 2 cm long, with sharp and sterilized scissors. The leaves at the base of the shoot were cleaned and the leaves at the top were left. For leaf cutting, the leaves on the shoots of the mother plant were manually turned and plucked from the shoot, and each leaf was used as a leaf cutting. For obtaining a stem with leaves, the cuttings are prepared as a leaf and a piece of stem by cutting a leaf and a stem part from the top and bottom of the stem where the leaf is attached to the stem. For stem cutting, the cuttings were prepared by cutting the stems of the plant into pieces about 2 cm long without leaves.

The rooting media sand and peat+perlite (3:1) were prepared as following;

For preparing sand medium, the stream sand was sieved and cleaned of foreign materials. Then, sand moistened with tap water was filled into viols. These pores were covered with pieces of blotting paper so that the sand would not flow from the pores at the bottom of the viols. For preparing peat + perlite medium, sterile peat and agricultural perlite were prepared by mixing at a ratio of 3:1, respectively.

Two different planting times were used. Planting immediately and planting after 3-d waiting. Cuttings brought from the field for planting without waiting (immediately) were prepared in the laboratory as described above. This study was conducted in factorial experimental design (2 medium x 4 cutting type x 2 waiting times x 3 IBA doses) on the media prepared for planting.

One of the synthetic auxins groups, IBA (Indole-3-buytric acid) was used to promote rooting in cuttings. The bottom part of each cutting was dipped into the IBA solution prepared at different doses (0, 50 and 100 mg l^{-1}) for 20 seconds before planting.

Powdered IBA was prepared in doses of 50 and 100 mg l^{-1}, with each dose being 100 ml. 100 ml containing 50 mg l^{-1} of IBA prepared as follows: 5 mg of powdered IBA was weighed and dissolved in 96% ethyl alcohol and the top was completed with 50 ml of ethyl alcohol. The solution was made ready for use by adding 50 ml of distilled water to the IBA and pure alcohol solution.

Cuttings were prepared in the laboratory and made ready for planting. The bottom parts of the terminal cuttings were immersed in the rooting medium up to the leaf starting point and planting was carried out this way. Leaf and leafy stem cuttings were placed on the prepared medium with the leaves on top, and the bottom parts were contacted with the medium by pressing them lightly by hand. Stem cuttings, were placed horizontally on the rooting medium and pressed lightly by hand and buried in the medium almost up to half their trunk diameter.

The examined parameters were rooting rate, plant height, plant diameter, number of shoots and rooted shoots, shoot length, root length, the distance between the exit point of the longest root on the cuttings and the end point in rooted cuttings, wet and dry weights of roots. The distance between the tip points of the shoots formed after the cuttings were rooted was measured as plant diameter.

The data were analysed by using SPSS 16.0 statistical software. In calculating rooting rates, the "ArcSin" transformation was applied since the obtained data was calculated as %. The data were subjected to a one-way analysis of variance. Comparisons of the means of the applications were done by using Duncan Multiple Comparison Test. Root weights were used for determining the root quality without any statistical analysis due to the collective taken root samples for each treatment group.

RESULTS AND DISCUSSION

The effects of peat + perlite and sand media on the rooting of cuttings and the growth of plants were investigated. Results showed that the effect of the media was statistically significant ($p<0.01$) on all parameters except rooting rate (%) and shoot length (cm). Peat medium gave higher values in all parameters examined. When all cutting types (terminal, leaf, leafy stem and stem) were evaluated together, the effects of the media on the rooting rate of all cuttings were insignificant ($P>0.05$). As a mean, a 34.21% rooting was obtained in peat + perlite medium while a 24.53% rooting was obtained in sand medium. The effect of medium on plant height was significant with the highest plant (1.14 cm) formed in peat + perlite. The media affected plant diameter at the $P<0.01$ level, and the widest diameter (2.60 cm) was obtained in peat + perlite medium. The shoot numbers of cuttings rooted in peat + perlite and sand media were 3.61 and 0.26, respectively. A 1.13 rooting occurred in these shoots in peat + perlite media, and a 0.25 in sand media. The longest shoot (0.61 cm) and longest root (10.28 cm) occurred in peat + perlite medium. The higher fresh and dry weights were obtained in plants grown in peat + perlite medium compared to sand medium (Table 1).

