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Original Research Article

Does Grafting Time Affect the Cactus Performance?

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ABSTRACT

Grafting contains the uniting of two living plant parts so that they grow as a single plant. To investigate the effect of grafting times and different rootstocks and scions on cacti grafting, a factorial arrangement based on completely randomized design was adopted as the experimental design, with four replicates for each treatment. Treatments were time of grafting at two levels (spring and autumn) rootstocks at five levels (*Cereus argentinensis, Borzicactus samaipatanus, Cleistocactus candelilla, Harrisia pomanensis* and *Eriocereus jusbertii*) and scions at fives levels (*Gymnocalycium, Echinocereus, Mammillaria, Rebutia* and *Coryphantha*). Factors studied were scions diameter and length and sprouting. Results showed that *Borzicactus samaipatanus* was found to have the best performance on scions development in the spring, while the rootstocks *Borzicactus samaipatanus* and *Cleistocactus candelilla* showed a higher efficiency in grafted-cacti in the autumn. *Echinocereus* sp. was the best scion for grafting onto the cactus rootstocks in both spring and autumn. A greater compatibility was observed when *Echinocereus* sp. was combined with *Cleistocactus candelilla.* In conclusion, our results show that cactus grafting in the spring is more successful than autumn.

Keywords: Grafting time, Rootstock, Scion, Compatibility

Aşılama Zamanı Kaktüs Performansını Etkiler Mi?

Aşılama, iki canlı bitki parçasının birleştirilerek tek bir bitki halinde büyümesini sağlamaktır. Aşılama zamanı, farklı anaçlar ve aşı kalemlerinin kaktüs üzerindeki etkilerini incelemek amacıyla 4 tekerürlü faktöriyel bir deneme kurulmuştur. Uygulamalar 2 farklı mevsimde (ilkbahar, sonbahar), 5 farklı anaçta (*Cereus argentinensis, Borzicactus samaipatanus, Cleistocactus candelilla, Harrisia pomanensis* and *Eriocereus jusbertii*) ve 5 farklı aşı kaleminde (*Gymnocalycium, Echinocereus, Mammillaria, Rebutia* and *Coryphantha*) yapılmıştır. Aşı kaleminin çapı, uzunluğu ve filizler incelenmiştir. Sonuçlar incelendiğinde, *Borzicactus samaipatanus*'un ilkbahar döneminde aşı kalemlerinde en iyi gelişimi gösterirken, *Borzicactus samaipatanus* ve *Cleistocactus candelilla* sonbaharda yüksek etkinlik göstermiştir. *Echinocereus* sp. hem ilkbahar hem de sonbaharda kaktüs anaçları üzerinde en iyi performansı gösteren aşı kalemi olmuştur. *Echinocereus* sp. ve *Cleistocactus candelilla* kombine edildiğinde çok daha iyi bir uyumluluk gözlenmiştir. Genel olarak bakıldığında ilkbahar döneminde yapılan aşılamanın sonbahara göre daha etkili olduğu belirlenmiştir.

Anahtar Kelimeler: Budama zamanı, Anaç, Aşı Kalemi, Uyumluluk

INTRODUCTION

Cactus is a member of the plant family *Cactaceae* within the order *Caryophyllales* with stems succulents to store water (Johnson and Smith 1972). Cacti can be propagated by seed, cuttings or grafting. Grafting is a usual method and has a major role in cactus propagation (Cullmann *et al*. 1986). Grafting comprises the uniting of two living plant parts so that they grow as a single plant. Cacti are easy to be grafted and it's possible to graft almost any two cacti successfully. Some specific reasons for grafting include: saving plants severely rotted or diseased, ensuring better growth and flowering by grafting scions of slow growing species into fast-growing stocks, developing unusual forms, and more (Motlaghzadeh 2007). The main reason for grafting cacti is to get faster growth. Some of cacti species are rare and grow slow, thus grafting is a worthy way to propagate them faster (Anderson 2001). It is especially useful when trying to obtain seeds. The grafting of cacti types is done simply on different species of cactus (Estrada-Luna *et al*. 2002).

