

Evaluating the Ratio of Vegetative and Reproductive Buds of Pistachio Trees in Rafsanjan Area to Determine the Yield Potential of the Next Year

Najmeh Pakdaman (PhD)^{1*}, Amanollah Javanshah (PhD)¹, Marieh Nadi (PhD)¹

¹ Research Assistant, Pistachio Research Center, Horticulture Sciences Research Institute, Agriculture Research Education and Extension Organization (AREEO), Rafsanjan, Iran.

Information	Abstract
<p>Article Type: Original Article</p>	<p>Background: Pistachio is one of Iran's most important agricultural products, whose export has a special economic and commercial value. Biennial and alternate bearing are among the problems that cause severe fluctuations in this product production and export. Indeed, in the high-yield year of pistachios, the reproductive (flower) buds fall off, leading to alternate bearing and crop decreasing in the next year (off). This year (2021) was a low crop year for pistachios in Rafsanjan; however, reports indicate a reduction in flower bud for next year, contrary to the flowering regulation.</p> <p>Materials and Methods: In the present study, four commercial cultivars of pistachio (Fandoghi, Kaleghoochi, Ahmad Aghaei, and Akbari) in different areas of Rafsanjan were sampled. Then, the percentage of vegetative and reproductive buds was determined by their cutting, staining, and microscopic examination.</p> <p>Results: The results showed that reproductive buds decreased this year and reached about 33% of the total buds, especially for Kaleghoochi and Ahmad Aghaei cultivars.</p> <p>Conclusion: Considering that only about 10% of flower buds in a cluster turn into fruit each year, it is recommended that pistachio orchards be managed properly with careful planning to prevent a reduction in crop production as much as possible next year.</p>
<p>Article History:</p> <p>Received: 13.10.2021 Accepted: 09.12.2021</p>	
<p>Doi: 10.22123/PHJ.2022.319643.1116</p>	
<p>Keywords: Vegetative bud Reproductive bud Alternate bearing Flowering Bud falling</p>	
<p>Corresponding Author: Najmeh Pakdaman</p> <p>Email: pakdaman@pri.ir</p> <p>Tel: +98-9133906806</p>	

► Please cite this article as follows:

Pakdaman N, Javanshah A, Nadi M. Evaluating the Ratio of Vegetative and Reproductive Buds of Pistachio Trees in Rafsanjan Area to Determine the Yield Potential of the Next Year. *Pistachio and Health Journal*. 2021; 4 (4): 71-79.

1. Introduction

Pistachio cultivation (*Pistacia vera* L.) originated in Central Asia and then spread throughout the Middle East and the Mediterranean. The history of pistachio cultivation in Iran dates back to about 3 to 4 thousand years ago [1, 2]. With the start of pistachio exports about 70 years ago, this product gained special economic and commercial value, and Iran was recognized as the first and most important producer of pistachios in the world. According to FAO statistics, the annual production of pistachios in Iran in 2017 was equal to 648934 tons, which decreased to about 337815 tons in 2019 [3, 4].

Alternate bearing of pistachios is one of the most significant problems causing severe fluctuations in crop production in the country. In fruit trees, flower bud formation is limited on the branches despite the abundant yield. However, flower buds are formed in pistachio trees every year, and in the high-yielding year (on), they fall in summer, causing alternate bearing [5-7].

The physiology and mechanisms of alternate bearing are still unknown, and not all attempts to control the falling of flower buds have been successful. Some early studies have identified competition between fruit development and flower buds for carbohydrate uptake as the cause of flower bud loss [7]. Therefore, the more fruit

a branch has, the more flower buds will fall. Studies have shown that flower buds on fruitless branches receive twice as many photosynthetic compounds (carbohydrates) as those on fruity branches [8]. Genetics, carbohydrates, nutrients, hormones, and environmental factors can cause flower buds to fall (Fig. 1) [7]. Pistachio flower buds fall in three stages [9]. The first stage is from flower bud formation to before kernel filling, with a more than 40% fall. The second stage, also known as the main stage of flower bud falling, lasts from the beginning of kernel filling to the approximate harvest time; flower buds fall up to about 50% or more at this stage. The third pistachio flower bud falling stage begins in late winter and lasts until early spring. In recent years, more attention has been paid to this stage, and the results of studies show that the percentage of flower bud falling in the third stage in natural climatic conditions and meeting the cold needs is between 5% to 15%. Flower buds fall at this stage due to genetic factors (type of cultivar and rootstock), the amount of cold supply, climatic and humidity fluctuations, and how to manage the garden. It seems that in the case of severe fluctuations in climate and humidity, as well as problems due to lack of cold requirements in some years, the percentage of the third stage falling will increase sharply [9].

