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Abscission of Pistachio Flowers and Fruits as Affected by Different Pollinators

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Abstract: This study was conducted in Ceylanpinar State Farm to determine influence of pollens of 9 different pollinators on the flower and fruit abscission of the pistachio. Comparison of pollinator effect on the abscission of flowers and fruits of 3 pistachio cultivars showed that pollens of *Pistacia vera* L. may increase or reduce flower and fruit abscission. Flower and fruit abscission occurred primarily during the flowering and small-fruit period, that the June and pre-harvest abscissions were low. Data collected for 3 consecutive years revealed that 83.4 to 88.2% of the flowers and fruits of Kirmizi pistachio cultivar abscised mainly during an initial 50 days after Full Blooming (FB). Siirt cultivar abscised during an initial 35 days after FB with a rate of 82.1 to 90.9%. Abscission rate of Ohadi cultivar were 84.5 to 88.6% that occurred during an initial 50 days after FB period. Males noted as 12 and 13 resulted the highest abscission in Siirt cultivar. Results demonstrated that pollinators affect flower and fruit abscission in pistachio.

Key words: Pistachio, flower, fruit abscission, male trees, pollination

INTRODUCTION

Pistachio trees had first been cultured in South Anatolia during Hittites time (Özbek, 1978). *Pistacia vera* is native to north Afghanistan, northeast Iran and central Asian republics (Kafkas, 2006). Iran, United States, Turkey and Syria are the main pistachio producers in the world, contributing over 90% of the world production (FAO, 2005). Pistachio production areas are 218500 ha and average production is 50000 metric tons (Acar, 2004) and that the average pistachio yield reaches to 229 kg per hectare in Turkey. The major cultivars in the world are Ohadi and Kalehghouchi in Iran; Kerman and Peters in the U.S. and Kirmizi, Uzun, Halebi, Siirt and Ohadi in Turkey (Kaska, 1995; Kafkas *et al*., 2006).

The genus *Pistacia* is a member of the *Anacardiaceae* family and consists of at least eleven species (Zohary, 1952) including *Pistacia vera* L., the cultured pistachio, has edible nuts and considerable commercial importance.

Pistachio is a dioecious fruit species, that the pistillate and staminate flowers are formed on different trees. Both the staminate and pistillate inflorescences form panicles with up to several hundred individual flowers (Crane and Iwakiri, 1981). Pistachio is a diploid (2n = 30, x = 15) and wind-pollinated tree (Ila *et al*., 2003). Both types of flowers are apetalous. The rachis, or central axis of the inflorescence, branches repeatedly with each branch bearing numerous flowers. Abscission may occur at the following points on the inflorescence; at the base of the pedicels supporting the individual flowers or young fruits; at the points of attachment of the lateral branches to the central axis of the rachis; at the point on the lateral branch and the central axis distal to which there is no developing fruit and at the point where the inflorescence is attached to the 1-year-old wood (Lin *et al*., 1984).

Commercial pistachio orchards usually contain one male tree for each 8 to 11 females. While information is becoming available on the performance of female pistachio cultivars, little is known about the behaviour of male clones as pollinators. However, pollination is important for this species; the marketable is the seed and to obtain a good fruit set, suitable male trees have to be interplant in the orchards as to wind and rain conditions.

Pollinator is a main effective factor in the pistachio productivity. The objective of this study is to determine influence of pollens of 9 different pollinators on the flower and fruit abscission of the pistachio.

MATERIALS AND METHODS

Plant material and sampling: This study was carried out at Ceylanpinar State Farm in Sanliurfa province of Turkey from 1998 to 2000 years. Climatic data of research area has been given in Table 1. Twenty-four male types had been selected and characterized phenotypically, phenologically and morphologically by Acar (1997) at pistachio plantations of Ceylanpinar State Farm. Nine different male

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Table 1: Climatic data of research area during three years (1998-2000) in Ceylanpinar State Farm in Sanliurfa

	Temperatures (°C)				
Months	Minimum	Average	Maximum	Relative humidity (%)	Annual precipitation (mm)
January	-5.1	5.7	17.3	68.8	45.2
February	-5.0	6.7	19.7	57.8	26.4
March	-2.3	10.3	25.7	56.7	35.8
April	3.3	17.2	33.1	55.7	35.6
May	9.6	23.8	33.4	40.7	6.0
June	14.9	30.0	43.4	33.0	0.5
July	17.3	33.7	46.6	33.7	0.0
August	17.8	31.7	45.9	34.0	0.0
September	11.0	25.9	38.8	37.3	0.0
October	4.1	19.3	35.7	41.5	7.3
November	-0.8	13.1	27.1	44.9	8.5
December	-2.9	8.3	19.7	65.6	43.3

types synchronized to Kirmizi, Siirt and Ohadi female pistachio cultivars were used as pollinator. The male types were Males 1, 16 and 23 for Kirmizi; Males 7, 12, 13 and 25 for Siirt; and Males 18 and 22 for Ohadi cultivar.

