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Full Length Research Paper

Investigations on fertilization biology and description of fruit characteristics of some persimmon (*Diospyros kaki*) cultigens

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Persimmon is a fruit that has increasing importance on export and prefer to be consumed because its taste, nutrient content and appearance. It can be grown at different ecological conditions without discerning climate and soil. In this sense, it is important to encourage persimmon cultivation. Pollinators need to be used for a good fruit set on cultural varieties. In this study that prepared from this point of view, fertilization biology, phenological and pomological observations were performed on Hachiya and Fuji cultivars that pollinated with different male types in Ödemi / zmir-Turkey. Additionally, viability (TTC and IKI) and germination tests were carried out. Consequently, it was observed that fruit set increased when pollinators were used.

Key words: Persimmon, pollination, fruit characteristics, phenology, pomology.

INTRODUCTION

Persimmon fruit that originated to China is spread Korea and Japan. Entrance date of persimmon to Turkey is unknown, but it has cultivated for a long time in our country. Persimmon is not selective and can adaptate to different ecological conditions, though it growns in tropical and subtropical climates, in general. In Turkey persimmon is growing in 42 different provinces, and this situation puts forward the presence of an important potential (Kaplankiran et al., 1997; Özça iran et al., 2004; eker and Toplu, 2003).

Persimmon trees have hermaphrodite, male and female flowers, however, forming of hermaphrodite flowers is in low ratio. Pollinator types must be used for fruit set in growing of some cultivars (eker, 2002). Astringency and fruit flesh color is variant in some cultivars, and constant in the others according to pollination and fertilization (Giordani, 2002; Holdeman, 2000; Özcan, 2005; Sugiura, 2005). Most of the cultivars grown commercially in Turkey are astringent. It is important to identify fertilization biology and fruit quality characteristics as regards to economically growing (Yildiz et al., 2004).

Persimmon shows different types of flower biology and most of the common cultivars are dioecie. Some of the cultivars are monoecie and they are used as pollinators. Besides, there are trimonoecie and androdioecie cultivars, too (Holdeman, 2000).

Fruit occurs by parthenocarpy or fertilization in persimmon cultivars (Özcan, 2005). Some cultivars are productive without pollination and fertilization in some regions and conditions. Persimmon cultivars generally tend to produce parthenocarpic fruits. The highest parthenocarpic fruit formation is seen in Hachiya and followed by Tanenashi and Triumph cultivars. On the contrary, parthenocarpic fruit formation of some cultivars is very low. They need pollination for proper yield. Hiratanenashi is an example of these cultivars (Holdeman, 2000).

Pollinator cultivars must be used for the fruit flesh color and astringency variant cultivars. This situation has influence on fruit set and quality. Gailey, Ghora Gali, Gosho and Zenji Maru cultivars are recommended as pollinator cultivars (Kaplankiran et al., 2004). All the yield can fall if flowers do not pollinate efficiently in cultivars like Isu. Hot and dry weather conditions in flowering period lead to inadequate pollination and low fruit set. It was pointed out that, especially under these conditions,

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Table 1. Phenological observations in persimmon cultivars and pollinator types.

	Cultivar/type	Beginning of flowering	Full flowering	End of flowering	Foliation	Harvest date
2006	Hachiya	April 25	May 1-3	May 6	March 15-30	November 25-29
	Fuji	May 3	May 5-10	May 20	March 15-30	November 25-29
	P1	May 2-5	May 10	May 20	March 15-30	November 25-29
	P2	May 2-5	May 10	May 20	March 15-30	November 25-29
2007	Hachiya	April 27	May 3-5	May 8	March 15-30	November 5-10
	Fuji	May 4	May 10-11	May 15	March 15-30	November 5-10
	P1	May 5-7	May 13	May 23	March 15-30	November 5-10
	P2	May 5-7	May 13	May 23	March 15-30	November 5-10
	P3	May 5-7	May 13	May 23	March 15-30	November 5-10
2008	Hachiya	April 26	May 1-3	May 6	March 15-30	November 7-12
	Fuji	May 4	May 5-7	May 12	March 15-30	November 7-12
	P1	May 4-6	May 14	May 24	March 15-30	November 7-12
	P2	May 4-6	May 14	May 24	March 15-30	November 7-12
	P3	May 4-6	May 14	May 24	March 15-30	November 7-12

bees must be used for pollination in Fuyu cultivar (Morton, 1987). Controlled pollination trials with different species and cultivars of persimmon are being done (Ikeda and Sugiura, 2003; Yamada and Sato, 2003). Effects of pollination on fruit set (Kim et al., 1997; Hasegawa et al., 2003; Krisanapook et al., 2004), pomological properties (Krisanapook et al., 2004; Leng and Yamamura, 2006) and pollen germination tests (Krisanapook et al., 2004) were investigated by different researchers. Taking this into consideration, the current research was performed to investigate fertilization biology, phenological and pomological observations in Hachiya and Fuji cultivars.