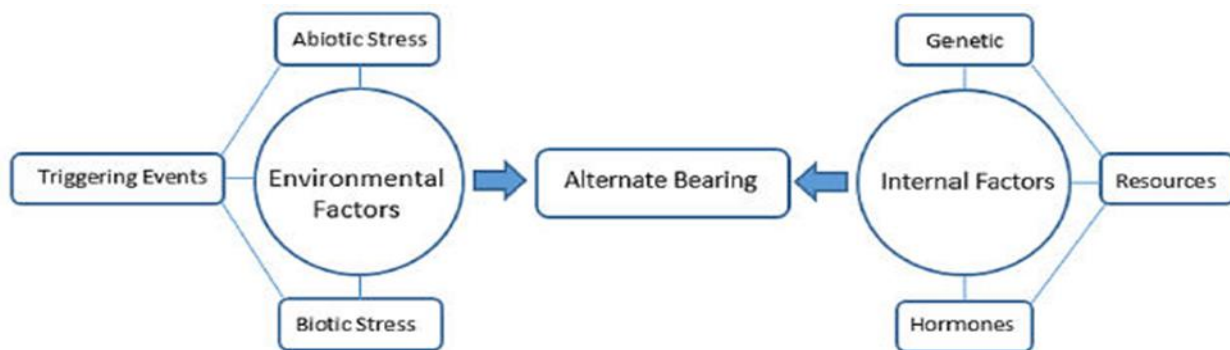


Fig. 1 Hypotheses related to pistachio alternate bearing (*Pistacia vera*) [7]

Morphologically, pistachio vegetative buds are narrow and elongated, and reproductive buds are round and swollen. After pistachio trees reach maturity, most of the lateral buds are reproductive buds, but the terminal and 1-2 buds below are vegetative [10]. While it is relatively easy to distinguish vegetative buds from reproductive, there is a third category of buds that are intermediate and cannot be easily distinguished as vegetative or reproductive.

In recent years, oral reports of farmers and agricultural experts have indicated a decrease in flower bud formation. In this regard, an attempt was made to sample the orchards in different areas of Rafsanjan region in a field study so that by the laboratory and microscopic examination of the buds, farmers could be guided for the next year's crop management.

2. Materials and Methods

This research was carried out in Rafsanjan area, located in the northwest of Kerman province with the coordinates of "24 '30 ° 30 north," 38 '59 ° 56 east, and an altitude of 1527 meters above sea level. Annual branches of four commercial cultivars of pistachio (Fandoghi, Kaleghoochi, Ahmad Aghaei, and Akbari) were sampled in cooperation with Agricultural Jahad of Rafsanjan from 24 gardens in different parts of the city (Ismail Abad, Kashkuyeh, Ferdows, Bahrman, Kabutarkhan, and the western suburbs of Rafsanjan) in November 2021. It is notable that 5 samples were prepared from each cultivar in each garden.

In the next step, thin cuts from longitudinal area of the buds were prepared by using a scalpel blade, so that the bud tissues were directly exposed to dye [11]. The cuts were then stained

by a simple one-step method using Fuchsin reagent for one minute and then washed with distilled water.

Samples were carefully evaluated by binocular microscope (Olympus Corporation, Japan, Model SZX2-ILLD), and the percentage of vegetative and reproductive species of commercial pistachio cultivars in different regions was calculated using the following formula:

$$\text{Bud (reproductive or vegetative) percentage} = \frac{\text{bud (reproductive or vegetative) numbers}}{[\text{reproductive buds} + \text{vegetative buds}] \times 100}$$

It should be noted that the buds at the end of the branch (vegetative buds) were not included in the calculations.

3. Results

According to the reports indicating a decrease in the number of pistachio flower buds this year, in this study, vegetative and reproductive buds in pistachio orchards in different parts of Rafsanjan city were studied in more detail.

Figs. 2 and 3 show some microscopic images of vegetative and reproductive buds. As can be seen, the scale-like (leaf-like) structure in the vegetative buds (Fig. 2), as well as the main and secondary axes and other components of the flower cluster in the reproductive buds (Fig. 3), can be well distinguished.

