

## Bazı Zeytin Çeşitlerinde Hermafrodit Çiçek Oranları ve Meyve Dökümü

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### ÖZ

Zeytin çeşitlerinde çiçek biyolojisi incelendiğinde erkek ve hermafrodit çiçek durumları değişiklik göstermektedir. Yapılan bu çalışma ile 3 farklı zeytin çeşidinin üç yıl süreyle Tarsus/Mersin ekolojisindeki erselik çiçek oranı tespit edilmiştir. Aynı zamanda döllemeden sonra çeşitlere ait uygulamalarda meyve dökümleri belirlenmiştir. İncelenen çeşitlerde kendine verimlilik ile tozlayıcı kullanımının meyve tutumuna etkisini belirlemek amacıyla başlangıçta uygulamaya alınmış çiçek sayıları ile karşılaştırılması sonucunda yüzde meyve tutma değerleri belirlenmiştir. Çeşitlerin çiçeklerinin açılmasından meyve bağlama aşamasına kadar geçen sürenin ise 10 ila 15 günlük bir süreyi kapsadığı saptanmıştır. Erselik çiçek oranları yıllar bazında benzerlik gösterirken, en yüksek Domat çeşidinde bulunmuş, bunu Sarı Ulak ve Gemlik çeşitleri izlemiştir. Domat, Gemlik ve Sarı Ulak çeşitlerinde yapılan tozlama denemeleri sonucunda meyve dökümlerinin kendileme uygulamalarında en fazla olduğu saptanmıştır. Yabancı tozlama uygulamalarında ise kendilemeye göre daha az döküm saptanmış ve tozlayıcı kullanımının meyve tutumu üzerine olumlu etkisi görülmüştür.

**Anahtar Kelimeler:** Zeytin, çiçek, meyve tutumu, tozlama, meyve dökümü

### Hermaphrodite Flower Ratios and Fruit Drop in Some Olive Cultivars

#### ABSTRACT

The intricacies of flower biology in olive cultivars reveal variations in the occurrence of male and hermaphrodite flowers. This study endeavours to ascertain the frequency of hermaphrodite flowers over a three-year period within the ecological context of Tarsus/Mersin. Simultaneously, post-fertilization fruit abscission rates specific to each cultivar were determined. By initially quantifying flower numbers and subsequently comparing them against fruit retention rates, this research aimed to elucidate the impact of self-pollination and cross-pollination on fruit set across the examined cultivars. The period from the opening of flowers to the stage of fruit setting was found to range from 10 to 15 days. While the ratios of hermaphrodite flowers remained similar across years, the highest ratio was observed in the Domat cultivar, followed by the Sarı Ulak and Gemlik cultivars. Pollination experiments conducted on the Domat, Gemlik and Sarı Ulak cultivars revealed that fruit drop rates were highest in self-pollination practices. Conversely, foreign pollination practices resulted in lower fruit drop rates compared to self-pollination, indicating a positive impact of pollinator use on fruit retention.

**Keywords:** Olive, flower, fruit set, pollination, fruit abortion

### INTRODUCTION

When examining the flower biology of olive cultivars, the conditions of male and hermaphrodite flowers exhibit variations. Cuevas and Polito [1] reported a staminate: hermaphrodite flower ratio of approximately 1:1 in their study on the Mission cultivar. Female organ abortion can occur during pistil differentiation [2]. Brooks [3] reported that hermaphrodite olive flowers tend to bloom earlier, while the results of Cuevas and Polito [1] indicate that early blooming is not specific to hermaphrodite flowers but is associated with better-nourished flowers within the cluster. Therefore, the most

significant advantage provided by staminate flower production in olives is the increase in the number of available pollen grains to ensure fertilization. The dry weight of hermaphrodite flowers was found to be 19% higher than that of staminate flowers.

Lavee et al. [4] examined the effect of flower number and distribution on fruit behavior in various olive cultivars over a 10-year period. The number of stamens within each cultivar and thinning the flowers by up to 50% did not significantly affect fruit retention. Removing half of the flowers resulted in double the fruit yield compared to the remaining ones. Typically, a considerable number of fruits are obtained from the flower cluster. In a productive

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flower cluster away from the center, 70-80% (double) of the fruits are obtained from various shoots. In Santa Caterina (Italy), a clear increase in fruit set per shoot was observed by removing 80% of the flowers from the flower cluster.