MATERIALS AND METHODS

In this study that was carried out between 2006 and 2008, the phenological observations and fertilization biology applications were realized in a grower garden in Ödemi / zmir - Turkey. Hachiya and Fuji cultivars and andro-monoecie pollinator types (P1, P2, P3) in the same garden were used as material.

Criteria like beginning of flowering, full flowering, end of flowering, foliation and harvest date were detected on the phenological observations of Hachiya and Fuji cultivars and pollinator andromonoecie types.

Fertilization biology practices were implemented consecutive three years. Controlled pollinations were carried out with two pollinator types (P1 and P2) in the first year and three types (P1, P2 and P3) in the other years.

Pollen which was used for hybridization studies was provided from the balloon stage male buds of the andromonoecie trees (Layne and Quamme, 1975). Anters were remained in room temperature for 24 h and obtained pollen were put into the glass bottless. Bottless were kept in the refrigerator at 4°C untill they were used (Leng and Yamamura, 2006). Pollen viability was determined by using TTC and IKI staining tests (Eti, 2000). To state pollen germination ratio of male parents used as pollinators, hanging drop method containing 20% sucroz was utilized (Krisanapook et al., 2004). The viability and germination tests were done three replicates and 300 pollen grains were counted in each replicates.

On the hybridization studies, flowers were emasculated by removing petals and anthers. After emasculation, pistils were pollinated (Leng and Yamamura, 2006; Layne and Quamme, 1975). As for isolation, balloon stage buds were isolated. For open pollination, buds on the shoots were counted and labelled. In every application, almost 300 to 500 buds were used. The experiment was carried out in three replicates. 40 to 45 days after treatments, fruit set was determined by counting small fruits.

The data belong to pollen viability and germination tests and fruit set were analyzed statistically by ANOVA using SAS computer programme (SAS, 1996). Fruit analyses have been carried out in 10 to 20 fruit samples of each treatment. Examined fruit characteristics are weight, width and lenght, skin color of fruit, flesh firmness, total soluble solid content, titretable acidity, and pH value (Karaçali, 2006).

Characters such as fruit shape, apex, wrinkling of calix, cracking, brown spots in fruit flesh, seed size, and astringency were considered at the evaluations and identifications of fruit pomological characters in the fruits that obtained from hybridization, selfing and open pollination treatments. UPOV persimmon descriptor was used for evaluations (Anonymous, 2004).

RESULTS AND DISCUSSION

Phenological observations

Data based on three years of phenological observations of cultivars and pollinator types were indicated in Table 1. Flowering period of Hachiya cultivar was detected as between end of April and beginning of May. As for the second cultivar, this period was determined as approximatelly first two weeks of May. Flowering period of pollinator types was recorded as first three weeks of May. Foliation period of persimmon cultivars and types

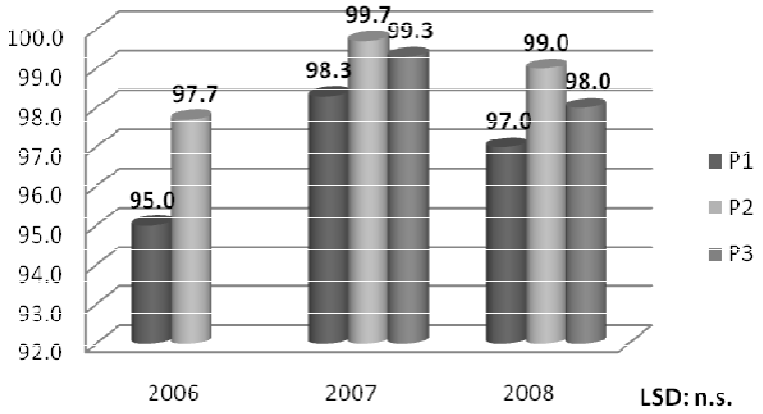

Figure 1. Pollen viability ratio of pollinator types in IKI test.

