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Effect of Self- and Cross-Pollination on Fruit Set and other Characteristics of 'Isfahan' Quince Cultivar

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ABSTRACT

Quince (*Cydonia oblonga* L.) tree has been introduced as a self-compatible tree, but due to the very low fruit set in some orchards/genotypes and some reports about self-compatible alleles, it is necessary to investigate the effect of using out-crossing for improving and increasing yield of different cultivars of this species. This study was carried out on 'Isfahan' quince cultivar in the orchard of Fajr Agricultural Company, Iran, in 2019 and 2020. The experiment was carried out in a randomized complete block design with four treatments including cross-pollination with 'Limouei' quince cultivar, open pollination, hand self-pollination, and self-pollination. The flowers of cultivar 'Isfahan' were emasculated in the balloon stage and were pollinated with the pollen of 'Limouei'. For self-pollination treatment, flowers in the balloon stage were covered with a bag without any emasculation or crossing. For hand self-pollination, 'Isfahan' flowers were emasculated and pollinated with 'Isfahan' pollen. The highest percentage of initial and final fruit sets was obtained in the cross-pollination treatment with 'Limouei' followed by the open pollination treatment. There was no fruit set in the self-pollination treatment. Outcrossing by 'Limouei' resulted in the highest number of seeds as well as the fruit weight. Fruit quality traits such as TSS, TA, firmness, pectin, and total phenol content did not show a significant difference among cross-pollination with 'Limouei', open pollination, and hand self-pollination. Using different cultivars with proper overlap at flowering time can increase the percentage of fruit set.

Keywords: *Cydonia oblonga* L., 'Limouei' quince, Out-crossing, Quince quality traits.

INTRODUCTION

Quince (*Cydonia oblonga* L.) is the monospecies of the genus *Cydonia*, which belongs to the family *Rosaceae*, subfamily Spiraeoideae (Bell and Leitao, 2011). Quince originated in southeast Europe and Asia Minor, and its distribution centers are Iran, Afghanistan, and southern Europe. Iran and Turkmenistan are considered quince origin (Daneshvand *et al*., 2012; Razavi *et al*., 1999). The most well-known cultivar in Iran is 'Isfahan' cultivar, which has a large cultivation area, and its optimal size and fruit quality are the reason for its expansion and popularity (Abdollahi, 2019).

One of the main problems for quince producers is the abscission of fruitlets in the early stages of growth, which has led to reduced yields and economic inefficiency. Numerous factors can affect the abscission of flowers and fruits, such as quantity and quality of water, soil quality, pruning, fertilizer, and environmental conditions before and after flowering. Under the same conditions, the most important factor is compatibility between the mother plant and the pollen donor that directly influences the fertilization (Ortega and Dicenta, 2004).

Quince has been introduced as self-compatible (Westwood, 1993), but there are reports about self-incompatibility in this species (Tatari *et al*., 2018). Quince cultivars are classified into four groups including self-

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compatible cultivars with fruit set above 10%, semi-self-compatible cultivars with fruit set rate between three to eight percent, semi-self-incompatible cultivars with one to two percent fruit set, and completely incompatible cultivars (Nagy-Deri *et al*., 2013). According to this classification, semi-self-compatible cultivars will have higher yields if they are cultivated with pollinizer cultivars. Also, semi-self-incompatible and completely incompatible cultivars need suitable and compatible cultivars for fruit sets.

The low average yield in 'Isfahan' quince cultivar is primarily related to the fruiting structure, low pollen production in this cultivar, and the lack of use of an appropriate pollinizer cultivar (Alipour *et al*., 2014; Benedek *et al*., 2001). The amount of fruit set and various abscission of 'Esme' quince cultivar in the Van region of Turkey were studied and the final fruit set rate in this cultivar in two-years studies was reported as 12.3% and 8.6%, respectively (Benedek *et al*., 2001). According to their study, the transition of blossom to fruit in the range of 20% to 25% is suitable for the optimal yield.

According to the field observations, lack of suitable pollinizer and unfavorable climatic conditions are not the only factors playing a role in the abscission phenomenon. Since lack of pollinizer or incomplete pollination is one of the main causes of fruit abscission, the aim of this study was to analyze pollination of quince cultivar 'Isfahan' in order to achieve higher yields and less abscission.

