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## Research Article

# Evaluation of “Zoshk”: A new mid-ripening sweet cherry cultivar with suitable fruit size and quality

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**ABSTRACT-** Introducing new sweet cherry cultivars with different ripening times is one of the most important goals of cherry breeding programs in Iran. ‘Zoshk’ cultivar was selected from the native sweet cherry genotypes of Khorasan Razavi Province by implementing eight research projects for 21 years since 1998. The results of this study showed that this cultivar had semi-spreading tree habits and a moderate degree of branching. The time of the first flowering of the ‘Zoshk’ cultivar was in the second week of April. A pollination study demonstrated that this cultivar was self-incompatible. ‘Sefid-90’, ‘Surati-e-Lavasan’, and ‘Dovomras-e-Mashhad’ cultivars were suitable pollinizer cultivars for ‘Zoshk’. In addition, the harvesting time of this cultivar was in the third week of June. The average fruit weight of the ‘Zoshk’ cultivar (10.17 g) was higher than those of ‘Shandiz’ (7.23 g), ‘Toos’ (6.87 g), and ‘Siah-e-Mashhad’ (7.80 g). Further, the total soluble solid was higher in ‘Zoshk’ (19.66%) compared to ‘Shandiz’ (16.63%) and ‘Toos’ (17.13%) cultivars. Moreover, the yield of ‘Zoshk’ in the economic fruiting stage was 33.67 kg per tree, higher than those of ‘Shandiz’ (22.43 kg) and ‘Toos’ (12.67 kg) cultivars. Regarding the high yield, average fruit weight, percentage of soluble solids, and extended ripening time of the ‘Zoshk’ cultivar, the expansion of this cultivar is recommended in some sweet cherry orchards in Iran.

### INTRODUCTION

The sweet cherry tree (*Prunus avium* L.) is a fruit-growing species that is highly important owing to its nutraceutical features (Höfer and Giovannini, 2017; Ganopoulos *et al.*, 2018). In the past years, new cultivars have been approved to be suitable for constant production having characteristics such as the low, moderate to vigorous growth, being self-fertile and having various ripening times, especially at the extremities of the maturation season of cherries (Kazantzis *et al.*, 2011; Schuster *et al.*, 2014).

Iran is the fifth-largest producer of cherries in the world after Turkey, the United States of America, Chile, and Uzbekistan with an annual production of 164,080 tons of cherries (FAO, 2020). ‘Siyah-e-Mashhad’ and ‘Tadane’ have previously been reported as the two dominant cultivars in more than 70% of the cherry orchards in Iran (Ganji Moghadam *et al.*, 2017). These cultivars are ripening from late June to mid-July. To supply consumer requirements, create a balance in supply and demand, and increase the income of cherry producers in the country, it is necessary to modify and introduce new desirable cultivars with different ripening ranges. For this purpose, obtaining extremely early-, early-, mid-, and late-ripening cultivars is one of the

most important goals of cherry breeding. The first very early cultivar, named ‘Adli’ (Ganji Moghadam *et al.*, 2017), and the early cultivars, ‘Shandiz’ and ‘Toos’ were introduced by Ganji Moghadam *et al.* in 2019 and 2020, respectively (Ganji Moghadam *et al.*, 2019; Ganji Moghadam *et al.*, 2020).

In the continuation of cherry breeding projects by Ganji Moghadam *et al.*, the first Iranian mid-ripening cultivars with desirable characteristics, ‘Zoshk’, was introduced in 2021. Replacing some of the old cherry cultivars with new mid-ripening cultivars such as ‘Zoshk’, due to the elimination of the limitations of cultivars with different maturity levels can play an important role in increasing the income of the Iranian cherry growers and supplying the requirements of the market. Therefore, the aim of this study was to introduce a new mid-ripening cultivar, known as ‘Zoshk’, and compare its characteristics with those of other commercial sweet cherry cultivars in Iran.