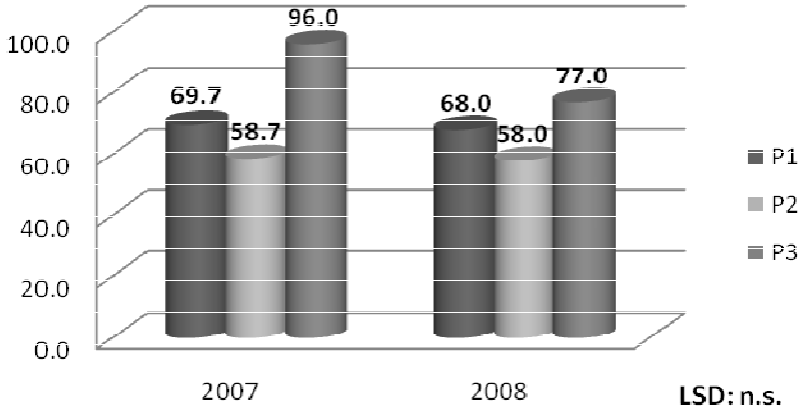

Figure 2. Pollen viability ratio of pollinator types in TTC test.

was stated as March 15 to 30, and harvest was made in November (Table 1). Similar phenological observations were obtained in persimmon cultigens grown in different ecological conditions (Akbulut et al., 2004; eker et al., 2004; Tangu et al., 2004; Toplu et al., 2009).

Fertilization biology

For pollen viability and germination tests of the pollinator male types, any statistical differences could not be detected for three years. However, P2 pollinator had the highest value in terms of viability in IKI test (Figure 1). In contrast with IKI test, pollen viability of P3 (96 and 77%, respectively) was found higher than P1 (69.7 and 68%, respectively) and P2 (58.7 and 58%, respectively) in both years for TTC test (Figure 2). According to germination test, P1 pollinator possessed the highest value, in general (Figure 3). Krisanapook et al. (2004), was stated that pollen germination ratio of different cultivars and types varied between 3.4 and 17.8%, in hanging drop method (15% sucroz), but there was no statistical difference between pollinators. In obtained data of our experiments, results took place between the variation range that stated above.

Fruit set of cultivars differed statistically according to treatments in 2006 and 2007 (P 0.01). In the first year of the trial, fruit set of Hachiya was higher than Fuji in all treatments. In both cultivars, fruit set was very low when flower buds were isolated (Figure 4).

In 2007, the highest fruit set was obtained with P2 pollinator (56.78%) for Fuji cultivar, and P3 pollinator (65.91%) for Hachiya cultivar (Figure 5) . In 2008, statistical difference did not occur in relation to fruit set. Even though, for Fuji cultivar, fruit set was the highest in crosses with P2 type (31.63%), this value was 35.24% (P1) in Hachia cultivar (Figure 6).

In an investigation carried out by Krisanapook et al. (2004), fruit set changed between 61.2 and 89.7% for Fuyu cultivar in control and crossing applications with 4 different male types. In this research, low fruit set may be due to the differences of pollinator types, cultivars used and climatic differences (Mowat et al., 1997).

As for general evaluation of fruit set through the

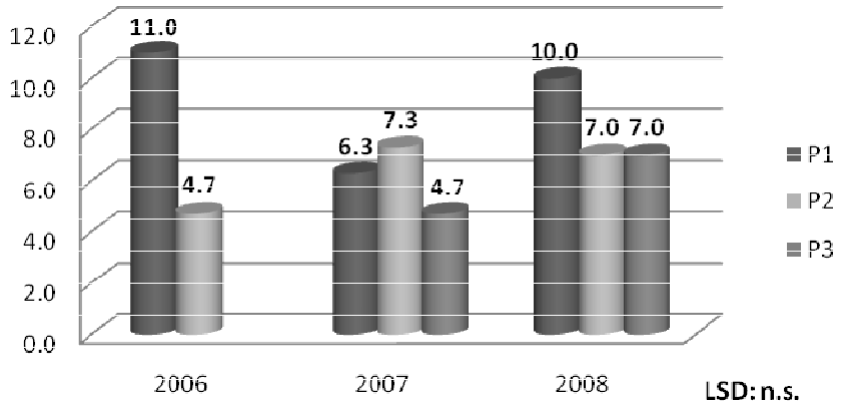

Figure 3. Pollen germination ratio of pollinator types.