Only a few species of cactus are not able to graft due to the lack of vascular cambium (Keen 1990) . Cactus can be grafted at any old but it is better to use 1-2 years old scions. Flat, cleft, bud and side are four kind of grafting used in cacti (Motlaghzadeh 2007). To get successful grafting, it's important to ensure grafting compatibility. The rootstock and scion should be compatible In terms of physiological and structural. The compatibility is excellent when the rootstock and scion are in the same species. Compatibility decreases with decreasing the family relationship. Estrada-Luna *et al*. (2002) compared the performance of five *Opuntia* species (*O. streptacantha* Lemaire, *O. robusta* Wendland, *O. cochinera* Griffiths, *O. leucotricha* De Candolle and O. *ficus-indica Linne*) as rootstocks on the development of *O. ficus-indica* as scion, who found that the *Opuntia* species stock-scion combinations were compatible and horizontal graft was the easiest and most successful technique for micrografting of prickly pear cactus. The best result was obtained when *O. ficus-indica* combined with *O. ficus-indica.* Although, grafting is a common technique to propagate cacti species**,** to the best of our

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knowledge, little or no documentary report has been published so far to explain cacti grafting. Thus, the objective of this study was to study the effect of grafting time, rootstocks and scions type on grafting cactus.

MATERIALS AND METHODS

The present experiment was carried out during 2012-2013 at greenhouses located in shahriar, Iran. A factorial arrangement based on completely randomized design was adopted as the experimental design, with four replicates for each treatment. Treatments were stocks (A) at five levels (*Cereus argentinensis, Borzicactus samaipatanus, Cleistocactus candelilla, Harrisia pomanensis* and *Eriocereus jusbertii), scions (B) at fives levels (Gymnocalycium, Echinocereus, Mammillaria, Rebutia and Coryphantha) and* time of grafting (C) at two levels (spring and autumn). The grafted cacti were kept at greenhouses with the following conditions: 15-25 °C, 25-35% relative humidity and suitable ventilation). Kristalen fertilizer was applied to improve cacti growth every 15 days. The selected stocks were strong and annual and reproduced by stem cuttings. Scions which were similar in size were taken from 5 cm of the stem or branch terminal bud of one or Two-year-old healthy cactus. The Scions used in present study were screened based on two features: the beauty and rarity of species and or poor success chance of species (such as Gymnos).

Rootstock were cultivated in the pot filled with garden soil, sand, compost mixture (1:1:1, v: v: v). The studied rootstock were irrigated a few days before grafting, because irrigation may increase the flow of sap from the cut surface of the rootstock.

Grafting

In the present study grafting was conducted using flat grafting which is one of the easiest types of grafting. After selecting the rootstock, with a sharp knife made a horizontal incision at the rootstock and scion (two levels of rootstock and scion must be smooth and coincide).since cactus has hard and sticky outer skin, to prevent shrinkage and wrinkling edges of rootstock and scion prepared using a diagonal cut. Then, the scion was inserted onto the sock and fitted the scion to the stock; the junction was tightly wrapped with strips or plastic tape.

Grafting steps

Step 1. At about 2.5 cm bottom of growth point on stock created a horizontal cut with a sharp and clean knife, and then removed the top part.

Step 2. About 5 to 6 mm outer shell around the rootstock was cut with a knife. Because the fleshy tissues of rootstock become wrinkled after grafting, this keeps scion on rootstock.

Step 3. Scion was separated from the bottom part with a horizontal incision. Then, About 5 to 6 mm outer shell around the scion was cut with a knife and the scion was placed on the top of the stock so that at least some of the vascular cambium of each part was in contact.

Step 4. The air between the connections was released by rotating the scion on the rootstock and pressing it against the stock. Then, a couple of rubber bands were used to hold the scion and the rootstock together. The grafted plant was kept in outdoors (not in the sun) at 10 ° C. The pots were sub-irrigated as needed during the experiment.