MATERIALS AND METHODS

Experimental Treatments

This experiment was performed in a quince orchard belonging to Isfahan Fajr Agricultural Holding in 2019 and 2020. Minimum and maximum air temperature as well as temperature differences during 2019 and 2020 in the studied quince orchard are shown in Table 1. The 15-year-old trees of 'Isfahan' cultivar were considered as the female parent and four experimental treatments were performed on this cultivar including cross-pollination with 'Limouei' quince cultivar, open pollination, hand self-pollination, and self-pollination. To prepare pollen grains, some 'Limouei' and 'Isfahan' branches containing sufficient number of flowers in the balloon stage were cut and transferred to the laboratory. The branches were placed in a sugar solution. After the

Table 1. Minimum and maximum temperature as well as minimum and maximum temperature differences during 2019 and 2020 in the studied quince orchard.

2019				2020			
Date	Maximum temperature (°C)	Minimum temperature (°C)	Temperature difference (°C)	Date	Maximum temperature (°C)	Minimum temperature (°C)	Temperature difference (°C)
24.4	28.3	11	17.3	16.2	21.7	7.5	14.2
25.4	29	15	14	17.2	20.7	12.1	8.6
26.4	29.4	16	13.4	18.2	18.9	8.7	10.2
27.4	29	15.5	13.5	19.2	22.7	6.5	16.2
28.4	30	12.6	17.4	20.2	20.4	3.2	17.2
29.4	29.8	16.8	13	21.2	19.5	4.4	15.1
30.4	21.2	13.7	7.5	22.2	14.1	-1.4	15.5
31.4	20.5	5.8	14.7	23.2	15.1	0	15.1
1.5	23	7.7	15.3	24.2	17.3	3.1	14.2
2.5	25	8.7	16.3	25.2	18.1	2.8	15.3

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flowers opened, the anthers were separated from the flowers and placed on paper at room temperature (24-26°C) for 24 to 48 hours. After the anthers started to shed pollen, the pollen grains were collected in sterile glass containers with cotton lids. To evaluate the pollen viability, pollen grains were placed in a Petri dish containing 1% agar, 15% sucrose, and 50 mg/L boric acids (Dalkilic and Osman Mestav, 2011), and the germination percentage of the pollen grains was recorded after 24 hours at room temperature using a light microscope in the laboratory. Pollens with more than 75% germination percentage were selected and were used as a source. Sterile glasses containing pollen grains were stored in a refrigerator at 4°C until pollination. With the swelling buds of 'Isfahan', suitable branches containing flower buds in four directions of each tree were randomly selected and covered with cloth bags. The flowers were emasculated with pence and scalpel before full bloom in the balloon stage. Flower buds, weak, immature and open flowers were also removed. When flowers were open and the stigma was ready to receive pollen grains, the bag was removed from the isolated branches and flowers were pollinated with pollen grains. The pollinated flowers were counted, labeled, and covered again with cloth bags. Pollination was performed using glass rods. To ensure pollination, the flowers were pollinated again with the pollen grains 24 hours later.

In the open pollination treatment, some flowers were selected in different directions of the tree so that after removing the open flowers and subsequent buds (completely closed), 100 flowers remained in the balloon stage. These flowers were counted and labeled. For hand self-pollination treatment, self-pollen grains were used for pollination. For each cross combination in different directions of the tree, 100 flowers were emasculated and then controlled pollination was performed. For self-pollination treatment, 100 flowers were counted in the balloon stage and covered with a cloth bag without emasculation or any cross. The cloth bags were removed after the petals fell such that the fruitlets were in normal conditions.

Evaluated Traits

The flowering time and flowering period of 'Isfahan' and 'Limouei' were recorded in 2019 and 2020 to determine the overlap of flowering times. In this study, initial and final fruit set percentage, number of seeds in the fruit, fruit weight, TSS, fruit firmness, Total Acidity (TA), pectin, and total phenol content of fruit were measured. Percentage of the initial fruit set was calculated in late May, while the final fruit set percentage was recorded in October.