Four combinations were constituted in Kirmizi cultivar as Kirmizi × 1, Kirmizi × 16, Kirmizi × 23 and open pollination; 5 combinations in Siirt cultivar as Siirt × 7, Siirt × 12, Siirt × 13, Siirt × 25 and open pollination and 3 combinations in Ohadi cultivar as Ohadi × 18, Ohadi × 22 and open pollination. Open pollination was used as control for each cultivar. Thus, 12 combinations were used in the study and 3 female trees for each combination during 3 years. Twelve inflorescences were selected and tagged on each of the 36 trees for each year. Inflorescences were bagged prior to anthesis to exclude pollens.

Pollens from selected males were collected and used in artificial pollination for fertilization and fruit set, in order to compare male performance on flower and fruit abscission in pistachio. Inflorescences that had some flowers with dehiscent anthers were removed from trees, brought into the laboratory and spread over brilliant paper. Pollens shed overnight was sieved and collected in laboratory conditions. Flowers were hand pollinated with fresh pollen of each male tree at full blooming and pollinated flowers were re-bagged.

Flower and fruit abscission: Individual flowers on pistillate inflorescences were counted 1 week after pollination. Pollinator traits were determined by counting flowers with 3 days interval starting from first blooming and continued for 15 days period to monitor flower abscission. Fruits on inflorescences were counted 15 days intervals until harvest time (8 times) to monitor small-fruit and/or fruit abscission during spring and summer of 1998, 1999 and 2000.

Statistical analysis: The data were tested for statistical significance using the ANOVA (analysis of variance) test from the statistical package MSTAT (Michigan State University, Lansing) and differences between means were separated with the Fischer's Least Significant Difference (LSD) calculated with $p \leq 0.05$.

RESULTS

Flower and fruit abscission: Effect of different male types on flower and fruit abscission of Kirmizi, Siirt and Ohadi pistachio cultivars were determined. Flowers on inflorescences were counted 1 week after hand pollination. Following this, flowers, small-fruits, fruits were counted at various intervals until harvest and fruit abscission was determined.

Flower and fruit abscission in Kirmizi cultivar: Mean flower numbers within each cluster in Kirmizi cultivar during full blooming was 110-132. Flower abscission began 10 days After Full Blooming (AFB) and the highest abscission occurred 16 days AFB in Kirmizi. Afterwards fruit abscission went on to decrease for up to 65 days AFB (10 June). Kernel development started by mid June in Ceylanpinar conditions and fruit abscission decreased gradually from 65 to 140 days AFB. Flower and fruit abscission of Kirmizi cultivar occurred primarily during the flowering and small-fruit period and these abscissions continued for about 40 days. Because of high flower and small-fruit abscissions, June and pre-harvest abscissions were low (Table 2).

When Kirmizi cultivar pollinated with males 1, 16, 23 and with open pollination; 85.1, 88.2, 83.4 and 85.7% of the flowers and fruits had dropped during an initial 50 days after Full Blooming (FB). The abscission rates decreased gradually. Similarly, overall abscission rates for 3 consecutive years were 87.1, 89.9, 84.9 and 87.4% for males 1, 16, 23 and with open pollination, respectively (Table 2).

Flower and fruit abscission in Siirt cultivar: Mean flower numbers within each cluster in Siirt cultivar during full

Table 2: Flower and fruit abscissions in Kirmizi cultivar pollinated by different males during the phenological periods of three years (in %)

	Sampling dates[z]													
Pollinators	7	10	13	16	19	35	50	65	80	95	110	125	140	Overall abscission (%)
Male 1	0.0	9.1a*	8.8b	23.0b	16.5a	16.0b	11.8b	1.1a	0.4a	0.2	0.1	0.1	0.2	87.1b
Male 16	0.0	8.5ab	12.8a	25.2a	15.0b	13.8c	12.9a	0.5bc	0.2b	0.2	0.0	0.1	0.6	89.9a
Male 23	0.0	7.9b	11.6a	22.0b	16.5a	14.8bc	10.6c	0.4c	0.5a	0.2	0.1	0.1	0.4	84.9c
Open pollination	0.0	8.1b	11.8a	22.6b	14.5b	19.9a	8.8d	0.6b	0.3ab	0.4	0.1	0.0	0.1	87.4b
LSD ($p \leq 0.05$)	ns	0.76	1.51	1.40	1.34	1.28	0.75	0.18	0.18	ns	ns	ns	ns	1.78