Step 5. After two weeks, the scion and rootstock was attached and removed the rubber bands and the irrigation of pots and strengthening of new plant was started.

Data were subjected to analysis of variance (ANOVA) using the GLM procedure of SAS (SAS Institute, 2002). Treatment means were separated with Duncan test at $P < 0.05$.

RESULTS

Effect of grafting time on diameter and length of grafted cactus

Grafting in the spring

The diameter and length of grafted cactus were measured at intervals of c1= 40, c2=80 and c3=120 days after grafting. Diameter and length of the grafted cactus was affected by different kind of rootstocks and scions at the 0.01 level (Table 1). A significant difference was found among the length and diameter of the plants at different time of grafting. The maximum and minimum diameter and length were detected in *Borzicactus samaipatanus* and *Cereus argentinensis* rootstocks, respectively (Table 3). The best and worst performance in term of diameter and length of scion was related to *Rebutia* and *Mammillaria*, respectively (Table 3). As time progressed, the plants size was increased so that on day 120 a greater diameter and length was found than 40 and 80 days (Table 3).

The rootstocks*scions effect was significant at the 0.01 level (Table 1). The diameter and length of different scions on various rootstocks was different. Here, grafting of *Mammillaria* on *Eriocereus jusbertii* resulted in a cactus with the maximum diameter, while grafting of *Gymnocalycium* on *Cereus argentinensis* produced plant with the minimum diameter. The results of the study showed that grafting of *Echinocereus* scion on *Cleistocactus candelilla* rootstock provided cactus with the best performance in length, in contrast grafting of *Gymnocalycium* on *Cereus argentinensis* was the poorest (Table 4).

Table 1. Analysis of variance for diameter and length of plants in the spring.

SOV	df	MS	
		Diameter	length
A	4	168.54***	249.1***
B	4	31.51***	16.39***
A*B	16	30.1**	37.87**
Eab	50	14.8	11.65
C	2	52.62***	339***
A*C	8	4.88***	14.78***
B*C	8	1.08 ns	3.99***
A*B*C	32	0.81ns	4.53***
Ec	100	1.23	1.55
CV%		7.22	6.98

A= rootstock; B=scion, c= grafting time
NS, * and ** not significant and significant at 1% and 5%, respectively.

Table 2. Analysis of variance for diameter and length of plants in autumn.

SOV	df	MS	
		Diameter	length
A	4	775.73***	1027.5***
B	4	199.84***	464.15***
A*B	16	91.82***	114.99***
Eab	50	30.37	27.86
C	2	50.69***	140.7***
A*C	8	0.93 ns	13.44***
B*C	8	1.53 ns	7.16***
A*B*C	32	2.06**	4.63***
Ec	100	0.8	2.65
CV%		5.08	6.47

A= rootstock; B=scion, c= grafting time
NS, * and ** not significant and significant at 1% and 5%, respectively

The interaction between rootstocks and time of grafting was significant (Table 1), indicating the length and diameter of the rootstock s in the different time of grafting does not change uniformly. *Eriocereus jusbertii* rootstock on day 80 after grafting had the highest diameter but on 120 day after grafting showed the minimum diameter. However, the diameter of rootstock increased as time processed. On day 120, *Borzicactus samaipatanus* showed the best performance in length (Table 5). Jeong *et al.* (2006) by studying the effects of vascular bundle sizes of scions (1.56, 2.10, and 3.83 ㎜)) and stocks (1.66, 2.48, and 3.94 ㎜) on graft-take and growth of grafted cactus, ruby ball, observed the diameter of grafted scions had increased until 60 days after grafting, but no significant differences were found among the treatments. Results also showed that vascular bundle size of stock primarily affected the rooting of the grafted plants regardless of scion size. The grafting success of all treatments was generally higher than 96% at 90 days after grafting. Moreover, many researchers reported that an interaction between rootstocks and scions exists resulting in high vigor of the root system and greater water and mineral uptake leading to increased yield and fruit enhancement (Lee 1994, Oda 1995, Bersi 2002, White1963, Leoni *et al.* 1990, Ioannou *et al.* 2002, Kacjan-Marsic and Osvald 2004). Ebadi and Salagi (2002) by studying the effect of graft time and callusing medium type on union of side and saddle grafting in Iranian walnut found that union percentage of side grafting was affected by grafting time and the best results was obtained in plants grafted near the end of December. Zenginbal (2007) compared eight grafting time from 15 April to 15 September by two T- and chip budding methods in Kiwifruit and observed that the most union percentage and activity of scion buds was observed in chip budding method on 15 May and 15 September.