Fruit weight was measured with scales. To determine the fruit firmness, a penetrometer (Model EFFEGI, Italy, plunger diameter 11.1 mm, depth 7.9 mm) was used and the applied force was recorded as pounds per square inch. TA was obtained by titration of the juice extracted with sodium hydroxide (0.1N) up to pH 8.1 and expressed as a percent of malic acid. TSS was measured using an ATAGO N-1α refractometer made in Japan. The pectin in the samples was measured by weighting method and by determining calcium pectinate (Thakur *et al*., 1996). The difference between the initial and final weight of filter paper was reported as pectin weight based on grams per 100 grams of fruit pulp. The total phenol content of fruit juices was measured using the Folin-Ciocâlteu method (Singleton and Rossi, 1965). Absorbance of the samples was determined at 765 nm wavelength with spectrophotometer model T80 UV/Visible and compared with the standard of gallic acid and expressed as mg gallic acid per 100 grams of fresh weight.

Data Analysis

The experiment was performed as a combined analysis based on a randomized complete block design with four treatments (cross-pollination, open pollination, hand self-pollination, and self-pollination of 'Isfahan' cultivar) and four replications. Analysis of data was performed by ANOVA method using statistical software SAS (version 9.1) and means comparison using the Least Significant Difference (LSD) test. For all traits, data normalization was performed with the ArcSin transformation.

RESULTS

Flowering Period and Pollen Grain Germination

The beginning of the flowering time and flowering period of 'Isfahan' and 'Limouei' in 2019 and 2020 are given in Table 2. According to this table, the two studied cultivars had an appropriate flowering overlap. Low temperatures in April 2020 delayed flowering compared to 2019 in both cultivars. The results of pollen germination showed that its rate of germination was more than 85% (Table 4).

Evaluation of the Studied Traits

The results of the analysis of variance (Table 3) showed that the studied treatments had a significant difference in all the evaluated traits. The year did not have a significant effect on the measured traits.

The highest percentage of initial (11.67%) and final (10.49%) fruit set of 'Isfahan' was obtained in cross-pollination with 'Limouei'. After that, open pollination had the highest percentage of the initial and final fruit set with averages of 8.29 and 6.55%, respectively. Hand self-pollination resulted in the insignificant percentage of initial (0.5%) and final (0.4%) fruit set and no fruit was produced in the self-pollination treatment. The percentage of fruit set in the two treatments of self- and hand self-pollination did not show significant difference (Figure 1). The highest number of seeds was obtained in cross-pollination with 'Limouei' with an average of 39.7, followed by open pollination (34.7) and hand self-pollination (22.5) (Figure 2).

Fruit weights of 'Isfahan' quince in pollination treatments with 'Limouei' and open pollination were not significantly different and showed averages of 481.2 and 458.9 g, respectively. Hand self-pollination with an average weight of 419.4 g had less fruit weight (Figure 3). Crossing combination 'Isfahan'×'Limouei' gave fruits with more pectin (0.228 g 100 g^{-1}). Open pollination (0.224 g 100 g^{-1}) and hand self-pollination (0.225 g 100 g^{-1}) did not show any significant differences in pectin content (Figure 4).

The significant differences between TSS, firmness, TA, and total phenol contents (Figures 5, 6, 7, and 8) were due to the differences between self-pollination treatment and other studied treatments. The lack of fruit set in self-pollination treatment led to a significant difference between treatments while there was no significant difference between cross-pollination with 'Limouei', open-pollination, and hand self-pollination.

DISCUSSION

Flowering Period

'Isfahan' and 'Limouei' had an appropriate flowering overlap in 2019 and 2020 (Table 2). Although flowering occurred earlier in 2019, the effect of the year on the phenology was not significant (Table 3). Flowering time did not affect fruit set percentage and other traits.

Fruit Set

Fruit set, a key developmental process that occurs following successful fertilization in higher plants, is the first step in fruit development (Joldersma and Liu, 2018). Fruit set and development occur following successful fertilization (Wang *et al*., 2020). The final fruit set had the same trend as the

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Table 2. Flowering period of 'Isfahan' and 'Limouei' in 2019 and 2020.

