Journal of New Results in Science (JNRS)

ISSN: 1304-7981
http://dergipark.gov.tr/en/pub/jnrs
Research Article
Open Access

Volume: 9
Issue: 2
Year: 2020
Pages: 9-16

***Received*:** 20.03.2020 ***Accepted*:** 29.06.2020

Plant and Fruit Characteristics of Ferraduel Almond Cultivar After Controlled Pollination and Irrigation

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ABSTRACT: The most important factor limiting almond cultivation is the necessity of pollination and late frosts. Thus, 'Ferraduel' almond cultivar, which is one of the late-flowering cultivars, is preferred in almond cultivation in recent years. 'Ferranges' and 'Picantilli' cultivars are used as a pollinator. Moreover, the yield is low due to insufficient pollination. In this research, where controlled pollination and irrigation were carried out, the 'Picantilli' variety was used as pollinator for the 'Ferraduel' almond cultivar. Pollen viability rates were determined as 40.00% for 'Picantili' and 37.83% for 'Ferraduel'. According to the results of the study, fruit set rate was not found significant according to treatments (Mean: 91.20%) while the harvested fruit rates were obtained as the highest with 27.69% from controlled pollination + irrigation treatment. Fruit weight with fruit shell and fruit meat weight were determined as 5.33 g and 1.18 g in trees pollinated in the open field, 6.74 g and 1.54 g in trees treated with other treatments.

Keywords *– Almond, Phenology, Pomology, Hand-Pollination, Irrigation*

1. Introduction

Badem's homeland is West and Central Asia. It has spread from this region to India and China in the east and to Iran, Syria and Mediterranean countries in the north. Anatolia is one of the gene centers of almond. almond is a type of fruit with very low cooling requirement. Due to the frequent damage of late spring frosts, it can not be grown economically in many regions of our country (Özçağran et al., 2007). In our country, almond production is obtained from growing almond orchard, almond orchard mixed with other fruit types or as a border tree for determining the boundaries of agricultural areas (Şimşek, 2015).

Late-blooming and productive varieties are preferred in countries with commercial almond cultivation. On the other hand, late flowering, self-fertility and good tree yield are among the priorities in breeding studies (Grassely, 1990; Kester and Asay, 1975). In recent years, in the areas where frost damage is not seen in our country, in addition to late flowering foreign cultivars such as 'ferraduel', 'ferragnes', 'picantillli', 'texas' and 'tuono', and olso native varieties such as '101-9' of Dokuzokuz and Gülcan (1979), '101-13', '106-1' and 'Gülcan 1 (101-23)' are preferred.

In recent years, almond production in Turkey began to increase rapidly, and 'Ferraduel' cultivar is preferred especially because of the late flowering. As pollinators, 'Ferragnes' and 'Picantilli' cultivars are recommended (Vargas et al., 1984; Meknes, 1996; Vargas et al., 1998). Although it is preferred because of late flowering, it can also be damaged by late spring frosts, especially in the transition regions. Among the main reasons for low yield in almonds are late spring frosts, and insufficient pollination and fertilization. It can also be said that the

reasons for pollination and fertilization deficiency are situation of pollinator cultivar, low temperatures during flowering period, absence of pollinator bees or insects (inability to function), arid and hot weathers, and rainfall during flowering period (Felipe, 1987; Felipe et al., 1998, Felipe and Aparisi, 1999;). The goal of traditional irrigation scheduling is irrigating to meet the water use (ETc) of the orchard fully and to avoid drought stress to the trees, there simply may not be enough water available to accomplish this in the future. Thus, the primary irrigation scheduling question in the future may well be when is the tree most stress-tolerant in terms of sustained productivity.

In general, the most water-stress-sensitive phenological stages of deciduous trees are ¯owering, fruit set, and the initial phases of fruit growth. Little work has been done on the sensitivity of the remaining preharvest and postharvest periods to water deficits in almond (Goldhamer and Viveros 2000). This work undertaken to assess the impacts of the effectiveness of pollination and irrigation in Ferraduel ' cultivar.

2. Material and Methods

2.1. Material

‘Ferraduel’ almond cultivar was used as plant material. Furthermore, ‘Picantilli’ cultivar was preferred as a pollinator. The cultivars which were eight years old were planted in the collection garden of the Department of Horticulture of the Faculty of Agriculture of Gaziosmanpaşa University in 2002, grown in dry conditions in Tokat conditions.

2.2. Method

For controlled pollination and pollen viability tests, the flowers of the 'Picantili' cultivar were removed during the balloon period, the anthers were transferred to the petri dishes under laboratory conditions, and they were kept for 2 days in 18-20 ^{o}C and used without waiting (Fig. 1).