The length of different scion types did not show a similar increase at different times. The maximum length of scions was found in *Echinocereus*, *Rebutia* and while *Mammillaria* had the minimum length (Table 6). In a study conducted by Heidari *et al*. (2011), the effect of three commercial hybrids of rootstock (ES101, ES152

and RS841) and two native populations (*Cucurbita maxima and Cucurbita moschata*) on the success of survival rate, yield and quality of greenhouse cucumber cv. Khassib were evaluated who found the success of grafting was affected by different type of rootstock. Different responses of vegetative growth to the grafted combinations to attributed to the rootstocks vigor and compatibility of rootstocks and scions (Lee and Oda 2003), increase in cytokinin production (Salehi *et al*. 2010), the higher activity of rootstock root (Salehi *et al*. 2009), extensive root system of rootstock (Edelstein *et al*. 2004), increase in resistance to soil-borne diseases and other unfavorable soil conditions and increased synthesis of plant growth substances (Yetisir and Sari 2003).

Table 3. Mean comparison of plants length and diameter for different rootstocks and scions.

Treatment	spring		autumn	
	diameter	length	diameter	Length
a1	20.304^{b}	14.541^{c}	17.408^{c}	13.71^{c}
a2	33.206^{a}	32.413^{a}	30.433^{ab}	34.964^{a}
a3	30.987^{a}	28.848^{ab}	31.528^{a}	33.583^{a}
a4	24.293^{b}	27.281^{b}	27.54^{b}	27.037^{b}
a5	31.582^{a}	30.673^{ab}	30.293^{ab}	26.751^{b}
b1	29.953^{ab}	28.101^{ab}	29.574^{a}	27.274^{b}
b2	25.929^{b}	28.667^{a}	30.098^{a}	36.064^{a}
b3	26.165^{b}	25.006^{b}	28.786^{a}	27.513^{b}
b4	30.454^{a}	28.42^{a}	23.282^{b}	20.739^{c}
b5	32.82^{a}	31.067^{a}	25.461^{b}	24.456^{bc}
c1	26.559^{c}	22.191^{c}	26.19^{c}	24.682^{c}
c2	29.252^{b}	29.086^{b}	27.683^{b}	27.457^{b}
c3	31.081^{a}	33.482^{a}	28.447^{a}	29.487^{a}

a1=Cereus argentinensis; a2= *Borzicactus samaipatanus, a3= Cleistocactus candelilla, a4=Harrisia pomanensis* and a5= *Eriocereus jusbertii), b1=Gymnocalycium,b2= Echinocereus, b3= Mammillaria, b4=Rebutia; b4= Coryphantha) c1*=spring ; c2= autumn). Means within each column sharing the same letter(s) are not significantly different based on Duncn test at p = 0.05.

Grafting in the *autumn*

The diameter and length of grafted cactus were measured at intervals of c1= 120, c2=165 and c3=219 days after grafting. Significant differences were found in diameter and length among the rootstocks and scions at the 0.01 probability level (Table 2). Result also indicated that diameter and length of the grafted plants were different at different time of grafting. Rootstocks *Borzicactus samaipatanus and Cleistocactus candelilla* had the highest length, while *Cereus argentinensis* was the poorest. Furthermore, the maximum diameter was observed for *Borzicactus samaipatanus, Cleistocactus candelilla and Eriocereus jusbertii*, in contrast the minimum diameter was observed for *Cereus argentinensis* (Table 3). Among the scions, *Echinocereus* had the highest length. Scions *Gymnocalycium*, *Echinocereus* and *Mammillaria* showed better performance in terms of diameter compared to *Rebutia* and *Coryphantha* (Table 3). The plants size was increased with time so that the cactus measured on day 219 had a greater diameter and length compared to those measured on 120 and 165 days, however, the length and diameter of plants were increased slowly with time (Table 3).