The percentage of vegetative and reproductive buds related to four commercial pistachio cultivars (Fandoghi, Kaleghoochi, Ahmad Aghaei, and Akbari) sampled from 24 orchards in different areas of Rafsanjan is presented in Table 1. As can be observed, in

most cases, the proportion of reproductive (flower) buds was lower than that of vegetative buds. In some areas (such as Toghari water well in the Ferdows area), 100% of the sampled buds were vegetative. However, in some areas, such as Ali Bajgani water well in Ferdows, the percentage of reproductive buds reached 81%.

As shown in Fig. 4, the percentage of vegetative buds was higher than reproductive buds in all cultivars (about 22% to 46%). The reduction of reproductive buds in Kaleghoochi and Ahmad Aghaei cultivars was more than Fandoghi and Akbari cultivars (Fig. 4).

Further examination of reproductive buds showed signs of burns in their tissue (Fig. 5).

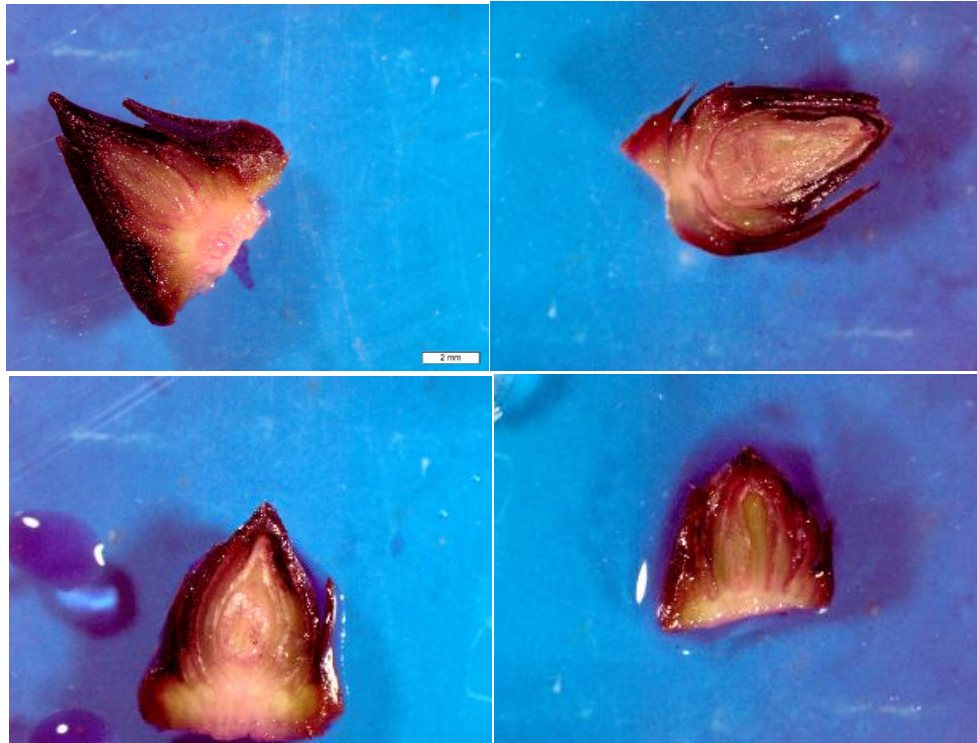


Fig. 2 Microscopic images of vegetative buds of pistachio.