Table 1. The effects of the medium on investigated parameters.
Çizelge 1. Ortamın incelenen parametreler üzerindeki etkileri.

Parameters	Peat+Perlite	Sand	SEM	P Values
Rooting rate (%)	34.21	24.53	2.99	0.106
Plant height (cm)	1.14	0.37	0.06	0.000
Plant diameter (cm)	2.60	0.27	0.16	0.000
Number of shoots	3.61	0.26	0.24	0.000
Number of shoots having root	1.13	0.25	0.05	0.000
Length of shoots (cm)	0.61	0.45	0.05	0.167
Length of root (cm)	10.28	1.51	0.48	0.000
Wet weight (g)	1.70	0.37	0.13	0.000
Dry weight (g)	0.27	0.05	0.01	0.000

The results showed that a 34.21% (peat + perlite) and 24.53% (sand) rooting occurred, in average, in all cutting types (Table 1). The highest rooting rate was obtained from terminal cuttings. The effects of media on the rooting of the terminal cuttings and the growth of plants were, also, examined independent from other cutting types, and the results are given in Table 2. By the way, the effects of media on all the parameters examined was significant ($P<0.01$) and the peat + perlite medium gave much higher values than the sand medium. A 100% rooting was obtained in the peat + perlite medium, while this rate was 98.12% in the sand medium. In terms of shoot number, approximately 10 times higher shoots occurred in plants rooted in peat + perlite medium compared to sand medium (Table 2).

Table 2. The effects of medium on parameters obtained from terminal cuttings.
Çizelge 2. Terminal çeliklerden elde edilen parametreler üzerine ortamın etkileri.

Parameters	Peat+Perlite	Sand	SEM	P Values
Rooting rate (%)	100.00	98.12	0.48	0.005
Plant height (cm)	2.56	1.48	0.08	0.000
Plant diameter (cm)	6.86	1.11	0.42	0.000
Number of shoots	10.12	1.06	0.67	0.000
Number of shoots having root	2.11	1.00	0.09	0.000
Length of shoots (cm)	1.97	1.82	0.02	0.004
Length of root (cm)	17.35	6.07	0.84	0.000
Wet weight (g)	5.44	1.50	0.34	0.000
Dry weight (g)	0.75	0.23	0.04	0.000

In this study, the effects of cutting types on rooting of cuttings and growth of plants were investigated. Results showed that the cutting types affected all parameters significantly (P<0.01) and the highest rooting rate (99.06 %) was obtained in terminal cuttings, followed by leafy stem (10.52), leaf (6.35) and stem (1.56%). When the effects of cutting type on root length (cm) and wet weight (g) were considered, the best values were obtained by the terminal cuttings as 11.71 cm and 3.47 g, respectively. The lowest results were obtained from the stem cuttings (Table 3).

Table 3. The effects of cutting types on investigated parameters.
Çizelge 3. Kesme şekillerinin incelenen parametrelere etkisi.

Parameters	Terminal Cuttings	Leaf Cuttings	Leafy stem Cuttings	Stem Cuttings	SEM	P Values
Rooting rate (%)	99.06	6.35	10.52	1.56	2.99	0.000
Plant height (cm)	2.02	0.41	0.49	0.09	0.06	0.000
Plant diameter (cm)	3.98	0.76	0.87	0.14	0.16	0.000
Number of shoots	5.59	1.09	0.84	0.22	0.24	0.000
Number of shoots having root	1.55	0.47	0.50	0.22	0.05	0.000
Length of shoots (cm)	1.90	0.08	0.15	0.01	0.05	0.000
Length of root (cm)	11.71	4.20	6.12	1.55	0.48	0.000
Wet weight (g)	3.47	0.30	0.31	0.06	0.13	0.000
Dry weight (g)	0.49	0.06	0.07	0.01	0.01	0.000