Table 4. Rootstocks and scions interaction on plants diameter and length.

Treatment	spring		autumn	
	diameter	length	diameter	Length
a1b1	16.213^{d}	11.86^{c}	16.07^{g}	12.936^{f}
a1b2	20.41^{d}	13.781^{c}	19.488^{fg}	15.157^{ef}
a1b3	20.65^{d}	15.29^{c}	16.243^{g}	10.787^{f}
a1b4	22.071^{d}	16.266^{c}	18.24^{g}	15.85^{ef}
a1b5	0^{e}	0^{d}	16.995^{g}	13.812^{f}
a2b1	30.89^{cd}	34.3^{ab}	30.018^{cde}	26.917^{cd}
a2b2	34.18^{bc}	26.305^{bc}	32.162^{bcd}	39.086^{b}
a2b3	31.226^{c}	29.622^{b}	30.021^{cde}	40.166^{b}
a2b4	32.597^{bc}	32.153^{ab}	31.476^{bcd}	34.298^{bc}
a2b5	36.067^{bc}	36.827^{ab}	28.487^{cdef}	34.351^{bc}
a3b1	35.62^{bc}	27.765^{bc}	42.997^{a}	33.415^{bc}
a3b2	21.506^{d}	38.22^{a}	28.644^{cdef}	54.098^{a}
a3b3	27.846^{cd}	26.993^{bc}	35.568^{abc}	36.975^{b}
a3b4	40.245^{b}	28.41^{bc}	22.607^{efg}	18.502d^{ef}
a3b5	29.894c^{d}	19.855^{c}	27.818^{cdef}	24.924^{cde}
a4b1	25.514^{cd}	24.758^{bc}	26.667^{cdef}	33.067^{bc}
a4b2	21.76	26.76^{bc}	31.912^{bcd}	37.031^{b}

a4b3	22.543^{d}	23.521b^{c}	33.354^{bcd}	24.37^{cde}
a4b4	26.416^{cd}	30.902^{ab}	20.464^{fg}	16.368^{def}
a4b5	25.698^{cd}	32.053^{ab}	25.302^{def}	24.348^{cde}
a5b1	33.888^{bc}	34.508^{ab}	32.116^{bcd}	30.031^{bc}
a5b2	32.697^{bc}	32.518^{ab}	38.284^{ab}	34.946^{bc}
a5b3	50.133^{a}	25.177^{bc}	28.744^{cdef}	25.263^{cd}
a5b4	28.144^{cd}	30.315^{ab}	23.62^{efg}	18.671^{def}
a5b5	36.814^{bc}	32.122^{ab}	28.7^{cdef}	24.844^{cde}

a1=Cereus argentinensis; a2= *Borzicactus samaipatanus, a3= Cleistocactus candelilla, a4=Harrisia pomanensis* and a5= *Eriocereus jusbertii), b1=Gymnocalycium,b2= Echinocereus, b3= Mammillaria, b4=Rebutia; b4= Coryphantha)*. Means within each column sharing the same letter(s) are not significantly different based on Duncn test at p = 0.05.

The length and diameter of the scions on different rootstocks were different. The grafting of *Echinocereus* on *Cleistocactus candelilla* produced a plant with maximum length, while the grafting of *gymnocalycium* on *Cereus argentinensis* resulted in a plant with minimum length (Table 5). A greater diameter was found in plants propagated from the grafting of *Gymnocalycium* on *Cleistocactus candelilla* (Table 5).