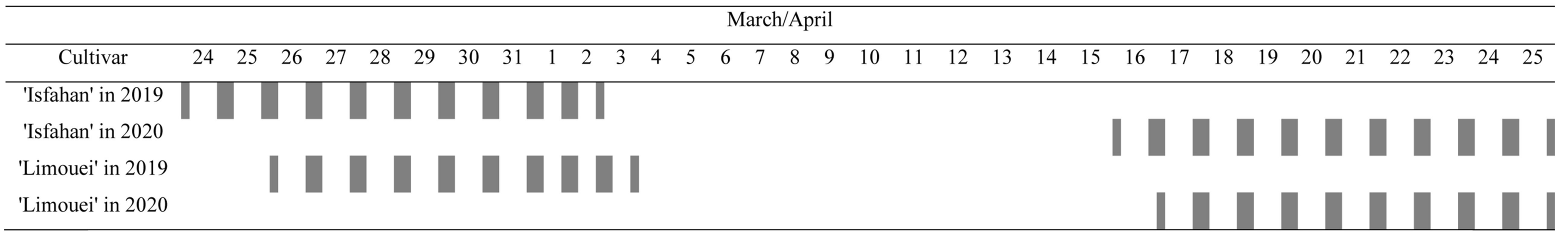

Table 3. Analysis of variation of year and quince pollination treatment on the measured traits.

Source of variation	Degree of freedom	Mean square								
		Initial fruit set	Final fruit set	Seed number	Fruit weight	TSS	Firmness	TA	Pectin	Phenol
Year	1	0.01^{ns}	0.002^{ns}	0.003^{ns}	0.26^{ns}	0.00001^{ns}	0.001^{ns}	0.00006^{ns}	0.00001^{ns}	0.004^{ns}
Rep (year)	8	0.06	0.107	0.16	1.03	0.01	0.001	0.0005	0.000006	0.05
Treatment	3	19.17^{**}	15.90^{**}	65.82^{**}	1060.52^{**}	31.08^{**}	13.79^{**}	0.24^{**}	0.05^{**}	221.37^{**}
Treatment×year	3	0.06^{ns}	0.04^{ns}	0.06^{ns}	0.208^{ns}	0.003^{ns}	0.0008^{ns}	0.00006^{ns}	0.000003^{ns}	0.006^{ns}
Error	24	0.11	0.16	0.17	0.67	0.009	0.001	0.0005	0.00002	0.01
Total	39	-	-	-	-	-	-	-	-	-
CV (%)	-	16.51	21.77	9.35	5.10	2.90	1.35	2.55	0.6	1.45

**,* and ns: Significant at the 1 and 5% probability level and non-significant difference, respectively.

Table 4. Average germination percentage of 'Isfahan' and 'Limouei' pollen grains in 2019 and 2020.

Quince cultivar	'Isfahan'	'Limouei'
Germination percentage of pollen grain	88	86

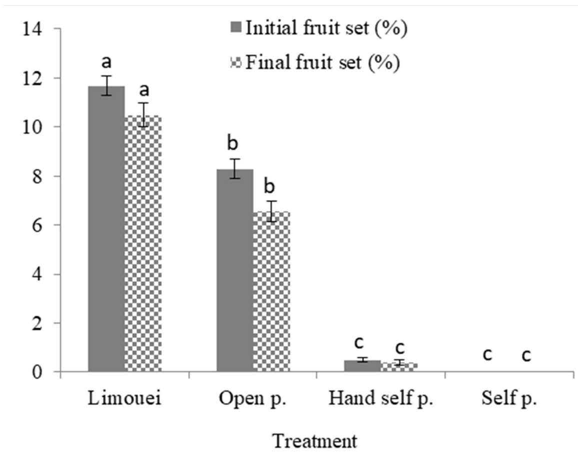

Figure 1. The effect of experimental treatments on the initial and final fruit set of 'Isfahan' quince.