Seifi et al. [5] examined the timing of flower opening, gender and the persistence of the corolla in Manzanilla, Mission and Frantoio olive cultivars. In each cultivar, 45 flower clusters were examined every morning from flower opening to corolla shedding. Hermaphrodite flowers primarily opened at the beginning of the flowering period, while male flowers opened later. Flowers at the tip and on primary branches opened earlier than those on secondary branches. The study found that flower position significantly influenced gender in Manzanilla and Mission cultivars. In the Manzanilla cultivar, hermaphrodite flowers exhibited significantly longer corolla persistence compared to male flowers. According to the results of this study, corolla persistence was dependent on daily temperature during flower opening. Despite the expectation that earlier-opening flowers in the Manzanilla cultivar would be pollinated earlier, it was observed that corollas remained intact for a longer duration. Additionally, the study demonstrated that thinning of buds and shoots applied 30 days before full bloom reduced pistil degeneration in the remaining flowers.

Moreno-Alías et al. [6] determined pistil abortion in six Spanish olive cultivars over three different years to assess the relative impact of genetic and environmental factors and evaluate possible interactions between two different morphological characteristics. Ovule development was found to be high for the Arbequina cultivar, moderate for Hojiblanca and Manzanilla de Sevilla cultivars and low for the Lechin de Sevilla cultivar. In contrast, while staminate flower development was high in these cultivars, the degree of ovary development was low for the 'Empeltre' and 'Morisca' cultivars. Rosatia et al. [7] found that pistil degeneration, expressed as a percentage of staminate flowers, showed a positive correlation with the average ovary mass in different olive cultivars. The absolute number of hermaphrodite flowers per shoot showed a negative correlation with both ovary mass and pistil elimination, while the number of staminate flowers per shoot increased with both parameters.

In olives, the shedding of male flowers begins shortly after full bloom [8], while the abscission of unfertilized hermaphrodite flowers occurs after the flowering period [7]. Rapoport and Rallo [9] investigated the number of defective and perfect flowers in shoots as well as fruit abscission using five 7-year-old 'Manzanilla' trees in Córdoba, Spain.

Cumulative abscission was observed to continue until 25 days after full bloom. The shedding of defective flowers began immediately after full bloom, peaked 8 days after full bloom and continued until the 15<sup>th</sup> day. Hermaphrodite flower or fruit abscission occurred significantly after full bloom, between 10 and 25 days, with the highest abscission observed 13 to 15 days after full bloom. A second abscission (fruit drop) due to competition for nutrients was observed around 18-20 days after full bloom.

Knowledge of fertilization biology is an important issue for increasing yield. Olive plants constitute both female + male flowers (hermaphrodite) and only male flowers. Therefore, it is necessary to determine the number of hermaphrodite flowers that will be effective in yield. This study aimed to determine the hermaphrodite flower ratio of three different olive cultivars over a period of three years in the ecology of Tarsus/Mersin. Additionally, fruit abscission rates in cultivars were determined after fertilization.

## MATERIAL AND METHODS

The aim of this study was to determine the effect of self-pollination and the use of pollinators on fruit set in examined cultivars. Initially, the number of hermaphrodite and male flowers formed on branches was calculated by counting the total number of flowers before their petals opened, while they were in the balloon stage, in bags. Subsequently, at the end of the flowering period, the remaining flowers were counted when the bags were removed. The first count provides the total number of hermaphrodite and male flowers, while the second count only provides the number of hermaphrodite flowers. Following this, fruit set levels during the fruit development period in open, cross (Domat, Gemlik and Sarı Ulak) and self-pollination treatments were determined through monthly fruit counts and monthly fruit set levels were presented in histogram graphs.

Thus, the periods and levels of fruit drop were determined. Additionally, the number of fruits remaining on the tree before harvesting was determined and the percentage fruit set levels were calculated by comparing them with the initial number of flowers introduced into the treatment.

## RESULTS AND DISCUSSION

### *Ratio of Hermaphrodite Flowers (%)*

Prior to flower blooming, the numbers of male and hermaphrodite flowers on shoots were tallied and

their percentages were calculated relative to the total flower count. Table 1 presents the proportions of hermaphrodite flowers for the cultivars examined within the scope of the trial in the years 2017, 2018 and 2019.

Following the counts conducted in 2017, significant differences among cultivars were found in terms of hermaphrodite flower ratios at a statistically significant level of  $p < 0.05$ . The highest proportion, at 51.68%, was observed in the Domat cultivar, which was determined to belong to a distinct group from the others. The hermaphrodite flower ratio for the Gemlik cultivar was 47.13%, while the lowest value was recorded for the Sari Ulak cultivar at 45.82%. No statistically significant difference was observed among mean directions in terms of hermaphrodite flower ratios, with values ranging from 50.75% (West) to 45.82% (North). Regarding the cultivar  $\times$  direction interaction, no statistically significant difference was found among the values, which ranged from 42.03% (Sari Ulak cultivar, North direction) to 53.82% (Domat cultivar, West direction) (Table 1).