In this study, two different planting times were applied, namely planting without waiting and planting with three days of waiting, and the effects of these times on rooting of cuttings and plant growth of rooted cuttings were investigated. Results showed that planting time did not significantly affect rooting rate (%), plant height (cm), plant diameter (cm), shoot number (piece), rooted shoot number (piece), shoot length (cm), root length (cm), fresh weight (g) and dry weight (g) (P>0.05). The highest rooting rate (30.15%) was obtained from cuttings planted by waiting for 3-d. Also, the number of rooted shoots in the cuttings planted by waiting for 3-d tended to give a higher rate (0.70 units) than the immediate planting (0.67 units). All other parameters examined were tended to be higher in immediate planted cuttings (Table 4).

Table 4. The effects of planting time on investigated parameters.
Çizelge 4. Dikim zamanlarının incelenen parametreler üzerine etkisi.

Parameters	Immediately	3-d waiting	SEM	P Values
Rooting rate (%)	28.59	30.15	2.99	0.795
Plant height (cm)	0.82	0.69	0.06	0.351
Plant diameter (cm)	1.55	1.32	0.16	0.375
Number of shoots	2.08	1.79	0.24	0.555
Number of shoots having root	0.67	0.70	0.05	0.756
Length of shoots (cm)	0.54	0.53	0.05	0.942
Length of root (cm)	6.34	5.45	0.48	0.354
Wet weight (g)	1.12	0.95	0.13	0.553
Dry weight (g)	0.17	0.15	0.01	0.509

Different IBA doses (0, 50 and 100 mg l^{-1}) were used in the propagation of *Sedum album* by cuttings, and the effects of these doses on the rooting rate of cuttings and different plant growth characteristics during their growth were investigated. Results showed that IBA doses did not affect the parameters examined significantly (P>0.05). The plant height (0.81 cm), plant diameter (1.47 cm), rooted shoot number (0.70 pieces), shoot length (0.55 cm), root length (6.01 cm) were higher in control (0 mg l^{-1} IBA) cuttings, while 50

mg l^{-1} increased rooting rate (30.23%) in cuttings compared to other doses. A 100 mg l^{-1}IBA gave the best results regarding the number of shoots (2.12), wet weight (1.23 g) and dry weight (0.17 g) (Table 5).

Table 5. The effects of IBA doses on investigated parameters.
Çizelge 5. IBA dozlarının incelenen parametreler üzerine etkisi.

Parameters	0 mg l^{-1}	50 mg l^{-1}	100 mg l^{-1}	SEM	P values
Rooting rate (%)	28.51	30.23	29.37	2.99	0.973
Plant height (cm)	0.81	0.78	0.68	0.06	0.727
Plant diameter (cm)	1.47	1.38	1.46	0.16	0.970
Number of shoots	1.90	1.78	2.12	0.24	0.847
Number of shoots having root	0.70	0.68	0.68	0.05	0.988
Length of shoots (cm)	0.55	0.54	0.51	0.05	0.969
Length of root (cm)	6.01	5.68	5.99	0.48	0.952
Wet weight (g)	0.97	0.90	1.23	0.13	0.573
Dry weight (g)	0.16	0.15	0.17	0.01	0.946

It was determined that the interaction of planting times x IBA doses on rooting and growth of cuttings had a statistically significant effects (P<0.01). The results showed that the highest rooting rate (31.56%) was obtained from the application of 100 mg l^{-1} IBA dose, when the cuttings were waited for 3-d. It was also determined that the interaction effect on the number of shoots and wet weight was statistically significant (P<0.01). In terms of shoot number, the highest value (31.56 number) was obtained from the cuttings that were kept for 3-d and 100 mg l^{-1} IBA dose, while the lowest value (27.18 number) was obtained from the cuttings immediately planted and 100 mg l^{-1} IBA dose. However, the other parameter were not affected by this interaction (P>0.05) (Table 6).