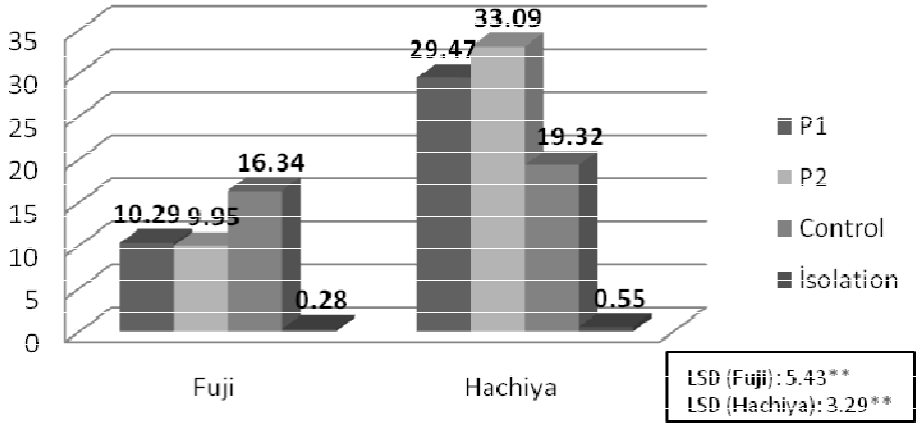

Figure 4. Fruit set of persimmon cultivars in 2006.

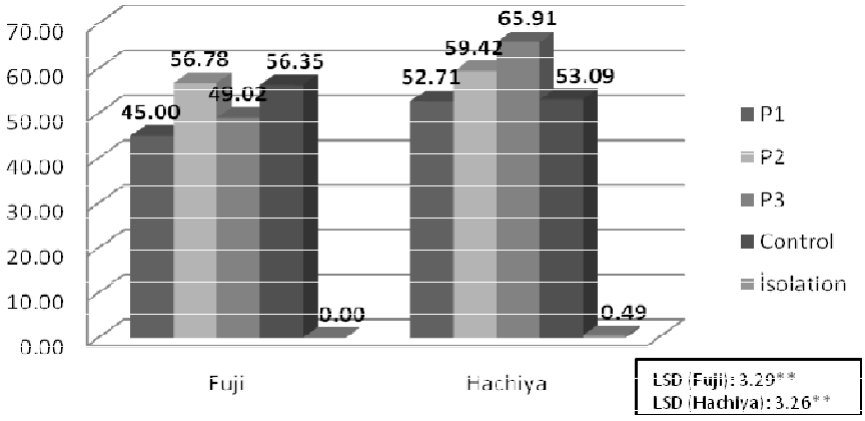

Figure 5. Fruit set of persimmon cultivars in 2007.

pollinator types, the highest fruit set was obtained in Fuji cultivar on the second and the third years of the trial in crosses with P2 type (Figures 5 and 6). This value was higher than the control treatment, too. Accordingly, it could be said that P2 and P3 types can be used as pollinators for this cultivar. In Hachiya cultivar, generally, higher fruit set was determined in three different pollinators than control application for three years