The increase in scions length was not similar at different time after grafting (Table 6). On days 165 and 219 *Echinocereus* had the maximum length and *Rebutia* showed the worst performance at different times (table 6). In a study carried out by Mahmoudi *et al*. (2007) on the effect of scion diameter and time of grafting on grafting success in *Larix decidua*, confirmed that the success of grafting was affected by time of grafting, scion diameter and their interaction. Moradipour *et al.* (2011) also studied the grafting of cucumber on *C. maxima* × *C. moschata*, *C. maxima* cv. Goriki, *Cucurbita ficifolia*. cv. Korodame *and Lagenaria siceraria*, who found that plants grafted on *C. maxima* cv. Goriki had the highest yield, while *Lagenaria siceraria* showed the poorest yield.

Table 5. Rootstocks and grafting time interaction on plants diameter and length.

Treatment	spring		autumn
	diameter	length	Length
a1c1	18.67^{f}	11.99^{h}	13.081^{e}
a2c1	31.031^{bc}	26.04^{e}	30.634^{c}
a3c1	26.162^{d}	20.02^{f}	29.602^{cd}
a4c1	22.632^{def}	20.479^{f}	25.572^{cd}
a5c1	30.195^{c}	26.871^{de}	24.523^{d}
a1c2	20.418^{ef}	15.186^{gh}	13.902^{e}
a2c2	33.753^{bc}	34.182^{abc}	34.67^{ab}
a3c2	31.955^{bc}	29.883^{cde}	34.226^{b}
a4c2	24.135^{de}	27.944d^{e}	27.406^{cd}
a5c2	46.378^{a}	31.018^{cd}	27.082^{cd}
a1c3	21.825^{ef}	16.446f^{g}	14.145^{e}
a2c3	35.18^{b}	38.014^{a}	39.588^{a}
a3c3	34.925^{b}	36.64^{ab}	36.922^{ab}
a4c3	26.11^{d}	33.419^{bc}	28.133^{cd}
a5c3	32.957^{bc}	34.128^{abc}	28.648^{cd}

a1=Cereus argentinensis; a2= *Borzicactus samaipatanus, a3= Cleistocactus candelilla, a4=Harrisia pomanensis* and a5= *Eriocereus jusbertii), c1=*spring ; c2= autumn). Means within each column sharing the same letter(s) are not significantly different based on Duncn test at p = 0.05.

Table 6. Scions and grafting time interaction on plants diameter.

Treatment	Spring	Autumn
	diameter	diameter
c1b1	25.574^{cdef}	22.183^{ef}
c1b2	31.39^{b}	20.52^{f}
c1b3	24.838^{cdef}	20.682^{f}
c1b4	18.982^{f}	22.553^{ef}
c1b5	22.626^{ef}	25.675^{de}
c2b1	27.818^{bcd}	29.857^{bcd}
c2b2	36.639^{a}	28.691^{c}
c2b3	27.64^{bcd}	25.474^{de}
c2b4	20.687^{f}	29.052^{cd}
c2b5	24.501^{def}	31.784^{abc}
c3b1	28.428^{bcd}	32.801^{abc}
c3b2	40.162^{a}	35.751^{a}

c3b3	30.058^{bc}	29.211^{bcd}
c3b4	22.546^{ef}	33.653^{ab}
c3b5	26.24^{bcde}	35.741^{a}

*b1=Gymnocalycium,b2= Echinocereus, b3= Mammillaria, b4=Rebutia; b4= Coryphantha) c1=*spring ; c2= autumn). Means within each column sharing the same letter(s) are not significantly different based on Duncn test at p = 0.05.