Fig. 1. The flowers of 'Ferraduel' almond variety during the balloon period (Gerçekcioğlu-2009/Tokat)

2.3. Pollen Viability Test

Pollen viability of ‘Picantilli’ and ‘Ferraduel’ almond cultivars was obtained with TTC test (Heslop-Harrison J. and Heslop-Harrison V, 1970).

2.4. Hand (Controlled) Pollination

Pollen viability of ‘Picantilli’ and ‘Ferraduel’ almond cultivars was obtained with TTC test (Heslop-Harrison J. and Heslop-Harrison V, 1970). The research was conducted in 2009. For

hand-pollination, the pollens of 'Picantilli' almond cultivar was used. Pollens were applied to the stigma with the help of brush and fingertips before the flowers of 'Ferraduel' (balloon and previous periods) open. Hand and open-pollinations were made on 3 trees and on different branches (3-7 branches) on each tree, with a total of over 100 Flowers (106-235 flowers), and marked (Fig. 2).

Fig. 2. Hand polination (Gerçekcioğlu-2009/Tokat)

2.5. Irrigation Treatment

Except the regular rains, trees (hand and open-pollinated) were irrigated 4 times as 100 liter for each time on specific dates (400 liter/tree in total).
Irrigation dates were as follows.

- 1st irrigation date (100 liter/tree): 29.05.
- 2nd irrigation date (100 liter/tree): 05.07.
- 3rd irrigation date (100 liter/tree): 20.08.
- 4th irrigation date (100 liter/tree): 27.08.

In the research, 4 different treatments were considered as hand- pollination+irrigation (H-p+i), open-pollination+irrigation(O-p+i), hand-pollination (Hp), and open-pollination(Op).

2.6. Pomological Characteristics

Fruit pomological measurements were made on fruits on all marked branches. Observations of fruit set were done at when petals fall, anthers fall or dry, stigma dries and sepals cover the stigma as a cap (Fig. 3) (Karaçalı, 1990). Harvested fruit rate was calculated in harvest time (when the green almond shell started to flake or can be flaked easily) (08.09.2009). The results were evaluated according to randomized blocks experimental design and were grouped according to the LSD test.

Fig. 3. Fruit period in almonds (Gerçekcioğlu -2009/TOKAT)

3. Results and Discussion

The flowering dates of the varieties were Table 1.

Table 1. Flowering periods of almond cultivars

Cultivar name	Beginning of the flowering	Full flowering	End of the flowering
Picantilli	24.03.	06.04.	10.04.
Ferraduel	30.03.	04.04.	08.04.

Pollens of 'Picantilli' almond cultivar were taken between 24.03.2009–30.03.2009. Flowers of 'Ferraduel' cultivar blooms the same with 'Williams' almond cultivar in the Tokat ecological conditions. However, still in this ecology, trees can be damaged very often from late spring frosts. According to our observations, while flowers were not damaged in 2007, 2008, and 2009, they were damaged in 2010, and fruits were harvested regularly in 2011. Commercial almond cultivation is not recommended in transition zones like Tokat except protected areas as Erbaa and Niksar districts with 250-300 altitude.

During the flower counting of 'Ferraduel' cultivar (100 flowers per tree), flowers without ovary or flowers with double ovary were found also (Fig. 4, Table 2). Moreover, there was no significant difference between the treatments. The results were Table 3.

Fig. 4. Three female organs within the same flower in 'Ferraduel' almond varieties (Gerkçekcioğlu-2009/TOKAT)

Table 2. Ovary shapes in flowers of '*Ferraduel*' cultivar

	With ovary (number)	Without ovary (number)	Double ovary (number)	Total (number)
Mean±sd	79.33±12.66	19.00 ± 12.49	1.70 ± 1.476	100.00

It was determined that pollen viability rate was 40% for 'Picaltilli' almond cultivar while it was 37.83% for 'Ferraduel' cultivar. Although this rate is lower than in the study by Sütyemez (2011), it can be considered successful. On the other hand, pollen viability rates can change by ecology and years (Güleryüz and Ülkümen, 1972). The results of fruit set rates and fruit characteristics of 'Ferraduel' cultivar are given in Table 3-5.

Table 3. The effect of treatments on some plant and fruit characteristics of '*Ferraduel*' almond cultivar[+]

Treatments	Fruit set (%)	Harvested fruit rate (%)	Fruit cracking rate (%)	Empty fruit rate (%)
Hand-pollination+irrigation	97.09	27.69 a	32.29	0.01
Hand- pollination	91.01	15.81 ab	8.46	0.01
Open-pollination +irrigation	90.91	8.78 b	70.76	0.01
Open pollination	85.79	4.52 b	25.56	1.86
	Repetition:NS Treatment:NS	Repetition:NS Treatment*	Repetition:NS Treatment:NS	Repetition:NS Treatment:NS
[+]: Difference between means indicated by different letters *Significant at a level of (5%) and **(1%) NS: Not significant				

According to applications, no difference was observed between the fruit set ratios. The harvested fruit ratios were found to be significant at the level of 5% and te highest rate was obtained from hand pollination + irrigation application. The experiment shows that hand pollination has a high impact on harvested fruit rate. Klein et all 2014, concluded that, Pollination strongly affected yield even under reduced water and no nutrient applications.