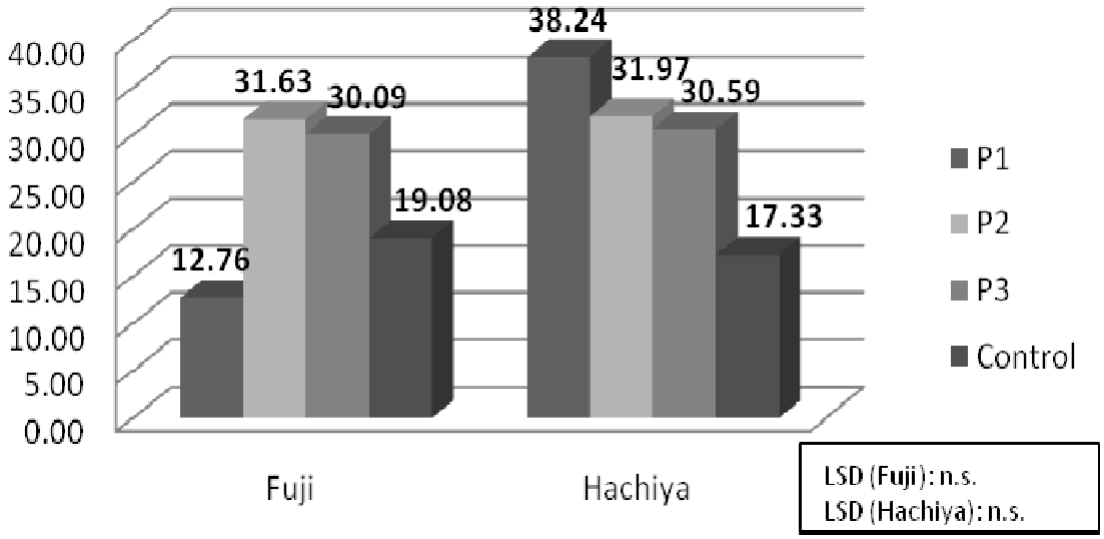

Figure 6. Fruit set of persimmon cultivars in 2008.

Table 2. Fruit characteristics on cultigens and cross pollinations.

Combination	Fruit weight (g)	Fruit width (mm)	Fruit lenght (mm)	TA (g / 100 ml)	pH	TSS (%)	Flesh firmness (N)	Fruit skin color		
								L	a	b
Hachiya control	61.89	48.78	42.35	1.75	5.61	20,83	0.80	69.11	15.88	60.43
Hachiya x P1	40.19	41.87	37.28	1.94	5.15	24.67	0.92	65.20	15.48	53.75
Hachiya x P2	41.67	40.38	37.93	1.86	5.39	26.10	1.25	69.20	14.20	60.39
Hachiya x P3	76.00	49.49	45.32	1.07	6.03	22.33	1.03	70.66	11.76	60.03
Fuji control	88.55	41.20	34.94	2.60	6.85	21.17	0.26	68.56	13.21	57.27
Fuji x P1	87.75	56.54	53.95	1.14	5.78	20.65	0.74	59.98	10.48	45.30
Fuji x P2	89.00	53.70	47.73	1.76	5.12	16.50	1.59	68.06	9.73	58.81
Fuji x P3	110.17	54.44	53.98	1.49	5.83	20.50	1.57	65.44	18.18	57.38
P1	54.40	45.35	42.12	2.19	5.08	26.00	0.41	60.60	16.47	50.07
P2	56.67	48.00	40.30	2.21	5.72	24.50	0.82	70.49	14.03	54.05
P3	45.00	39.32	45.63	1.62	6.14	21.00	1.18	69.07	16.85	58.09

(Figures 4, 5 and 6). The obtained data about using pollinators leads to higher fruit set are parallel to the data stated by Morton (1987), Kim et al. (1997), Holdeman (2000), Hasegawa et al. (2003) and Krisanapook et al. (2004).

With respect to fruit set according to years, it can be noticed that fruit set was higher in both cultivars in second year than the other years (Figure 5). This consequation can be occur as a physiological condition of the tree, because of the lower fruit yield of previous year.

Fruit characteristics and description

The data of determinated characters of fruits that obtained from artificial pollinations and control treatments can be seen in Table 2. Average fruit weight was detected 61.89 g for Hachiya and 88.55 g Fuji cultivars in control. Data obtained from the changes in average fruit weight gained from different combinations are in convenience with the data obtained by Leng and Yamamura (2006). On the other hand, in ecological conditions of Adana-Turkey, this value for different origins of Hachiya cultivar (France and Italy) was determined 147.7 and 148.7 g, respectively, and 158.3 g in Fuji cultivar (Ye ilo lu et al., 2004) . The reason of low fruit weight in this experiment could be ecological differences (Table 2). The highest values of different combinations were obtained for average fruit weight and lenght in P3 crosses of both cultivars. As for fruit width, the highest values were attained in P3 crosses for Hachiya (49.49 mm), and P1 crosses for Fuji (56.54 mm) cultivars.

Titretable acidity changed from 1.07 to 1.94 g / 100 ml for Hachiya, and from 1.14 to 1.76 g/100 ml for Fuji

Table 3. Fruit descriptions of cultivars, pollinator types and treatments (2006).