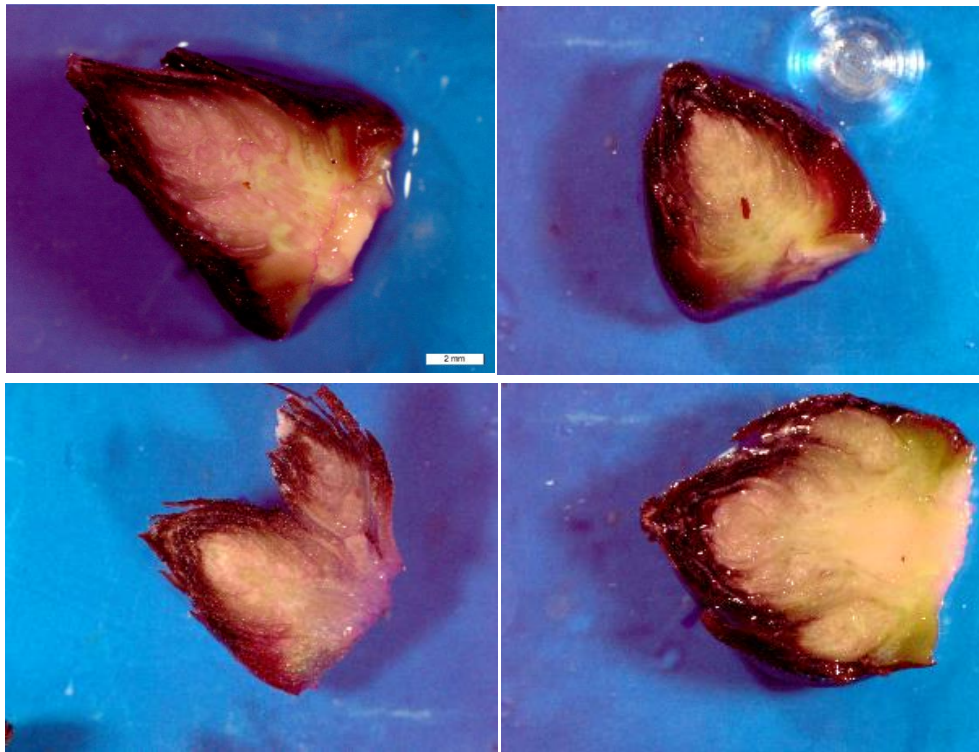


Fig. 3 Microscopic images of reproductive (flower) buds of pistachio.

Table 1. Percentage of vegetative and reproductive buds in samples of four commercial cultivars of pistachio (Fandoghi, Kaleghoochi, Ahmad Aghaei, and Akbari) in different areas of Rafsanjan area.

No. sample	Cultivar	Cultivation area	Percentage of vegetative buds	Percentage of reproductive buds
1	Fandoghi	Ismail Abad	50	50
2	Kaleghoochi	Ismail Abad	94	6
3	Ahmad Aghaei	Ismail Abad	68	32
4	Akbari	Ismail Abad	75	25
5	Fandoghi	Kashkuyeh	73	27
6	Kaleghoochi	Kashkuyeh	55	45
7	Ahmad Aghaei	Kashkuyeh	54	46
8	Akbari	Kashkuyeh	42	58
9	Fandoghi	Water well in Islam Abad of Javadieh Mortazavi- Ferdows area	56	44
10	Kaleghoochi	Toghari water well in Ferdows area	100	0
11	Ahmad Aghaei	Toghari water well in Ferdows area	100	0
12	Akbari	Water well of Ali Bajegani- Ferdows area	19	81

13	Fandoghi	Bahreman- Rafsanjan	79	21
14	Kaleghoochi	Bahreman- Rafsanjan	82	18
15	Ahmad Aghaei	Bahreman- Rafsanjan	78	22
16	Akbari	Bahreman- Rafsanjan	79	21
17	Fandoghi	Water well of Kabutarkhan Endowment	72	18
18	Kaleghoochi	Water well of Haj Mohammad Reza in Kabutarkhan	88	12
19	Ahmad Aghaei	Water well of Kabutarkhan Endowment	75	25
20	Akbari	Water well of Kabutarkhan Endowment	63	37
21	Fandoghi	Arya water well – western suburbs of Rafsanjan	35	65
22	Kaleghoochi	Arya water well – western suburbs of Rafsanjan	32	68
23	Ahmad Aghaei	Arya water well – western suburbs of Rafsanjan	87	13
24	Akbari	Arya water well – western suburbs of Rafsanjan	40	60