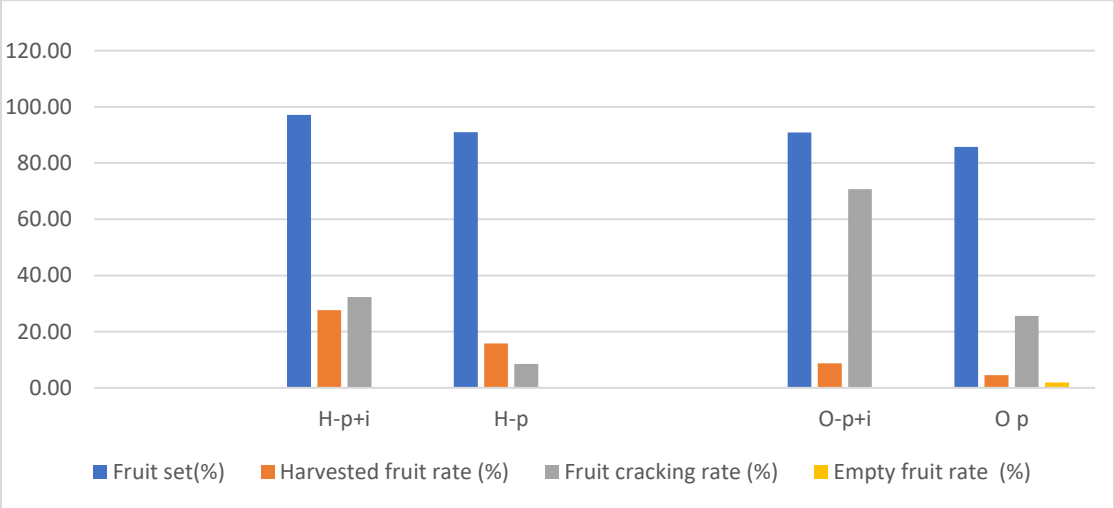

Fig. 5. The effect of treatments on some plant and fruit characteristics of '*Ferraduel*' almond cultivar

Table 4. The effect of treatments on some fruit characteristics of '*Ferraduel*' almond cultivar

Treatments	Width (mm)	Diameter (mm)	Length (mm)	Thickness of shell (mm)
Hand- pollination+irrigation	18.83 a	27.29 a	37.09 a	4.28 a
Hand- pollination	18.78 a	26.97 a	37.16 a	4.22 a
Open-pollination +irrigation	18.79 a	27.92 a	37.78 a	4.33 a
Open pollination	17.77 b	24.85 b	34.93 b	3.97 b
	Repetition:NS Treatment*	Repetition:NS Treatment**	Repetition:NS Treatment*	Repetition* Treatment*
[+]: Difference between means indicated by different letters *Significant at a level of (5%) and **(1%) NT: Not significant				

All applications had an impact on fruit properties. The difference between the applications in terms of width and height was found to be significant at the level of 5%. The highest width value was determined in Hand- pollination+irrigation application and the lowest was found in open pollination fruits. In terms of fruit length, the values were found to be highest in Open-pollination+ irrigation application. Diameter values were found significant at the level of 1%. The highest diameter value was obtained from open pollination + irrigation application. Shell thickness was 5% significant on the basis of repetitions and applications, and the lowest shell thickness was determined in open polinated plants (Table 4).