I. Year	Hachiya				Fuji				Pollinators	
	P1	P2	Control	Isolation	P1	P2	Control	Isolation	P1	P2
Fruit shape (lateral)	Broad ovate	Broad ovate	Circular	Circular	Broad ovate	Circular	Circular	Circular	Elliptic	Elliptic
Fruit shape (cross section)	Irregular rounded	Irregular rounded	Irregular rounded	Irregular rounded	Irregular rounded	Circular	Circular	Irregular rounded	Circular	Circular
Shape of apex in longitudinal section	Rounded	Rounded	Rounded	Retuse	Rounded	Rounded	Rounded	Retuse	Rounded	Rounded
Grooving at apex	Absent or weak	Moderate	Moderate	Moderate	Moderate	Moderate	Absent or weak	Moderate	Moderate	Moderate
Shallow concentric cracking around apex	Moderate	Absent or weak	Moderate	Absent or weak	Absent or weak	Moderate	Moderate	Absent or weak	Moderate	Absent or weak
Cracking around apex	Absent or weak	Absent or weak	Absent or weak	Absent or weak	Absent or weak	Absent or weak	Absent or weak	Absent or weak	Absent or weak	Absent or weak
Longitudinal grooving	Absent to very shallow	Absent to very shallow	Absent to very shallow	Absent to very shallow	Absent to very shallow	Absent to very shallow	Absent to very shallow	Shallow	Absent to very shallow	Shallow
Wrinkles at calyx end	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent
Calyx attachment	Slightly depressed	Slightly depressed	Slightly depressed	Slightly depressed	Slightly depressed	Level	Slightly depressed	Slightly depressed	Slightly depressed	Level
Groove at calyx end	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent
Cracking at calyx end	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent
Calyx size compared with fruit diameter	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium
Attitude of calyx	Semi -erect	Semi -erect	Semi -erect	Semi -erect	Semi -erect	Semi -erect	Semi -erect	Semi -erect	Horizontal	Horizontal
Presence of brown specks in flesh	Present	Present	Present	Present	Present	Present	Present	Present	Present	Present
Size of brown specks in flesh	Large	Large	Small	Small	Large	Large	Large	Small	Small	Small

Table 3. Contd.

Seed size	Large	Large	Large	-	Medium	Medium	Small	-	Medium	Small
Seed shape in lateral view	Semi broad elliptic	Semi broad elliptic	Semi broad elliptic	-	Semi broad elliptic	Semi broad elliptic	Semi broad elliptic	-	Semi broad elliptic	Semi broad elliptic
Fruit astringency	Absent	Absent	Absent	Present	Absent	Absent	Absent	Present	Absent	Absent
Seed number	2.1	1.8	1.5	-	1.7	1.6	1.7	-	0.9	0.7

cultivars. The variation range of pH value of fruit juice was 5.15 - 6.03 and 5.12 - 6.85, in Hachiya and Fuji cultivars, respectively. The highest total soluble solid content was found in Hachiya x P2 (26.10%). As for fruit flesh firmness, the toughest fruits were attained in P2 crosses for both cultivars, on the other hand, the softest ones were got in controls. This situation is of great importance from the point of storage and marketing of fruits. Orange coloured fruits that have high attraction were found in P1 combination of Hachiya, and P3 combination of Fuji cultivars. On the similar investigations about persimmon cultivars and selected types, fruit characteristics were identified, and pomological qualifications evaluated to put forward the differences among cultivars and types (Akbulut et al., 2004; Onur and Ta demir, 1987; Sütyemez and Ergeno lu, 2000; eker et al., 2003, 2004; Tangu et al., 2004; Yildiz et al., 2004; Ye ilo lu et al., 2004; Çandir et al., 2009; Toplu et al., 2009).

Description

Data obtained from the fruit descriptions of the first and the second year fruit samples of Hachiya and Fuji cultivars, pollinator types, cross combinations and control applications can be followed in Tables 3 and 4.

It was observed that there are kernels in the fruits attained from control and pollinated combinations in both years. As concerns isolation, there was no kernel inside of the fruits of isolated Hachiya and Fuji cultivars in 2006. In 2007, although there was very few fruit set at the beginning of the season in isolated flowers, after fruit falls, any fruits could not be obtained from both cultivars. So, it can be indicated that, the open pollination comes true for persimmon cultivars as there are kernels in control treatments that there is no artificial pollination (Tables 3 and 4). These findings are confirmed by similar data of Krisanapook et al. (2004). In our investigation, kernel number increased in case of using pollinator types, in general. This data is similar to results obtained by Leng and Yamamura (2006). It was detected that fruits obtained from isolation treatments of Hachiya and Fuji cultivars and control group of Hachiya cultivar are astringent in 2006. In usage of pollinators astringency disappeared (Table 3). Although fruit shape was not stable according to years, fruit shape changed in case of using pollinators, especially in 2006.