### MATERIALS AND METHODS

During the identification and collection of cherry germplasms, it was found that some of the genotypes completely differed from the other ones (UPOV, 2008). In the first five years of the project, the selected ‘Zoshk’

genotype was planted in Golmakan Agricultural Research Station in an aggregate statistical design with five trees per replication. The vegetative, reproductive, and pomological characteristics were determined for 6 years (UPOV, 2008). All phenological, morphological, and pomological traits of the promising 'Zoshk' genotype were compared with those of the five cultivars including 'Siah-e-Mashhad', 'Shandiz', 'Toos', 'Siah-e-ghazvin', and 'Pishras-e-Mashhad' in a randomized complete block design with three replications. Flower phenology stages were recorded based on the methods described by Tzoner and Yamaguchi (1999).

To determine compatibility (or incompatibility) and the pollinizers of 'Zoshk' cultivar, three branches per tree, each with approximately 100 flowers, were selected in different directions and they were isolated by covering them inside cloth bags and then labeled. One of the branches was isolated to allow the occurrence of natural self-pollination. In each replicate, a separate branch was marked without being isolated so that it could be open pollinated (Ganji Moghadam *et al.*, 2014). At the time of the artificial pollination, the isolated flowers of the above-mentioned cultivars were pollinated with their pollen grains and pollen grains of other eight cultivars including 'Surati-e-Lavasan', Sefid-90, 'Dovomras-e-Mashhad', 'Sunburst', 'Siyah-e-Mashhad', Sweet Heart, Bing, and Haj Yousefi). To do this, the stigmas of the flowers were drawn and pollinated using a special brush for pollen grains. To ensure pollination, it was performed again 24 hours later, and the branches were isolated again. After pollination, the final fruit set was calculated based on the following equation (Westwood, 1993):

$$\text{Fruit set percentage} = \left( \frac{\text{The number of fruits}}{\text{The number of pollinated flowers}} \right) \times 100$$

The pomological characteristics of some traits including fruit weight and stone weight were measured and recorded by a digital scale. The percentage of soluble solids was calculated using a hand-held refractometer at room temperature (in the range of 18-23 °C). In addition, the total acid content was measured

by the titration of sodium hydroxide (0.1 N) based on the predominant acidity of the cherry fruit (i.e., malic acid).

To measure the annual vegetative growth, at the end of the growing season (in September), the average vegetative growth related to the current season of six branches of each tree was measured in different directions, and then the average annual vegetative growth was determined in centimeters. Finally, leaf length, leaf width, leaf length to leaf width ratio, petiole length, peduncle length, and peduncle thickness were measured using a caliper.

### Data analysis

The data were analyzed by MSTAT-C software, version 14.2. The analysis of variance (ANOVA) was performed based on a randomized complete block design with three replications, and the means were compared using Duncan's multiple range test at 1% or 5% probability levels.

## RESULT AND DISCUSSION

### Morphological and Phenological characteristics

The characteristics of the mid-ripening 'Zoshk' cultivar, their growth status from the planting time (1998) to 2020 and their reproductive characteristics were evaluated in Mashhad. Phenological studies revealed that this cultivar has semi-spreading tree habits, a moderate degree of branching, and normal internode length (Fig. 1).

Flower characteristics and phenological stages of flowering were determined based on observational notes during the flowering period. The result represented that the mid-ripening 'Zoshk' cultivar had 5, 5, and 25-35 sepals, petals, and stamens, respectively. The petals had a round shape and a middle-type arrangement (Fig. 1).



**Fig 1.** The vegetative and reproductive characteristics of the cherry 'Zoshk' cultivar: (A) 'Zoshk' cultivar trees showing semi-spreading tree habits, a moderate degree of branching, and normal internode length in a sweet cherry orchard in Khorasan Razavi Province; (B) 'Zoshk' cultivar flowers having 5, 5, and 25-35 sepals, petals, and stamens, respectively; (C) 'Zoshk' cultivar fruits on a cherry tree; (D) 'Zoshk' cultivar having average fruit weight and high total soluble solid.