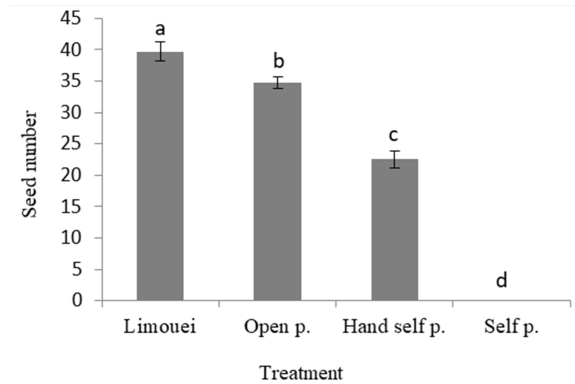

Figure 2. The effect of experimental treatments on the seed number of 'Isfahan' quince.

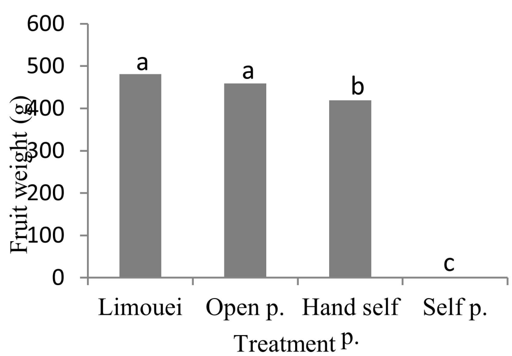

Figure 3. The effect of experimental treatments on the fruit weight of 'Isfahan' quince.

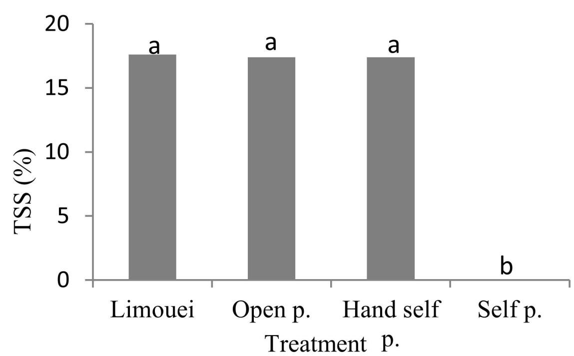

Figure 4. The effect of experimental treatments on TSS of 'Isfahan' quince.

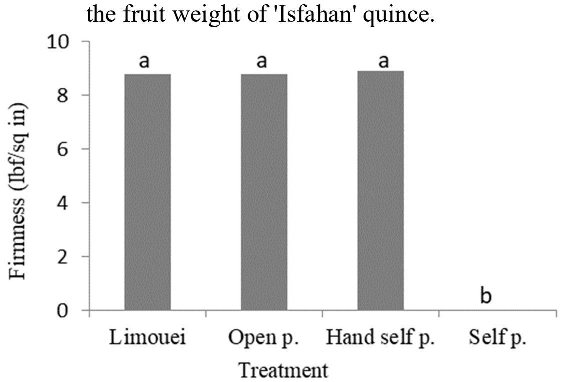

Figure 5. The effect of experimental treatments on the firmness of 'Isfahan' quince.

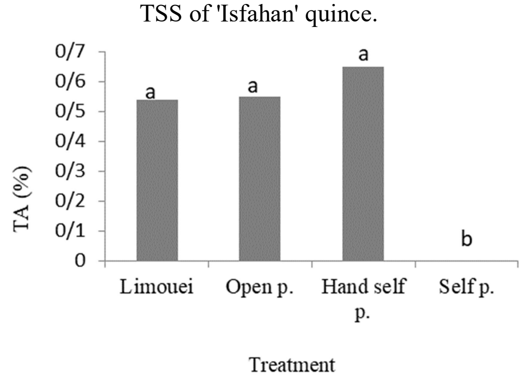

Figure 6. The effect of experimental treatments on TA of 'Isfahan' quince.