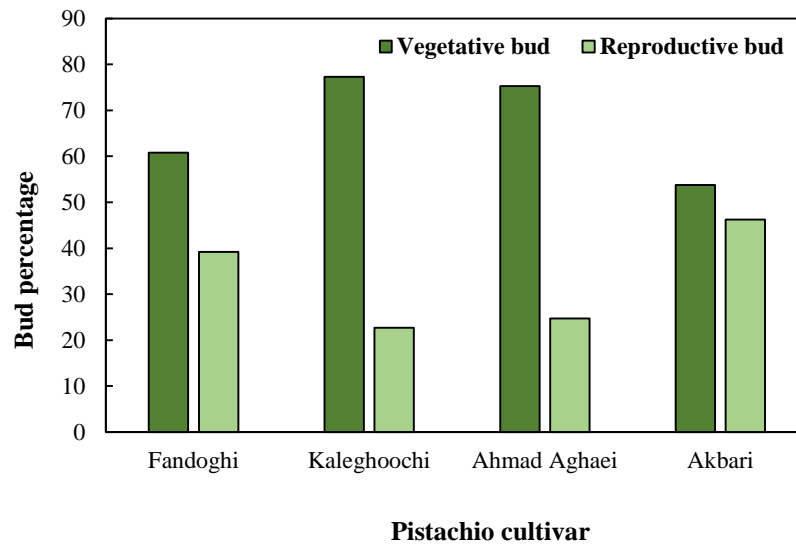


Fig. 4 Percentage of vegetative and reproductive (flower) buds in different commercial cultivars of pistachio (Fandoghi, Kaleghoochi, Ahmad Aghaei, and Akbari) in Rafsanjan city.

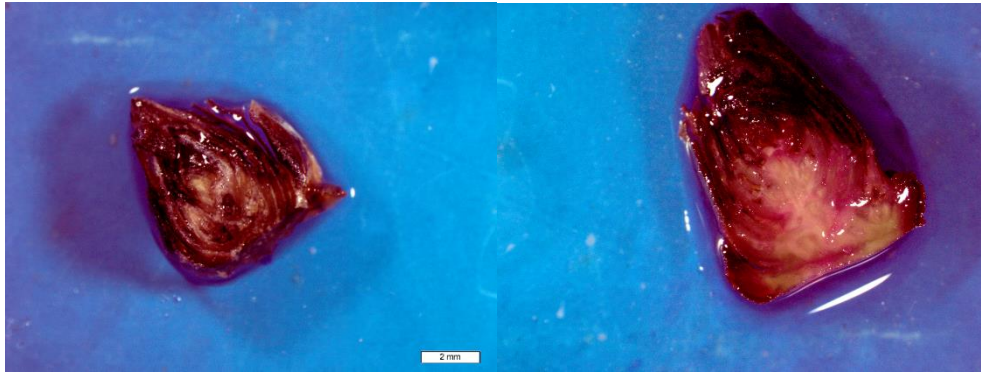


Fig. 5 Microscopic images of damaged reproductive (flower)buds.

4. Discussion

Alternate bearing is common in fruit trees. However, based on the available knowledge, its mechanism is unique in pistachio. The formation and falling of flower buds in the high-yield year is a clear reason for the alternate bearing phenomenon in pistachio [7].

Research shows that 80% of lateral buds in mature pistachio trees are flower buds with the ability to become fruit clusters [10, 12]. This year, however, the number of flower buds has decreased to 33% of the total buds. It should be noted that this year is a low-yield year (off), and according to the flowering rule, pistachio trees should have the most flower buds.

This study also showed that some buds, especially reproductive ones, were burned and damaged possibly due to repeated use of pesticides and sulfur [13, 14].

In pistachios, the flowering or conversion of vegetative buds to reproductive buds begins in May. There are several steps involved in a vegetative bud to become a flower bud, requiring a balance between carbohydrates, nutrients, and growth regulators. Severe climatic fluctuations disturb this equilibrium pattern and affect flowering [7, 15, 16]. On the other hand, flower buds may fall off after formation, which may

occur in three stages, including 1- from flower bud formation to kernel filling stage, 2- from the beginning of kernel filling to approximately harvesting time, and 3- from late winter to early spring [9].

Studies show that various environmental (biotic and abiotic) stresses such as nutritional stresses, irrigation tensions (reduction of quantity and quality of irrigation water), pests, and diseases cause physiological imbalance, disturbance of photosynthesis and producing carbohydrates, as well as hormonal imbalance in flower buds and an increase in their falling [5-7, 17].

Since in the present study, data was collected in November, the decrease in the percentage of flower buds is related to the disorder in flower formation or bud loss in the first and second stages.

While this complication is widespread, it seems that horticultural management factors such as nutrition, pest, and disease control do not play a role in this reduction since this study included orchards with different management methods. On the other hand, climate change can be considered as the main cause of this decrease because this study shows that the reduction of flowering is not a function of regional and managerial boundaries. A decrease in the

quantity and quality of irrigation water may be another factor contributing to the loss of flower buds this year.