Sprouting in scions

Some of the scions produced buds on bottom or end of scions after grafting. A significant difference was found between the grafting done in spring and autumn in term of site of sprouting at the 0.01 level (Table 7). In plants grafted in the spring, buds formed both in the end and bottom of scions, while in plants grafted in the autumn, buds formed only in the end scions (Figure 1). Calculation of Shannon's index revealed that firstly sprouting in the spring was more than that of in the autumn; secondly a grater sprouting occurred in the end of scions compared to the bottom of scions. The activity of buds begin to increase at the beginning of winter, thus the reserves are consumed faster by scion after grafting, because the activity of bus has been begun before complete connection and in addition to food consumption may cause the moisture loss from scions by evapotranspiration. Accordingly, the grafting success in the spring is higher than autumn (Aminzadeh *et al*. 2013). Jeong *et al.* (2007) studied Effect of stationary room temperature on graft-take and post-graft growth of grafted cactus *ruby ball*, who found the graft-take at 62 days after grafting, was mostly 97% in all temperature treatments. They reported that the after-grafted growth of grafted cacti was best at 25℃ followed by 30 and 35℃. Results also indicated that the marketability of the grafted cacti was affected by stationary room temperature due to the effect of temperature on their growth. In a study mahmoudi *et al*. (2007) evaluated the effect of grafting time and scion diameter on grafting success in *Larix deciduas.* They found that the best time in term of the vegetative activity of rootstock and scion occurred when rootstock buds begun to swell and scion buds were asleep. Results showed that the best scion diameter was more than 2 mm.

Table 7. Shannon index for germination of scions in the spring and autumn.

Time of grafting	End of scion	Bottom of scion
Spring	0.337	0.534
Autumn	0.425	0.000

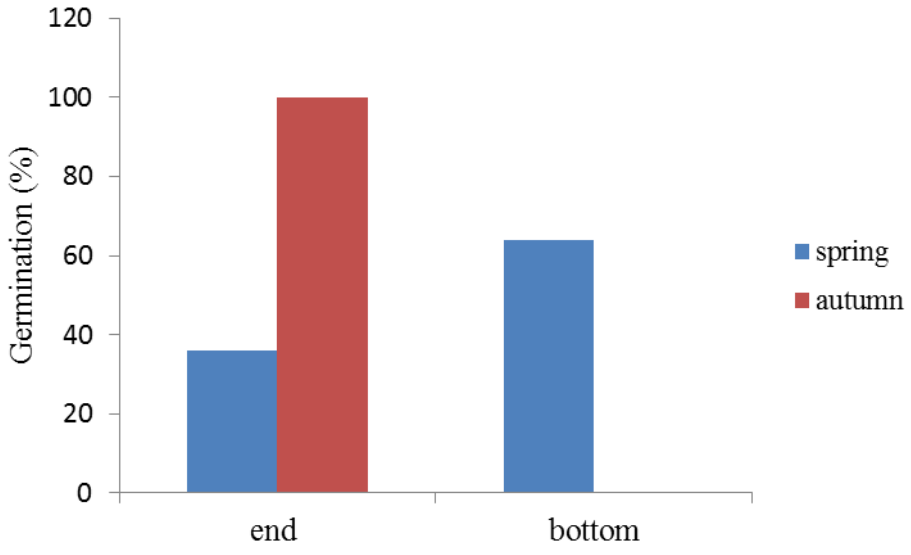

Figure 1. The germination percentage for scions in the grafting times.

CONCLUSION

The results showed that the quality of the grafting was different in the spring and autumn together. There was a significant difference in terms of sprouting between grafting in the spring and autumn. In the spring buds were formed at the bottom and end of the scions but in the autumn sprouting occurred only in the end of scions. The

results showed a significant effect of rootstock on the grafting success and efficiency in cactus. Thus, the selection of appropriate rootstocks and scions is one of the possible solutions to improve the vegetative propagation of cactus.

REFERENCES

Aminzadeh F, Fatahi Moghadam MR, Ebadi A, Hassani D, and Balanian H (2013). Effect of grafting time, antioxidant and plant growth regulators on minigrafting in walnut (*Juglans regia* L.). Seed and plant improvement journal. 29: 280-292.

Anderson EF (2001). The *Cactus Family*, Pentland, Oregon: Timber Press, ISBN 978-0-88192-498-5.

Bersi, M. 2002. Tomato grafting as an alternative to methyl bromide in Marocco. Institut Agronomieque et Veterinaire Hasan II. Marocco.

Clayton PW, Hubstenberger JF, and Phillips GC (1990). Micropropagation of Members of the Cactaceae Subtribe Cactinae. Journal of the American Society for Horticultural Science. 115:337-343.