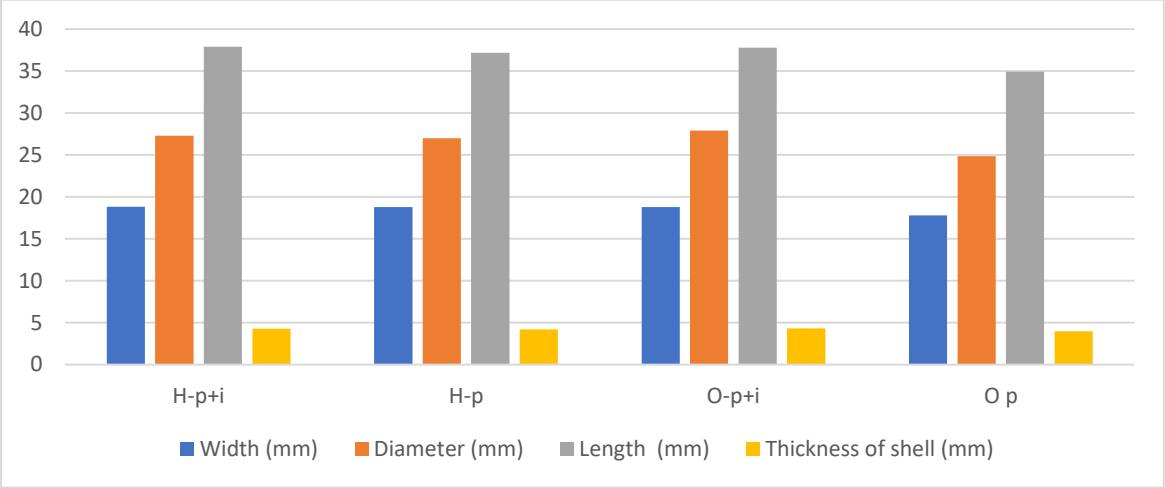

Fig. 6. The effect of treatments on some fruit characteristics with shell

Table 5. The effect of treatments on some fruit characteristics of '*Ferraduel*' almond cultivar[+]

Treatments	Fruit weight with shell (g)	Kernel Weight (g)	Kernel yield rate (%)	Rate of double kernel (%)
Hand- pollination+irrigation	6.58 a	1.50 a	22.85	0.75
Hand- pollination	6.78 a	1.56 a	23.26	2.27
Open-pollination +irrigation	6.86 a	1.55 a	22.63	0.01
Open pollination	5.33 b	1.18 b	22.03	2.77
	Repetition:NS Treatment*	Repetition:NS Treatment*	Repetition:NS Treatment:NS	Repetition:NS Treatment.:NS
[+]: Difference between means indicated by different letters *Significant at a level of (5%) and **(1%) NT: Not significant				

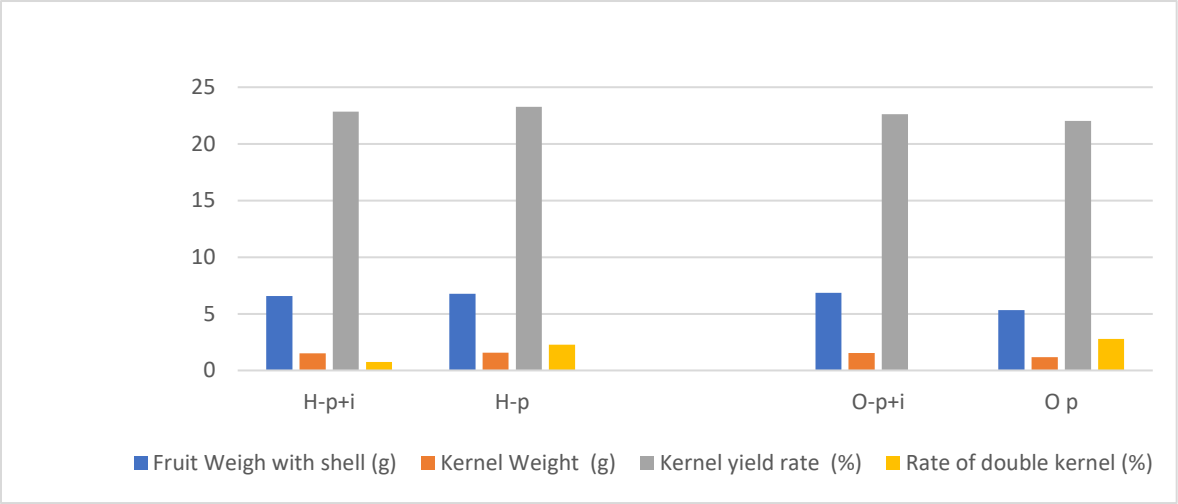

Fig. 7. The effect of treatments on some fruit characteristics of '*Ferraduel*' almond cultivar

In the research, fruit weigh with shell and kernel weight ratios were statistically significant. The highest shell weight was determined In open pollination + irrigation and the highest kernel weight was determined in Hand- pollination application. Kernel yield rate was not statistically significant. There were no double seeds in open pollination + irrigation application but this rate highest in trees open polinated (Table5). In the experiment fruit weight with shell and kernel weight were highly inflected by the aplications.

Nanos et al 2002, reported that, irrigation did not influence kernel weight. In the farm, they examined (irrigated for the years 1997–1999) mean kernel yield values 6.6 kg per tree for Texas and 5.6 kg for Ferragnes cultivar. The respective values for the non-irrigated farm were 3.7 and 2.3 kg. Irrigation may have increased kernel yield due to higher number of flowers and fruit set they concluded. Atlı et al. 2008, reported that, under the irrigated conditions of Gaziantep region (2003-2007), the fruit weight with shell of Ferraduel cultivar as 3.89, kernel weight as 1.05 and kernel yield rate as 2.1. The double seed rate was 0.3% in their experiment. Our results showed that for almond, pollination and should be a high priority, and irrigation must be managed because of its well known effects.

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