Table 6. The effects of planting or waiting times and IBA doses on rooting and plant growth.
Çizelge 6. Dikim veya bekleme süreleri ile IBA dozlarının köklenme ve bitki büyümesi üzerine etkileri.

Parameters	Immediately			3-d waiting			Effects (P Values)			
	0 mgl^{-1}	50 mgl^{-1}	100 mgl^{-1}	0 mgl^{-1}	50 mgl^{-1}	100 mgl^{-1}	SEM	DZ	IBA	DZxIBA
Rooting rate (%)	29.53	29.06	27.18	27.50	31.40	31.56	2.99	0.02	0.11	0.000
Plant height (cm)	0.88	0.84	0.73	0.74	0.71	0.63	0.06	0.00	0.03	0.910
Plant diameter (cm)	1.66	1.42	1.58	1.27	1.34	1.35	0.16	0.01	0.68	0.401
Number of shoots	29.53	29.06	27.18	27.50	31.40	31.56	41.47	0.02	0.11	0.000
Number of shoots having root	0.71	0.65	0.64	0.68	0.71	0.71	0.05	0.48	0.00	0.642
Length of shoots (cm)	0.58	0.53	0.50	0.51	0.54	0.53	0.05	0.62	0.24	0.058
Length of root (cm)	6.77	6.40	5.86	5.25	4.96	6.13	0.48	0.02	0.74	0.120
Wet weight (g)	0.98	0.85	1.52	0.97	0.94	0.95	0.13	0.00	0.00	0.000
Dry weight (g)	0.16	0.16	0.20	0.16	0.15	0.14	0.01	0.01	0.48	0.095

When the medium x IBA dose interaction was examined, the effect of the interaction on the wet weight of the plants was found statistically significant (P<0.01). The control (having no IBA dose) plants planted in the peat + perlite medium reached the highest wet weight (1.77 g). It was determined that these control plants reached the least wet weight (0.18 g) in sand medium. While the medium X IBA interaction had no effect on the rooting rate and other examined parameters (P>0.05), the highest rooting rate was obtained from cuttings (35.62%) planted in peat + perlite medium and applied 50 mg l^{-1} IBA. This rate was followed by cuttings planted in peat + perlite medium and applied 100 mg l-1 IBA (33.75%) and non-IBA applied cuttings (33.28%) planted in peat + perlite medium. The lowest rooting rate (23.75%) was obtained in control cuttings planted in sand medium (Table 7).

Table 7. The effects of medium and IBA doses on rooting and plant growth.
Çizelge 7. Ortam ve IBA dozlarının köklenme ve bitki büyümesi üzerine etkileri.

Parameters	Peat			Sand			SEM	Effects (P Values)		
	0 mgl^{-1}	50 mgl^{-1}	100 mgl^{-1}	0 mgl^{-1}	50 mgl^{-1}	100 mgl^{-1}		Media	IBA	MxI
Rooting rate (%)	33.28	35.62	33.75	23.75	24.84	25.00	41.47	0.00	0.11	0.457
Plant height (cm)	1.24	1.18	1.00	0.37	0.37	0.36	0.06	0.00	0.03	0.071
Plant diameter (cm)	2.71	2.46	2.63	0.22	0.30	0.30	0.16	0.00	0.68	0.361
Number of shoots	3.56	3.30	3.96	0.25	0.26	0.28	3.32	0.00	0.06	0.086
Number of shoots having root	1.15	1.12	1.11	0.25	0.25	0.25	0.76	0.00	0.94	0.940
Length of shoots (cm)	0.65	0.60	0.59	0.45	0.47	0.44	0.80	0.00	0.24	0.226
Length of root (cm)	10.57	9.81	10.45	1.4	1.55	1.54	6.65	0.00	0.74	0.653
Wet weight (g)	1.77	1.60	1.72	0.18	0.19	0.75	1.87	0.00	0.00	0.000
Dry weight (g)	0.26	0.25	0.28	0.06	0.06	0.05	0.25	0.00	0.48	0.270