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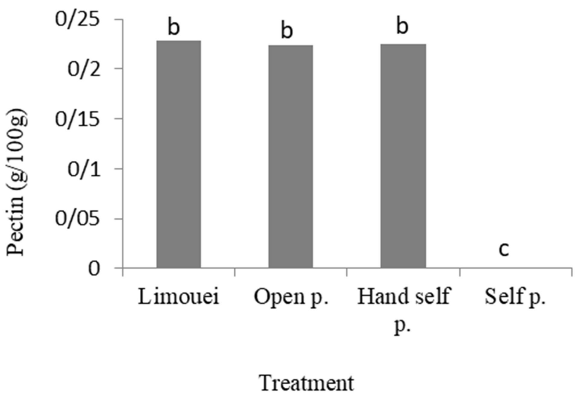

Figure 7. The effect of experimental treatments on pectin of 'Isfahan' quince.

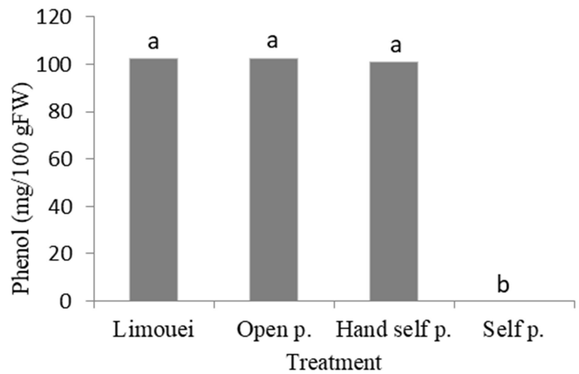

Figure 8. The effect of experimental treatments on the total phenol of 'Isfahan' quince.

initial fruit set. Cross-pollination with 'Limouei' and open pollination showed a higher percentage of initial and final fruit sets than self-pollination (Figure 1). Benedek *et al*. (2001) stated that the density of flowers in quince trees was lower than other pome fruits, so, the conversion rate of flower to fruit in the range of 20% to 25% is suitable for optimal yield. The final fruit set of 'Ekmek' quince cultivar in Van region of Turkey was reported as 12.3% and 8.6% in two years (Benedek *et al*., 2001), more than the results of the present research.

Unlike apple and pear, quince is introduced as a self-compatible tree in most references, though self-incompatibility alleles have been reported in some quince cultivars by Abdollahi (2021).

Some species close to the quince in the Maloideae subfamily, such as pear and apple, show different degrees of parthenocarpy depending on the cultivar. Parthenocarpy, a valuable trait in some self-incompatible species, produces seedless fruit without fertilization (Wang *et al*., 2020).

The tested quince cultivars were not prone to the formation of parthenocarpic fruits (Radovic *et al*., 2020). Therefore, the emergence of low fruit set in most cultivars is the result of self-incompatibility. Conducting self-pollination, manual self-pollination, and free pollination experiments on a number of pear cultivars showed that fruit set in self-pollination treatments was parthenocarpous (Faoro and Orth, 2010).

Self-pollination in quince cultivars has had different results. But and Klimenko (2001) stated that the percentage of final fruit set in self-pollinated quince ranged from 0.0 to 9.8%. The differences in results can be associated with varying degrees of fertility in certain cultivars. In a study conducted in central Serbia, the evaluated parameters in all cultivars and genotypes in open pollination treatment were more than self-pollination. Only Leskovacka' and Vranjska cultivars had the highest pollen tube growth and fruit set percentage in self-pollination treatment. These two genotypes were introduced as self-compatible, and the rest as self-incompatible (Radovic *et al*., 2020). Other researchers have also reported a decrease in fruit set in quince self-pollination treatment (Deri and Farkas, 2013; Talaei *et al*., 2007).

In all three products of apple, pear, and quince, cross-pollination increases fruit set. In a research, both initial and final fruit sets were significantly higher after cross-pollination than after self-pollination or un-pollination in pear cv. Agua de Aranjuez (Sanzol and Herrero, 2007). Rufato and Paulo (2011) reported that open pollination and cross-pollination between 'Packham's Triumph'×'Clapps Favorite' provided higher fruit sets (17 and 18%, respectively). The

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production of fruit with good commercial value can be achieved when there is a high density of pollinizer plants in the apple orchards, even in cases of semi-compatibility (Brancher *et al*., 2021).