The results of the phenological study on cherry cultivars in this research indicated that the beginning of the flowering time of sweet cherry cultivars varied between 27 March in the 'Toos' cultivar to 10 April in the 'Takdane' cultivar and the full bloom stage varied between six days to 11 days later after flowering time in the 'Siyah-e-Mashhad' cultivar and the 'Zoshk' cultivar, respectively (Table 1). Also, the data in Table 1 indicated that the flowering of the 'Zoshk' cultivar begins in the first week of April and the full bloom stage occurs 11 days later.

#### Self-incompatibility of the 'Zoshk' cultivar

The experimental results indicated a significant difference ( $P > 1\%$ ) between self-pollination and open pollination in terms of fruit set percentage in the 'Zoshk' cultivar (Fig. 2). In the 'Zoshk' cultivar, the results demonstrated that open pollination, natural self-pollination, and artificial self-pollination with the 'Zoshk' cultivar itself showed fruit set percentages with averages of 18.78%, 0.5%, and 8.47%, respectively (Fig. 2). Based on these results, the 'Zoshk' cultivar was considered incompatible in terms of self-pollination and required a suitable pollinizer cultivar to form a suitable fruit.

#### Effect of pollinizer cultivars on the fruit set percentage of the mid-ripening 'Zoshk' cultivar

The results showed that the pollen type was significant on the fruit set percentage of the 'Zoshk' cultivar at a probability level of 1% (data not shown). To determine appropriate pollinizer cultivars, the effects of pollens of eight pollinizer cultivars including 'Sefid-90', 'Surati-e-Lavasan', 'Dovomras-e-Mashhad', 'Sunburst', 'Siah-e-Mashhad', 'Sweet heart', 'Bing', and 'Hajyusefi' were investigated on the fruit set percentage of the 'Zoshk' cultivar. The results represented the pollens of the 'Sefid-90', 'Surati-e-Lavasan', 'Dovomras-e-Mashhad' and 'Sunburst' cultivars with an average of 46.74%, 42.8%, and 41.7% were suitable pollinizer cultivars for the 'Zoshk' cultivar, respectively (Fig. 3). In the establishment of new orchards with the 'Zoshk' cherry cultivar, the use of pollinating trees such as 'Sefid-90', 'Surati-e-Lavasan', 'Dovomras-e-Mashhad' and 'Sunburst' cultivars is recommended at least 10% of the original cultivar trees.

#### Pomological and biochemical traits

The results related to some pomological and biochemical traits of the fruits of the 'Zoshk' cultivar revealed that some traits of the fruits of the 'Zoshk' cultivar that have been tested in this study had significant differences from those of the fruits of the other studied cultivars at probability levels of 1 and 5% (Data not shown).

The 'Zoshk' cultivar with an average fruit weight of 10.17 g had a higher average weight compared to those of 'Siyah-Mashhad' (7.8 g), 'Shandiz' (7.23 g) and 'Toos' (6.87 g) commercial cultivars (Fig. 4). The stone

shape of the 'Zoshk' cultivar was oval and its average core weight was 0.36 g (Table 2). However, the stone core weight of the 'Zoshk' cultivar did not have significant differences from those of the 'Siyah-e-Mashhad', 'Shandiz' and 'Toos' cultivars at probability levels of 1% (Table 2). Regarding its high average weight, ripening time (mid-June), and other characteristics, this cultivar could have the highest economic value of cherries. The results of the current study are consistent with those of other studies in terms of the pomological characteristics of some sweet cherry cultivars (Fotirić Akšić and Nikolić, 2013; Pal *et al.*, 2017). Bieniek *et al.* (2011) found that the average over three years of the sweet cherry fruits' weight has ranged between 3.78 and 6.45 g under the soil and climate conditions of Lithuania.