Medium x cutting type interaction had significant effects on all examined parameters (P<0.01). The highest rooting rate (100%) was obtained from the terminal cuttings planted in peat medium. On the other hand, 98.12% rooting occurred from the terminal cuttings planted in sand medium. The effects of other cutting types were interacted with medium. Rooting did not occur in leaf, leafy stem and stem cuttings in sand medium. Rooting rates were as 21.04%, 12.70% and 3.12% were obtained in leafy stem, leaf and stem cuttings planted in peat + perlite medium, respectively. While the terminal cuttings gave better results compared to the other cuttings in terms of plant height. Terminal cuttings (2.56 cm) planted in peat + perlite medium produced higher plants compared to terminal cuttings (1.48 cm) planted in sand medium. Peat + perlite medium gave higher results than sand medium in all parameters examined. Especially, in terms of the number of shoots formed by the terminal cuttings, almost 10 times more shoots occurred in the peat + perlite medium compared to sand medium. Also, the longest roots (17.35 cm) were obtained from the terminal cuttings planted in peat + perlite medium (Table 8).

Table 8. The effects of medium and cutting types on rooting and plant growth.
Çizelge 8. Ortam ve çelik türlerinin köklenme ve bitki gelişimine etkileri.

Parameters	Peat + Perlite				Sand				Effects	
	Terminal Cuttings	Leaf Cuttings	Leafy stem Cuttings	Stem Cuttings	Terminal Cuttings	Leaf Cuttings	Leafy stem Cuttings	Stem Cuttings	SEM	Med x Cut Type
Rooting rate (%)	100.00	12.70	21.04	3.12	98.12	0.00	0.00	0.00	2.99	0.000
Plant height (cm)	2.56	0.83	0.98	0.19	1.48	0.00	0.00	0.00	0.06	0.000
Plant diameter (cm)	6.86	1.51	1.74	0.29	1.11	0.00	0.00	0.00	0.16	0.000
Number of shoots	10.12	2.18	1.68	0.45	1.06	0.00	0.00	0.00	0.24	0.000
Number of shoots having root	2.11	0.95	1.00	0.45	1.00	0.00	0.00	0.00	0.05	0.000
Length of shoots (cm)	1.98	0.16	0.30	0.02	1.82	0.00	0.00	0.00	0.05	0.000
Length of root (cm)	17.35	8.40	12.24	3.11	6.07	0.00	0.00	0.00	0.48	0.000
Wet weight (g)	5.44	0.60	0.63	0.12	1.50	0.00	0.00	0.00	0.13	0.000
Dry weight (g)	0.75	0.13	0.15	0.03	0.23	0.00	0.00	0.00	0.01	0.000

The effects of peat + perlite and sand, which are used as rooting media in the study, on the rooting of cuttings and the growth of plants were investigated. Results showed that the effects of the media on all parameters, except rooting rate (%) and shoot length (cm) parameters, were statistically significant (P<0.01). Peat + perlite media gave higher values in all parameters examined. Our study was conducted in ordinary greenhouse conditions during summer. Although irrigation was applied regularly and equally in both