[z]Where sampling date did not coincide in 1998, 1999 and 2000, the days after full blooming are given. *The lower capitals next to numbers indicate different groups determined by LSD test ($p \leq 0.05$), ns: Not significant

Table 3: Flower and fruit abscissions in Siirt cultivar pollinated by different pollinators during the phenological periods of three years (in %)

	Sampling dates[z]													
Pollinators	7	10	13	16	19	35	50	65	80	95	110	125	140	Overall abscission (%)
Male 7	0.0	14.6b*	13.3d	18.7bc	19.5a	15.9d	6.6a	1.3a	0.5	0.3a	0.5a	0.2	0.1b	91.7c
Male 12	0.0	15.0b	21.0a	20.1ab	14.7c	18.1c	4.1b	0.9b	0.7	0.2ab	0.1b	0.0	0.4a	95.3a
Male 13	0.0	18.4a	19.7ab	17.4c	15.8b	19.6bc	2.3c	0.7b	0.6	0.3a	0.1b	0.1	0.1b	95.2a
Male 25	0.0	14.5b	18.2b	20.3a	13.7d	22.2a	2.7c	1.6a	0.7	0.1b	0.2b	0.2	0.1b	94.4ab
Open pollination	0.0	14.3b	16.1c	17.2c	15.0bc	21.5ab	6.1a	1.6a	0.4	0.1b	0.1b	0.3	0.1b	92.8bc
LSD ($p \leq 0.05$)	ns	1.71	1.88	1.44	0.98	1.97	0.86	0.39	ns	0.15	0.18	ns	0.22	2.28

[z]Where sampling date did not coincide in 1998, 1999 and 2000, the days after full blooming are given. *The lower capitals next to numbers indicate different groups determined by LSD test ($p \leq 0.05$), ns: Not significant

Table 4: Flower and fruit abscissions in Ohadi cultivar pollinated by different males during the phenological periods of over three years (in %)

	Sampling dates[z]													
Pollinators	7	10	13	16	19	35	50	65	80	95	110	125	140	Overall abscission (%)
Male 18	0.0	27.4b*	12.8	9.9b	10.0b	16.8b	7.7a	1.5	1.6	1.5	0.3	0.5	0.4	90.2
Male 22	0.0	30.5a	13.6	8.5c	8.0c	19.4a	5.3b	1.1	2.7	2.1	0.0	0.2	0.1	91.5
Open pollination	0.0	28.2b	12.2	12.2a	11.6a	19.7a	4.6b	0.7	0.9	0.9	0.1	0.1	0.4	91.7
LSD ($p \leq 0.05$)	ns	1.03	ns	1.15	0.92	1.71	1.52	ns	ns	ns	ns	ns	ns	ns

[z]Where sampling date did not coincide in 1998, 1999 and 2000, the days after full blooming are given.*The lower capitals next to numbers indicate different groups determined by LSD test ($p \leq 0.05$), ns: Not significant

blooming was 125-174. Flowers began to abscission 10 days after full blooming and its severity changed with respect to combinations used. The highest abscission occurred 35 days AFB in Siirt crossed with male 25 and open pollination and 13 days AFB in Siirt crossed with males 12 and 13. Siirt x male 7 combination exhibited the highest abscission 19 days AFB. Flower and fruit abscission occurred primarily during the flowering and small-fruit period in Siirt cultivar and continued for about 25 days. By the mid-May (35 days AFB), flower and small-fruit abscissions decreased (Table 3) and abscission of fruits also gradually decreased until harvest.

In Siirt cultivar, 82.1, 88.9, 90.9, 88.9 and 84.1% of the flowers and fruits had dropped during an initial 35 days after FB as compared to overall abscissions as 91.7, 95.3, 95.2, 94.4 and 92.8% when pollinated with males 7, 12, 13, 25 and open pollination, respectively. The highest abscission obtained from female trees pollinated with males 12 and 13, the lowest abscission occurred with male 7 and followed by open pollination (Table 3).

Flower and fruit abscission in Ohadi cultivar: Mean flower numbers within each cluster in Ohadi cultivar during full blooming was 59-94. Flowers first abscised on 10 days AFB as the highest abscission when compared to other cultivars. Afterwards, flower and small-fruit abscission decreased until 19 days AFB and increased again 35 days AFB. Flower and fruit abscission occurred primarily during the flowering and small-fruit period in Ohadi cultivar and continued about 25 days. Abscission went on to 65 days AFB with high degree and decreased gradually (Table 4).