The fruit peduncle length of the 'Zoshk' cultivar was 4.5 cm and the thickness of the peduncle was 1.34 mm (Table 2). This cultivar, similar to the 'Siyah-e-Mashhad' cultivar, had a long fruit peduncle length, which can be important in introducing cherry cultivars with long-peduncle lengths. Another distinguishing feature of this cultivar was the thickness of the fruit peduncle, as it had a thicker peduncle in comparison with the 'Siyah-e-Mashhad' cultivar (Table 2). Likewise, Olmstead *et al.* (2007) concluded that fruit size depends on cell length and was significantly influenced by the environment. Further, fruit peduncle is one of the traits that is used in identifying cherry cultivars.

Table 2 also provides the results related to the biochemical characteristics of the fruit of the 'Zoshk' cultivar and those of other sweet cherry cultivars. The soluble solid of 'Zoshk' and 'Siyah-e-Mashhad' cultivars were 19.66% and 20.95%, respectively (without significant difference at 1% probability), which were higher than those of 'Shandiz' (16.63%) and 'Toos' (17.13%) cultivars. It has been reported that the contents in the soluble solid are extremely important in sweet cherries since the taste of the fruits highly depends on it (Corneanu *et al.*, 2020). The recorded values on the soluble dry substance contents of the fruits of the 'Zoshk' cultivar in the current study (Table 2) were in agreement with those of other similar studies (Janes *et al.*, 2010; Papapetros *et al.*, 2018).

The highest and lowest juice pH rates belonged to 'Shandiz' and 'Pishras-e-golmakan' cultivars with an average of 3.56 and 3.30, respectively (Table 2). The juice pH of the 'Zoshk' cultivar was estimated to be 3.42 (Table 2). Serradilla *et al.* (2012) reported pH values of sweet cherry cultivars between 3.26 and 4.36 which were very close to the results of this study.

#### Fruit ripening

The cultivar of 'Zoshk' was completely different in fruit ripening time from those of the introduced cultivars, namely, 'Adli', 'Shandiz', and 'Toos' (Ganji Moghadam *et al.*, 2017; Ganji Moghadam *et al.*, 2019; Ganji moghadam *et al.*, 2020). The fruits of the 'Zoshk' cultivar were harvested about three weeks later than 'Shandiz' and 'Toos' cultivars (Table 3). The ripening

of the ‘Zoshk’ cultivar occurred in the third week of June. In addition, the mid-ripening cultivar of cherries has not so far been introduced in Iran. Hence, ‘Zoshk’ can be the first one introduced as a domestic cultivar.

### Evaluation of leaf traits

The evaluation of leaf length, leaf width, leaf length to leaf width ratio, and petiole length in mid-ripening cultivars are shown in Table 4. The data of these traits showed that the highest and lowest leaf blade lengths were related to ‘Siah-e-Mashhad’ and ‘Zoshk’ cultivars with an average of 16.79 and 12.24 cm, respectively. Moreover, the highest and lowest leaf width were observed in ‘Siah-e-Mashhad’ and ‘Zoshk’ cultivars with an average of 6.84 and 5.52 cm, respectively. Based on these results, the highest leaf length to leaf width ratio belonged to the ‘Siah-e-Mashhad’ cultivar (2.47 cm), which was found to be 2.00 cm for the ‘Zoshk’ cultivar. The comparison results of the petiole length of five cherry cultivars with the ‘Zoshk’ cultivar revealed that the petiole length of cultivars varied between 3.68 and 4.44 cm so that ‘Siah-e-Mashhad’ and ‘Zoshk’ cultivars had the highest (4.44 cm) and lowest (3.68 cm) petiole length, respectively (Fig. 1 and Table 4).