medium, peat + perlite media retained moisture more and longer. The reason why rooting does not occur especially in leaf, leafy stem and stem cuttings in sand environment can be explained as the sand's inability to kept moisture as long as peat + perlite. In addition, vegetatively propagated species can show different reactions in different environments. As a matter of fact, Manda et al. (2019) achieved 100% rooting in 5 species in their multiplication study with 7 *Sedum* species, while 100% rooting rate was achieved in 4 species in perlite + peat (1:1) and sand media. In the study, the lowest rooting rate (60%) was obtained in the sand environment of *Sedum pallidum* species, and in perlite + peat and sand medium in *Sedum spurium* and *Sedum rupestre* species. Anton and Cristescu (2009) studied 17 species, including 4 *Sedum* species (*S. mexicanum*, *S. linearum*, *S. pachyphyllum*, *S. morganianum*). They determined that rooting time, rooting percentage and root system development were different according to plant type, species and temperature conditions. Jeong (1999) stated that the most effective rooting medium was a mixture of 70% vermiculite + 30% perlite with a rooting rate of 94.4%. He reported that sand and vermiculite media were in the second rank regarding rooting rate 87.8% while the worst rooting medium was peat medium with 52.2 % rooting rate. In the same study, the highest rooting rate (66.6%) of leaf cuttings was obtained in sand medium, while the lowest rooting rate (20%) was obtained in 70% vermiculite + 30% peat medium. Their study, which found the peat medium as the worst environment, contradicts our study. This contrast may be due to the fact that their pre-drying the cuttings prepared in a relative humidity environment with 100%, 87.4%, 81.7% or 76.7%, unlike our study. It was determined that the effect of the environment on plant heights with the highest value 1.14 cm was obtained in peat + perlite medium. The media affected the plant diameter at the $P<0.01$ level, and the largest diameter was obtained with an average of 2.60 cm in peat + perlite medium. It was determined that the shoot numbers of cuttings rooted in peat + perlite and sand media were 3.61 and 0.26, respectively, and an average of 1.13 rooting occurred in these shoots in peat + perlite media, and 0.25 in sand media. The longest shoot length (0.61 cm) and longest root length (10.28 cm) occurred in peat + perlite medium. Also, the higher results were obtained from the plants grown in peat + perlite medium in fresh and dry weights compared to sand medium. Şenol and Söğüt (2017) found out that the average number of roots (number) in *S. sediforme* species was determined as 2.25, 7.91 and 2.58 in peat, volcanic tuff and peat + volcanic tuff (1:1) environments, respectively. The average biomass weight in the same media was measured as 16.95, 12.91 and 22.61 g, respectively. Our findings were agree with their study, which reported that the highest number of roots and biomass weight occurred in peat medium.

In our study, the effects of cuttings on the rooting and growth of plants were investigated. It was found that the cutting types affected significantly all parameters ($P<0.01$) and the highest rate of rooting (99.06 %) was obtained from the terminal cuttings, followed by the leafy stem (10.52 %), leaves (6.35) and stem (1.56%). When the effect of cutting type on root length (cm) and wet weight (g) was examined, the best values were obtained from the terminal cuttings as 11.71 cm and 3.47 g, respectively. In this part of the study, the lowest values were obtained from stem cuttings. The fact that the terminal cuttings contained more leaves than other types of cuttings since they may have caused a higher rate of rooting. In addition, the fact that these leaves in the terminal cuttings attached to a stem may help to be more resistant to poor conditions heat and humidity compared to other cutting types. Jeong (1999) reported that the rooting started 20 days after planting and completed 40 days later in cuttings taken from the upper and lower parts of the stem. In another study, leaf cuttings were used in vegetative propagation and only 1.7% rooting was obtained in *Sedum pachyphyllum* (Czekalski, 1998). Terminal cuttings can be used for vegetative propagation of *Sedum oreganum*, resulting the easiest rooting in late spring and early summer (Hodzic, 2020). Stem cuttings gave 100% rooting in *Sedum sediforme* species (Arı et al., 2015). Also, in a study conducted with *Sedum sediforme*, terminal cuttings responded faster and at higher rates to rooting compared to leafless stem cuttings (Aprile et al., 2020). Our findings are consistent with these researchers' findings.