Tatari *et al*. (2018) recommended that Viduja' cultivar and KVD2 and KVD4 quince genotypes be used together in the establishment of new orchards to effectively prevent the dropping of flowers and fruitlets and, subsequently, increase yield in quince orchards. According to the results, 'Isfahan' cultivar needs to be pollinated with another cultivar in order to have a proper fruit set. Similarly, Nuzzo and Rubbi (2004) studied 12 quince cultivars in Italy and found that most of them were self-incompatible and required cross-pollination to produce economic yield.

In species of the Rosaceae family, there is a gametophyte system of incompatibility, in which the fertilization outcome is determined by the haploid S-genotype of pollen (Hegedus *et al*., 2012). This type of incompatibility is controlled by two genes of S-locus, with one of them controlling the style component (S-RNases) (Sonneveld *et al*., 2006) and the other the pollen component (S-specific F-box protein) (Sonneveld *et al*., 2005).

The presence of pollinizer cultivars with suitable overlapping of flowering time and allelic compatibility is very effective in preventing the abscission of quince cultivars and genotypes (Tatari *et al*., 2018). Probably, the presence of a suitable pollinizer leads to the formation of fruits that can tolerate adverse conditions more than self-pollinated fruits. Even in years when the climatic conditions are not suitable for fruit and seed set, fruits with ovaries full of seeds increase fruit tolerance to abscission (Tatari *et al*., 2018).

Fruit set in open pollination treatment was lower than the controlled crossings of 'Limouei'. It has been reported that the number of transferred pollen grains to the stigma in open pollination compared to manually controlled crosses can have positive or negative effects on fruit sets. In open pollination, more than 50 pollen grains are transferred to the stigma, while in controlled crosses this number reaches several hundred pollen grains (Stosser *et al*., 1996). When pollen density is high, increasing inhibition of pollen tube growth can lead to increased competition among pollen tubes (Beyhan and Karakas, 2009. It seems that, in the present study, pollen grain density had no negative effects on fruit set in the controlled crossing treatment, consistent with the results of Beyhan and Karakas (2009).

Seed Number and Fruit Weight

The number of seeds per fruit produced by self-fertilization is used to assess self-fertility (Tassinari *et al*., 2004). In the present study, cross-pollination with 'Limouei' and open pollination had a large number of seeds in the fruit (Figure 2). The quince fruits have five carpels and normally each carpel has about 10 seeds. Fallen fruits in self-pollination treatments had no seeds or few seeds. Self-pollination treatment was also fruitless. The number of seeds was higher in pollinated treatments. Similarly, Matsumoto *et al*. (2012) reported that the number of seeds in the semi-compatible apple fruits decreased. In a study, some crosses were carried out between pear cultivars. Open pollination provided fruits with a higher number of seeds (Rufato and Paulo, 2011). It has been established that in order to form full-fledged seeds in the fruit of the pear, a full cross-pollination with good pollinators is necessary (Mozhar, 2021). None of the produced quince fruits were seedless at harvest, indicating that there was no parthenocarpic fruit set in the quince and that fertilization was necessary for fruit set and growth. Akbari Bisheh *et al*. (2016) also reported that 'Isfahan' quince is not parthenocarpic. The function of the seeds in the fruit is to produce gibberellins and auxins, which prevent the formation of an abscission layer in the peduncle. The complete formation of seeds inside the

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carpel is very effective in the durability of fruits on the tree (Watanabe *et al*., 2008).

According to the results, pollination with other pollen sources (cross-pollination with 'Limouei' and open pollination) produced fruits with higher fruit weight than self-pollination treatments (Figure 3). Seeds affect quantitatively and qualitatively the sink strength of individual fruits through plant growth regulators. Therefore, the number of seeds also affects the size and weight of the fruit (Keulemans *et al*., 1996). Matsumoto *et al*. (2012) did not observe a positive correlation between fruit weight and the number of seeds in the apple. Similarly, in a study, the higher number of seeds did not have significant effect on pear fruit weight and diameter, but the presence of seeds increased the size of the fruit in pear (Rufato and Paulo, 2011). Buccheri and Di Vaio (2005) found a positive relationship between seed number and fruit weight in apples (cv. Annurca Tradizionale, Annurca Rossa del Sud, and Golden Delicious). A positive correlation between fruit weight and number of seeds in quince has also been reported by Razavi *et al*. (1999) that is consistent with our results.