Ebadi A, and Salagi M (2002). The effect of graft time and callusing medium type on union of side and saddle grafting in Iranian walnut. J. of Seed and Plant, No. 18, pp. 299-305.

Edelstien M (2004). Grafting vegetables-crop plants: pros and cons. Acta Horticulture. 659: 235-237.

Est rada-Luna AA, Lopez-peralta C, and Cardenas-Soriano E (2002). Invitro micrografting and the history of graft union formation of selected species of prickly pear cactus (Opuntia spp.). Scientia Horticulturae. 92: 317-327.

Heidari AA, Kashi A, Saffari Z, and Kalatejari S (2011). Effect of different Cucurbita rootstocks on survival rate, yield and quality of greenhouse cucumber cv. Khassib. Plant Ecophysiology. 2: 115-120.

Jeong SJ, Kim WS, and Lee J (2007). Effect of Stationary Room Temperature on Graft-Take and Post-Graft Growth of Grafted Cactus Ruby Ball. Horticulture Environment and Biotechnology. 48: 93-396.

Jeong SJ, Lee JS, Lee SC, and Kim WS (2006). Effects of Vascular Bundle Sizes of Scions and Stocks on Graft-Take and Growth of Grafted Cactus, Ruby Ball. Horticulture Environment and Biotechnology. 47: 144-149.

Johnson AT, and Smith HA (1972). Plant Names Simplified *:* Their Pronunciation Derivation & Meaning, Buckenhill, Herefordshire: Landsmans Bookshop, ISBN 978-0-900513-04-6, p. 19

Kacjan-Marsic N, and Osvald J (2004). The influence of grafting on yield of two tomato cultivars (*Lycopersicon esculentum* Mill.) grown in a plastic house. Acta Agriculturae Slovenica. 83: 243-249.

Keen Bill (1990). Cacti and Succulents*:* step-by-step to growing success, Marlborough, Wiltshire: Crowood Press, ISBN 978-1-85223-264-1

Lee JM (1994). Cultivation of grafted vegetables I, current status, grafting methods and benefits. HortScience. 29: 235-239.

Lee JM, and Oda M (2003). Grafting of herbaceous vegetable and ornamental crops. Horticulture Reviews. 28:61-124.

Leonardi C, and Romano D (2004). Recent issues on vegetable grafting. Acta Horticulturae. 631: 163-174.

Leoni S, Grudina R, Cadinu M, Madeddu B, and Garletti MC (1990). The influence of four rootstocks on some melon hybrids and a cultivar in greenhouse. Acta Horticulturae. 287: 127-134.

Motlaghzadeh R (2007). The World *of Cacti*: Raising Cacti in the Garden, Home and apartments. Comprehensive Culture Publications. 255 pages

Oda M (1995). New grafting method for fruit-bearing vegetables in Japan. Japan Agricultural Research Quarterly. 29: 187-194.

Salehi R, Kashi A, Babalar M, and Delshad M (2010). Identification of cytokinin in xylem sap of grafted and ungrafted melon under different train treatments. Proceeding of the 6th Iranian Horticulture Science congress. Guilan University. Page 239 (In Farsi).

Salehi R, Kashi A, Lee SG, Hou YC, Lee JM, Babalar M, and Delshad M (2009). Assessing the survival and growth performance of Iranian melons to grafting onto *Cucurbita* rootstocks*.* Korean Journal Horticulture Science Technology. 27:1-6.

White RAJ (1963). Grafted greenhouse tomatoes give heavier crops. *New Zealand Journal Agriculture*, 106: 247-248. International Journal of Agricultural Research. 2: 736-740.

Yetisir H, and Sari N (2003). Effect of different rootstock on plant growth, yield and quality of watermelon. Australian Journal of Experimental Agriculture. 43: 1269-1274.

Zenginbal H (2007). The effects of different grafting methods on success grafting in different Kiwifruit (Actinidia deliciosa and A. chev). International Journal of Agricultural Research. 2: 736-740.