5. Conclusion

Each flower cluster in pistachio has one hundred to several hundred flowers, eventually about 10% of which turn into fruits [18]. While the percentage of flower buds this year, a low-yield year (off), has reached about 33% of the total buds, pistachio orchards must be managed properly with careful planning to prevent the

decreasing of crop production as much as possible in the next year.

Acknowledgments

We would like to thank Pistachio Research Center (PRC) and Agricultural Jihad of Rafsanjan for supporting us and providing pistachio samples in this research, respectively.

Conflict of Interest

The authors declare no conflict of interest.

Funding: This study is financially supported by Pistachio Research Center.

References

- 1- Abrishami MH, Esmailpour A, Emami SY, Basirat M, Tajabadipour A, Hoseinifard SJ, Haghdel M, Hokmabadi H, Shakerardekani A, Sedaghat R, Sedaghati N, Alavi SH, Mohamadi AH, Hashemirad H. Iran's pistachio: Jameeye-No Publication; **2020**. (In Persian).
- 2- Hokmabadi H. Pistachio wastes in Iran and the potential to recapture them in value chain. *Pistachio and Health Journal*. **2018**; 1(4): 1-12.
- 3- FAO, Food and Agriculture Data. 2017. <https://www.fao.org/faostat/en/#data/QCL>
- 4- FAO, Food and Agriculture Data. **2019**. <https://www.fao.org/faostat/en/#data/QCL>
- 5- Talaei AR, Esmaili Zadeh M, Lesani H, Javanshah A, Hokm Abadi, H. Effect of shott gridling, fruit thinning, urea, zinc sulfate and sucrose application on inflorescence bud retention in pistachio cv. Ohadi. *Iranian Journal of Horticultural Science*. **2010**; 41(3): 265-274. (In Persian).
- 6- Alizadeh M, Rahemi M. Influence of foliar application of urea combined with 6-benzyladenine to decrease flower bud abscission in pistachio nut. *Iranian Journal of Agricultural Science*. **2003**; 34(3): 665-659. (In Persian).
- 7- Khezri M, Heerema R, Brar G, Ferguson L. Alternate bearing in pistachio (*Pistacia vera* L.): A review. *Trees*. **2020**; 34(4): 855-868.
- 8- Rahemi M, Ramezani A. Potential of ethephon, NAA, NAD and urea for thinning pistachio fruitlets. *Scientia horticultrae*. **2007**; 111(2): 160-163.
- 9- Khezri M. Controlling the abscission of pistachio inflorescence buds. *Iran Pistachio Association*. **2017**; 2(16): 9-12. (In Persian).
- 10- Esmailpour A. Pruning of adult pistachio trees: *Pistachio Research Center*; **2020**. (In Persian).

- 11- Nojavan S, Naseri L, Hassanpour H. The effect of foliar nutrition with potassium sulfate and zinc sulfate on winter cold hardiness of grapevine buds cv. Bidaneh Ghermez (*Vitis vinifera* L.). **2021**; 4(30): 143-159.
- 12- Ferguson L, Haviland DR. Pistachio production manual:University of California; **2016**. 334 p.
- 13- Heidari N, Rezaei H, Amiri MA, Basirat M, Gholamalizadeh M, Mohamadkhani A, Akbari Moghadam A, Rezaei A, Nejati M, Pourhosseini R. Comparing the effect of different sulfur compounds on the common pistachio psylla. Iran Pistachio Association. **2019**; 4(38): 16-18. (In Persian).
- 14- Afrousheh M, Hasheminasab H. Sulfur application as pesticide in pistachio orchard: health and safety. Pistachio and Health Journal. **2018**; 1(3): 52-63.
- 15- Javanshah A, Nazoori F. Global warming, dormancy and chilling requirement on temperate trees: Pistachio Research Institute; **2008**. 198 p. (In Persian).
- 16- Tadayon MS, Hosseini SM. Increasing the efficiency of supplemental foliar nutrition on improving reproductive disorders of pistachio by application of plant growth regulators. Journal of Plant Growth Regulation. **2021**; 1-15.
- 17- Esmaeilpour A, Tajabadipour A, Hasheminasab H, Hassani D. Investigating the causes of leaves and buds drop and reduction of pistachio production in Kerman province. 2nd National Conference on Iran Pistachio; Rafsanjan **2018**. (In Persian).
- 18- Crane JC. Morphology and reproduction of pistachio. Horticultural Reviews. **2011**; 3: 376-393.