### Yield evaluation

One of the most important traits in evaluating promising cultivars in the introduction of sweet cherries is the yield per unit area. Based on the evaluation results of

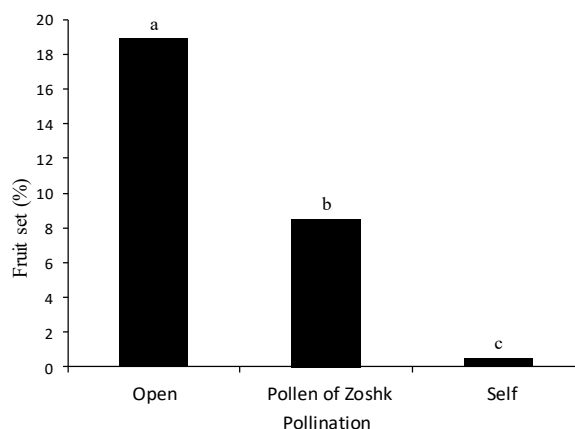
this study, the ‘Zoshk’ cultivar had a higher average yield (33.67 kg per tree) compared ( $P \leq 1$ ) to ‘Siyah-e-Mashhad’ and other cultivars (Fig. 5). Therefore, the high yield is one of the distinguishing features of this cultivar compared to the formerly introduced cultivars.

### CONCLUSIONS

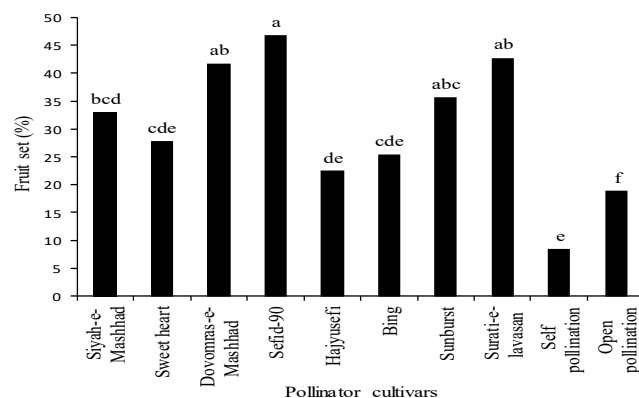
Overall, obtaining new cultivars with different ripening times is one of the important goals of cherry breeding programs. In this regard, after the introduction of the first very early cherry cultivar called ‘Adli’ in 2015, two early cultivars named ‘Shandiz’ and ‘Toos’ were obtained in 2019 and introduced as the second and third Iranian early cultivars. These two cultivars are ready to be harvested one week after the ‘Adli’ cultivar in the third and fourth weeks of May, respectively. Following the introduction of new cultivars, the mid-ripening ‘Zoshk’ cultivar with high size and suitable quality in the third week of June was introduced as the first Iranian mid-ripening new cultivar in 2020. The vegetative characteristics of ‘Zoshk’ cultivar were semi-spreading tree habits, a moderate degree of branching, and standard (regular) internode length. Also, ‘Zoshk’ cultivar had a high yield, average fruit weight, high percentage of soluble solids, and extended ripening time. Therefore, it is recommended to cultivate this cultivar in some sweet cherry orchards in Iran.

**Table 1.** Comparison of beginning and end of flowering and full bloom times of ‘Zoshk’ cultivar with those of other cherry cultivars (Average data of years 2014-2020)