Other Fruit Traits

Although the effect of treatments on pectin content, total phenols, firmness, TSS, and TA traits was significant, these traits were not affected by cross-pollination, because the lack of fruit set in self-pollination treatment leads to significant effect of treatments on these traits, as shown in Figures 4, 5, 6, 7, and 8. In the research of Tatari *et al*. (2018), pollen source had no significant effect on the fruit TSS and firmness in ‘Viduja’ quince, similar to the present study.

There is a metaxenia in some species of fruit trees. This means that the pollen grain affect the physical and chemical characteristics of the fruit. In this case, the pollen can be effective in the formation and growth of the embryo and can cause small, large, complete, or incomplete embryos, and thereby it has an influence on the growth and development of fruit (Cheng *et al*., 2020). In this study, the physical and chemical properties of the fruit were almost not affected by cross-pollination with 'Limouei'.

CONCLUSIONS

The occurrence of self-incompatibility leads to the abscission of quince flower and fruitlets that lead to low fruit set and low yields in some quince cultivars. The most important quince cultivar in Iran is ‘Isfahan’. Cultivation of a single cultivar and lack of pollinizer in the orchard leads to a reduction of the yield to one-tenth of the normal yield. Therefore, for obtaining high yields in commercial ‘Isfahan’ quince orchards, cultivation of different cultivars with overlapping flowering times and allelic compatibility can be recommended. The presence of pollinizer cultivars with the suitable overlapping of flowering time is very effective in preventing the abscission of quince cultivars and genotypes

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اثر خود-دگرگرده افشانی بر تشکیل میوه و دیگر خصوصیات به رقم اصفهان

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چکیده

درخت به (*Cydonia oblonga* L.) به عنوان یک درخت خودسازگار معرفی شده است، اما به دلیل درصد تشکیل میوه بسیار کم در برخی باغ‌ها و ژنوتیپ‌ها و وجود برخی گزارش‌ها در خصوص آلل‌های خودسازگاری، ضروری است که اثر استفاده از دگرگرده‌افشانی برای بهبود و افزایش محصول در ارقام مختلف

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این گونه مورد بررسی قرار گیرد. این پژوهش بر روی به رقم اصفهان در باغ شرکت کشاورزی فجر طی سال-های ۱۳۹۹ و ۱۴۰۰ انجام شد. این آزمایش در قالب طرح بلوک‌های کامل تصادفی با چهار تیمار شامل گرده-افشانی با به رقم لیمویی، گرده‌افشانی آزاد، خودگرده‌افشانی دستی و خودگرده‌افشانی به اجرا درآمد. گل‌های به رقم اصفهان در مرحله بالون اخته شده و با گرده به رقم لیمویی گرده‌افشانی شدند. برای تیمار خودگرده-افشانی، گل‌ها در مرحله بالون بدون اخته گردن و گرده‌افشانی با کیسه پوشانده شدند. برای خودگرده‌افشانی دستی، گل‌های به رقم اصفهان اخته شده و با دانه گرده به اصفهان تلقیح شدند. بیشترین درصد تشکیل میوه اولیه و نهایی در تیمار گرده‌افشانی با گرده رقم لیمویی و سپس با تیمار گرده‌افشانی آزاد به دست آمد. در تیمار خودگرده‌افشانی میوه‌ایی تشکیل نشد. دگرگرده‌افشانی با گرده به لیمویی منجر به تشکیل میوه‌هایی با بیشترین تعداد بذر و بیشترین وزن میوه شد. صفات کیفی میوه مثل TSS، TA، سفتی بافت میوه محتوای پکتین و فنل کل اختلاف معنی‌داری را بین تیمارهای گرده‌افشانی با لیمویی، گرده‌افشانی آزاد و گرده‌افشانی دستی نشان نداد. استفاده از ارقام مختلف با همپوشانی مناسب زمان گل‌دهی می‌تواند درصد تشکیل میوه را افزایش دهد.

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