CONCLUSION

In this trial that carried out in different persimmon cultivars and types, it was found that pollen viability of pollinator types is high enough in IKI and TTC viability tests. On the other hand, pollen germination ratio was found lower than other fruit species, but, the obtained data remained in the interval of findings of other researchers belong to persimmon species.

In the isolation treatments of Hachiya and Fuji cultivars, it was detected that there is no fruit set or just a low ratio of fruit set was defined, and there was not any kernels in obtained few fruits. Fruit set was higher in Hachiya x P1, P2, and P3 and Fuji x P2 and P3 pollination combinations than control. Effects of pollinators in fruit characteristics appeared in different way. This consequation puts forward the importance of using pollinator types. It was observed that fruits attained from pollination applications with different types and control applications had kernels. According to this situation, the open pollination come true for persimmon cultivars as there are kernels in fruits of control treatments that artificial pollination is not carried out.

ACKNOWLEDGEMENT

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Table 4. Fruit descriptions of cultivars, pollinator types and treatments (2007).

II. Year	Hachiya				Fuji				Pollinators		
	P1	P2	P3	Control	P1	P2	P3	Control	P1	P2	P3
Fruit shape (lateral)	Circular	Circular	Circular	Circular	Circular	Oblate	Circular	Circular	Elliptic	Elliptic	Elliptic
Fruit shape (cross section)	Circular	Circular	Circular	Circular	Circular	Circular	Circular	Circular	Circular	Circular	Circular
Shape of apex in longitudinal section	Rounded	Rounded	Rounded	Rounded	Rounded	Rounded	Rounded	Rounded	Rounded	Rounded	Optuse
Grooving at apex	Absent or weak	Moderate	Moderate	Moderate	Absent or weak	Absent or weak	Absent or weak	Moderate	Moderate	Absent or weak	Moderate
Shallow concentric cracking around apex	Absent or weak	Absent or weak	Absent or weak	Absent or weak	Absent or weak	Absent or weak	Absent or weak	Moderate	Absent or weak	Absent or weak	Absent or weak
Cracking around apex	Absent or weak	Absent or weak	Strong	Strong	Moderate	Moderate	Moderate	Moderate	Absent or weak	Absent or weak	Strong
Longitudinal grooving	Absent to very shallow	Absent to very shallow	Absent to very shallow	Absent to very shallow	Absent to very shallow	Absent to very shallow	Absent to very shallow	Absent to very shallow	Absent to very shallow	Absent to very shallow	Absent to very shallow
Wrinkles at calyx end	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent
Calyx attachment	Level	Level	Slightly depressed	Level	Level	Slightly depressed	Slightly depressed	Slightly depressed	Level	Level	Level
Groove at calyx end	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent
Cracking at calyx end	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent
Calyx size compared with fruit diameter	Large	Large	Small	Small	Small	Medium	Medium	Small	Medium	Small	Large
Attitude of calyx	Horizontal	Horizontal	Horizontal	Semi - erect	Horizontal	Semi -erect	Horizontal	Semi -erect	Horizontal	Horizontal	Semi - erect
Presence of brown specks in flesh	Present	Present	Present	Present	Present	Present	Present	Present	Present	Present	Present

Table 4. Contd.

Size of brown specks in flesh	Large	Large	Large	Small	Large	Large	Large	Large	Small	Small	Large
Seed size	Small	Small	Small	Small	Large	Large	Large	Large	Medium	Small	Small
Seed shape in lateral view	Semi broad elliptic	Ovate	Semi broad elliptic	Semi broad elliptic	Semi broad elliptic	Semi broad elliptic	Semi broad elliptic	Semi broad elliptic	Semi broad elliptic	Semi broad elliptic	Narrow elliptic
Fruit astringency	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent
Seed number	2.6	2.1	1.7	1.9	2.3	2.0	1.8	1.3	1,2	0.8	1.0

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