In this study, two waiting times immediately planting without waiting and planting after 3-d. The effects of these waiting times on the rooting of cuttings and plant growth of the rooted cuttings were investigated. Results showed that the waiting times did not affected rooting rate, plant height, plant diameter, shoot number, rooted shoot number, shoot length, root length, fresh weight and dry weight ($P>0.005$). However, the highest rooting rate (30.15%) was obtained in cuttings planted by waiting for 3-d. The number of rooted

shoots in the cuttings planted by waiting for 3-d gave a higher rate (0.70 units) than the immediate planting (0.67 units). Immadiate planting without waiting tended to affect all other parameters positively. In general, it is recommended to wait for a few days after the cutting is prepared to allow callus formation in succulents (Jeong, 1999; Hodzic, 2020). Our study showed that the effects of the waiting time on the parameters examined were insignificant. However, evidently, the number of rooted shoots in the cuttings planted by waiting for 3-d tended to give a higher rate (0.70 units) than the immediate planting (0.67 units).

Different IBA doses (0. 50, 100 mg l^{-1}) were used in the propagation of *Sedum album* by cuttings, and the effects of these doses on the rooting rate of cuttings and different plant growth characteristics were investigated. The results showed that the effects of IBA doses on all parameters examined were insignificant (P>0.05). Control cuttings were higher in plant height (0.81 cm), plant diameter (1.47 cm), rooted shoot number (0.70 pieces), shoot length (0.55 cm), root length (6.01 cm), while 50 mg l^{-1} applied cuttings had highest rooting rate (30.23%) compared to the cuttings applied with other doses. With the application of IBA as 100 mg l^{-1}, the best results were obtained from the number of shoots (2.12), wet weight (1.23 g) and dry weight (0.17 g). In propagation studies, the rooting rate may vary according to the plant type, time, environment used, type of cutting, type and dose of plant growth regulator used. As a matter of fact, in a study conducted with different varieties of *Sedum edule*, NAA (200 mg l^{-1}) was the most suitable plant growth regulator application for fleshy-leaved "lunar shadow", "blue apple" and "black claw" leaves. It was reported that the best application for "Luna lotus" leaf cuttings is 100 mg l^{-1} IBA (Chen et al., 2018). In another study conducted with *Pachyveria pachytoides* and *Sedum morganianum* species, it was found that the leaves with hormone injection in both species formed 100% shoots. Treatments of 4.0 or 6.0 mg l^{-1}+ BAP and 0.1 mg l^{-1} + NAA's produced shoot number per leaf in *P. pachytoides* as 5.08-5.14 and in *S. morganianum* as 6.22-6.74. In addition, it was determined that the number of roots decreased with increased BAP concentration (Xu and Zheng, 2017). On the other hand, Jeong (1999) reported that growth regulators had no effect on rooting rates in *S. rotundifolium* species.

CONCLUSION

As a result, it can be recommended to use peat+perlite (3:1) medium, which can retain moisture well and also has a good porous structure, for the propagation of *Sedum album* by cuttings. It has been determined that reproduction can be made with any type of cutting when appropriate media are used, but good results will be obtained from terminal cuttings, and it can be recommended to use terminal cuttings when there is enough rootstock material. In our study, it was determined that the effect of IBA, which is frequently used in propagation with cuttings, on the parameters we examined was statistically insignificant. For this reason, it is recommended to use 50 mg l^{-1} or 100 mg l^{-1} IBA doses, as it increases the rooting rate and the number of shoots, especially in the studies to be carried out on field coating. In general, it has been suggested in various studies that in propagation of succulents with cuttings, it is necessary to wait for a while after the cuttings are prepared. In our study, in which we examined the effects of different waiting times (immediate planting and planting with three days waiting), it was determined that there was no significant difference between waiting times. Therefore, it has been determined that the cuttings can be planted as soon as they are taken, and if there is a need to wait for any reason, it will not have an effect on rooting.

CONFLICT OF INTEREST

There is no disagreement between the authors.

DECLARATION OF AUTHOR CONTRIBUTION

EE: Gathered the information, analyzed the data, and wrote the manuscript.

BA: conceptualized and designed the study and checked the final draft.

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