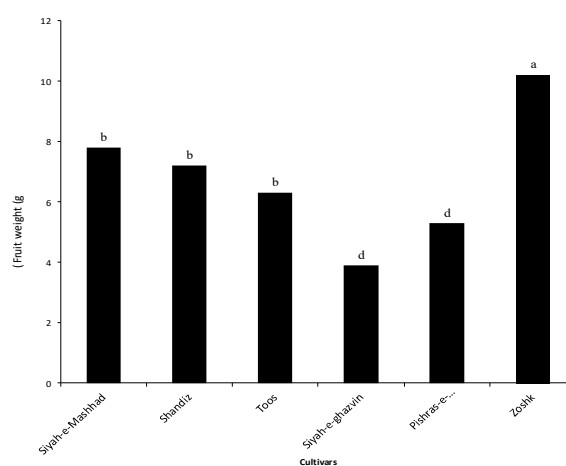
Cultivar	Time of beginning of flowering (date)	Full bloom time (date)	End of flowering (date)
‘Adli’	29 March	6 April	10 April
‘Shandiz’	30 March	6 April	12 April
‘Toos’	27 March	5 April	12 April
‘Siyah-e-Mashhad’	9 April	15 April	22 April
‘Taktane’	10 April	17 April	26 April
‘Zoshk’	5 April	16 April	22 April



**Fig. 2.** Comparison of the effect of controlled pollination on fruit set percentage of ‘Zoshk’ cultivar. The different letters on each column showed a significant difference at 1% probability.



**Fig. 3.** Comparison of the effect of pollens of pollinizer cultivars on fruit set percentage of 'Zoshk' cultivar. The different letters on each column showed a significant difference at 1% probability.



**Fig. 4.** Comparison of fruit weight (g) of 'Zoshk' cultivar with those of other sweet cherry cultivars. The different letters on each column showed a significant difference at 1% probability.

**Table 2.** Comparison of pomological and biochemical traits of 'Zoshk' with those of other sweet cherry cultivars.

Cultivars	peduncle length (cm)	peduncle thickness (mm)	Stone weight (g)	Total soluble solid (%)	pH	Titriable acidity (%)
'Siyah-e-Mashhad'	4.53a <sup>#</sup>	0.88b	0.33a	20.95a	3.36cd	1.43a
'Shandiz'	3.60b	1.02b	0.37a	16.63b	3.56a	0.12b
'Toos'	2.43c	1.26a	0.38a	17.12b	3.43bc	1.06a
'Siyah-e-ghazvin'	2.80c	1.37a	0.23b	15.80b	3.52ab	0.10b
'Pishras-e-golmakan'	3.63b	0.98b	0.20b	21.40a	3.30d	0.44b
'Zoshk'	4.50a	1.34a	0.36a	19.66a	3.42bc	1.05a

<sup>#</sup> Means followed by the same letters in each column are not significantly at 1% probability.

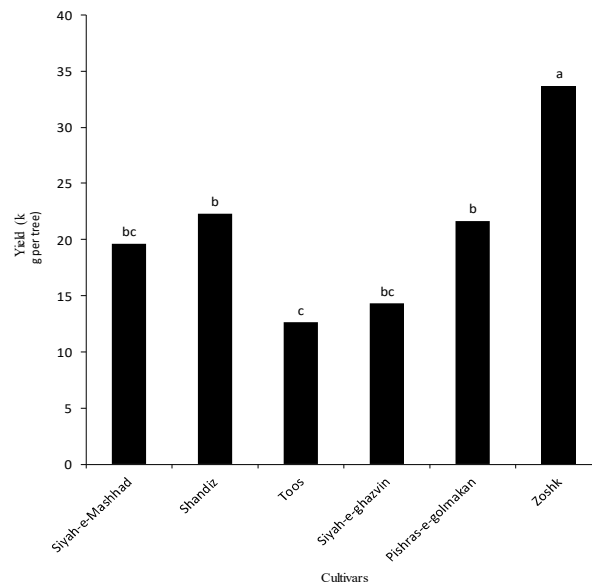
**Table 3.** Comparison of ripening time of 'Zoshk' cultivar with those of other sweet cherry cultivars (mean of years 2014-2020).