Flower and fruit abscission in Ohadi during an initial 50 days were 84.5, 85.3 and 88.6% and overall abscission rates were 90.2, 91.5 and 91.7% when pollinated with males 18, 22 and open pollination, respectively (Table 4).

DISCUSSION

Flower and fruit abscissions in pistachio directly effect yield as other horticultural crop species. In this study mean flower numbers within each cluster were 110-132, 125-174 and 59-94 in Kirmizi, Siirt and Ohadi cultivars, respectively. Ayfer *et al.* (1990) reported 80-130 flowers in each cluster and reported 83.5% of abscission. Atli *et al.* (1995) selected 4 suitable pollinators for Uzun, Halebi, Kirmizi, Siirt and Ohadi pistachio cultivars among 20 different male types in Gaziantep in Turkey.

Characterization of the male types such as features for growth, flower synchronization, inflorescence, pollen production, pollen viability and germination rates were observed in the study.

Fruit set in pistachio is determined by flower and small fruit abscission seen as cluster shedding and sparsing. Cluster shedding mainly occurs at lower branches and results of accumulation of food resources and hormones at the branch tips (Ayfer *et al*., 1990). Cluster sparsing is related to pollination and fertilization and was the main subject of this study.

Flower and fruit abscission of pistachio trees are affected by two climatic factors that are low/high temperature and rain. High temperatures may affect the abscission throughout the flowering and small-fruit period. During the flowering period and later on, transpiration is rather strong in fruit trees. Pistachio trees have been grown at poor and waste areas in Turkey and they cannot set their water balances in such soils which have low water capacity. Therefore, leaves which have higher osmotic power than flower and small-fruit can absorb water from flowers and small-fruits when leaves exposed to water stress. Thus, flowers and small-fruits have abscised (Ayfer, 1959). In this study, we determined the flower and fruit abscissions caused by male trees; we also reported the abscission percentages during generative growth.

Ayfer *et al.* (1990) reported overall abscission of 83.5% in pistachio occurred during three periods. The first period was characterised with very early flower abscission occurred at tips of the clusters and resulted 6% drop. The second period started right after full blooming and continued for a month and resulted 71.2% abscission of flowers and small fruits. The third period was June abscissions with 6.3% fruit drop. The overall abscission rate was reported to be 83.5% (Ayfer *et al*., 1990). In present study overall abscission rates for Kirmizi was 84.9-89.9% and in Siirt and Ohadi, overall abscission rates for flower and fruits were over 90%.

Main flower and fruit abscissions had occurred during an initial 35 days after FB in Siirt and 50 days after FB in Kirmizi and Ohadi pistachio cultivars. Flowers and fruits of both artificial pollinated and open pollinated trees were highly abscised at all combinations, but Siirt cultivar's abscission was higher than those of Ohadi and Kirmizi. There are some reasons for flower and fruit abscission. The majority of pollinated pistils of pistachio did not reach maturity and were either shed or resulted in seedless or small-seeded fruits because of embryo sac degeneration (Shuraki and Sedgley, 1996). Boron (B) nutrition affects fruit set and yield in pistachio. B applications included enhanced pollen germination, reduced flower drop and decreased blanking percentage (Brown *et al*., 1994). Few pollen grains on the stigma, which may be related to less competition between pollen tubes in the pollen tube pathway, have provided higher fertilization and lower fruit abscission (Shuraki and Sedgley, 1997).

In pistachio, final fruit set changed between 9.40-16.50% of flowers (Ayfer *et al*., 1990; Kuru and Ayfer, 1990; Acar *et al*., 2001) and it was not only depend upon pollination and fertilization but also appears to be dependent upon nutrition, irrigation, pruning, etc. (Goldhamer *et al*., 1988; Arpaci *et al*., 1995; Tekin *et al*., 1995). High abscission resulted in this study could depend on poor soil, insufficient care, high temperatures and rainfed conditions at Ceylanpinar during the experiments (Table 1).

Ayfer *et al.* (1990) reported 33.3% of flowers that died of before reaching up to receptive maturation. Such flowers did not have mother cells and located within clusters of full blooming stage. In addition during full blooming of pistachio, 26.7 and 23.3% of flowers were at sporogenesis and gametogenesis stages, respectively. The yield was determined by developmental stage of the female flowers and this is affected by rainfed conditions during spring and autumn, soil processing, fertilization and pruning.

In this study, pollinators and their types are found to be effective in fruit set; therefore this also could be a factor in flower and fruit abscission in pistachio.

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