Cultivars	Harvest time						
	2014	2015	2016	2017	2018	2019	2020
'Adli'	14 May	8 May	8 May	10 May	10 May	7 May	10 May
'Toos'	16 May	17 May	15 May	18 May	19 May	22 May	17 May
'Shandiz'	14 May	12 May	15 May	12 May	14 May	15 May	18 May
'Siyah-e-ghazvin'	22 May	26 May	19 May	26 May	24 May	18 May	23 May
'Zoshk'	12 June	10 June	13 June	15 June	11 June	10 June	15 June
'Siyah-e-Mashhad'	20 June	18 June	22 June	15 June	20 June	18 June	23 May
'Taktane'	1 July	29 June	3 July	27 June	6 July	29 June	1 July

**Table 4.** Comparison of leaf traits of ‘Zoshk’ cultivar with those of other sweet cherry cultivars.

Cultivars	Leaf length (cm)	Leaf width (cm)	Leaf length/Leaf width (cm)	Petiole length (cm)
‘Siyah-e-Mashhad’	16.79a <sup>#</sup>	6.84a	2.47a	4.44a
‘Shandiz’	14.30b	6.75a	2.38a	4.22a
‘Toos’	14.02b	6.53a	2.18b	4.14ab
‘Siah-e-ghazvin’	13.15c	6.03b	2.05c	3.89bc
‘Pishras-e-golmakan’	12.38d	5.96b	2.03c	3.83c
‘Zoshk’	12.24d	5.52c	2.00c	3.68c

<sup>#</sup> Means followed by the same letters in each column are not significantly at 1%.



**Fig. 5.** Comparison of the yield of the mid-ripening ‘Zoshk’ cultivar with those of other mid-ripening cultivars of sweet cherry. The different letters on each column showed a significant difference at 1% probability.

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## ارزیابی "زشک": رقم گیلای جدید میان رس با اندازه و کیفیت میوه مناسب

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### اطلاعات مقاله

#### تاریخچه مقاله:

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واژه‌های کلیدی:

خودناسازگاری

رقم جدید

زشک

گیلاس

ویژگی‌های میوه

**چکیده** - معرفی ارقام جدید گیلای با زمان رسیدن متفاوت یکی از مهم ترین اهداف برنامه های پرورش گیلای در ایران است. رقم "زشک" از بین ژنوتیپ های گیلای بومی استان خراسان رضوی با اجرای ۸ پروژه تحقیقاتی به مدت ۲۱ سال از سال ۱۳۷۷ انتخاب شد. نتایج این مطالعه نشان داد که رقم "زشک" دارای عادت رشد نیمه گسترده و درجه شاخه زایی متوسط است. زمان اولین گلدهی برای "زشک" در هفته دوم فروردین ماه بود. مطالعه گرده افشانی نشان داد که این رقم خود ناسازگار است. ارقام "سفید - ۹۰"، "صورتی لواسان" و "دوم رس مشهد" ارقام گرده افشان مناسب برای "زشک" بودند. بعلاوه، زمان برداشت این رقم در هفته سوم خرداد بود. میانگین وزن میوه رقم "زشک" (۱۰/۱۷ گرم) بیشتر از میانگین وزن میوه ارقام "شاندیز" (۲۳/۷ گرم)، "توس" (۶/۸۷ گرم) و "سیاه مشهد" (۷/۸۰ گرم) بود. هم چنین، "درصد مواد جامد محلول کل" در رقم "زشک" (۱۹/۶۶ درصد) بیشتر از "درصد مواد جامد محلول کل" رقم "شاندیز" (۱۶/۶۳ درصد) و رقم "توس" (۱۷/۱۳ درصد) بود. عملکرد "زشک" در مرحله باردهی اقتصادی ۳۳/۶۷ کیلوگرم در هر درخت بود که از مقادیر تعیین شده برای هر درخت ارقام "شاندیز" (۲۲/۴۳ کیلوگرم) و "توس" (۱۲/۶۷ کیلوگرم) بیشتر بود. با توجه به عملکرد بالا، میانگین وزن میوه، درصد مواد جامد محلول و زمان رسیدن "زشک"، گسترش کاشت این رقم در برخی از باغات گیلای ایران توصیه می شود.