In 2018, due to the observed periodicity in the Domat cultivar, the values for this cultivar were not included in the table. Following the conducted counts, no statistical difference was found among the cultivar and direction means, as well as the cultivar  $\times$  direction interaction (Table 1). Upon comparison of cultivars, it was determined that the Sari Ulak cultivar had a higher hermaphrodite flower ratio (60.22%) compared to the Gemlik cultivar (57.81%). The highest value among direction means was determined to be 62.47% (South), while the lowest value was 55.99% (North). Regarding the cultivar  $\times$  period interaction, values ranged from 55.79% (Sari Ulak cultivar, North direction) to 65.47% (Sari Ulak cultivar, South direction).

In the 2019 evaluations, while the mean hermaphrodite flower ratios for cultivars were statistically significant at  $p < 0.001$ , neither the means for directions nor the interaction between cultivar and direction reached statistical significance (Table 1). Among cultivar means, the Domat cultivar exhibited the highest hermaphrodite flower ratio (62.67%), followed by the Sari Ulak cultivar (53.94%), whereas the lowest ratio was observed in the Gemlik cultivar (47.01%). Direction means ranged from the highest of 56.03% (North) to the lowest of 51.20% (East). Regarding the interaction between cultivar and period, the hermaphrodite flower ratio ranged from a minimum of 43.77% (Gemlik cultivar, West direction) to a maximum of 70.73% (Domat cultivar, North direction).

The highest hermaphrodite flower ratios among cultivars were found in the Domat cultivar in 2017

and 2019, while in 2018, it was observed in the Sari Ulak cultivar. Conversely, the lowest ratios were determined to be in the Sari Ulak cultivar in 2017 and in the Gemlik cultivar in 2018 and 2019. Regarding directions, the highest hermaphrodite flower ratios were observed in the West in 2017, in the South in 2018 and in the North in 2019, while the lowest values were detected in the North in 2017 and 2018 and in the East in 2019.

Table 1. Ratio of hermaphrodite flowers (%)<sup>1,2</sup>

Year	Cultivars	Directions				Average
		North	South	East	West	
2017	Domat	50.60	50.65	51.66	53.82	51.68 A
	Gemlik	44.84	49.16	45.26	49.28	47.13 AB
	Sari Ulak	42.03	45.62	46.44	49.18	45.82 B
	Average direction	45.82	48.48	47.79	50.75	
LSDcultivar: 3,756* LSDdirection: N.S. LSD cultivar $\times$ direction: N.S.						
2018	Domat	-	-	-	-	-
	Gemlik	56.18	59.46	55.86	59.75	57.81
	Sari Ulak	55.79	65.47	58.87	60.75	60.22
	Average direction	55.99	62.47	57.36	60.25	
LSDcultivar: N.S. LSDdirection: N.S. LSD cultivar $\times$ direction: N.S.						
2019	Domat	70.73	61.37	57.94	60.66	62.67 A
	Gemlik	47.17	49.21	47.87	43.77	47.01 C
	Sari Ulak	50.18	55.99	47.79	61.80	53.94 B
	Average direction	56.03	55.52	51.20	55.41	
LSDcultivar: 4,421*** LSDdirection: N.S. LSD cultivar $\times$ direction: N.S.						

<sup>1</sup>Angle transformation has been applied in the statistical analysis of percentage values (values in parentheses represent angle values).

<sup>2</sup>Differences indicated by different letters within the same column were found to be statistically significant.

N.S.: Not Significant; \*\*\*Represents  $p < 0.001$ .

Reale et al. [10] reported a correlation between ovary degeneration and starch content in Leccino and Dolce Agogia olive flowers. At this stage, starch grains were only detected in the ovaries, styles and stigmas of hermaphrodite flowers, with no starch accumulation observed in male flowers. In this study, the percentage of staminate (male) flowers was found to be higher in the Dolce Agogia cultivar compared to the Leccino cultivar. The results demonstrate the importance of carbohydrate nutrition, with higher starch content found in hermaphrodite (perfect) flowers compared to staminate (imperfect) flowers.

Reale et al. [11] reported that pistil degeneration in olives can occur at different stages, with functional staminate flowers sometimes containing poorly developed ovaries or ovaries lacking ovules. Additionally, the percentage of imperfect flowers can be higher when there are more flowers on shoots. Similarly, we believe that the tendency of the Sari Ulak cultivar to produce a large number of flowers may lead to a higher incidence of imperfect and button-shaped fruit formation.

Rosatia et al. [7] found a positive correlation between pistil degeneration, expressed as the percentage of staminate flowers and the average ovary mass in different olive cultivars. The absolute

number of hermaphrodite flowers per shoot showed a negative correlation with both ovary mass and pistil elimination, while the number of staminate flowers per shoot increased with both parameters. Mete and Mısırlı [12] conducted full flower counts in the Domat, Edinciksu, Esek, Kilis, Samanlı, Uslu and Arbequina olive cultivars after shedding anthers and corollas and removing the ovaries. The highest full (hermaphrodite) flower formation in both years of the trial was observed in the Arbequina cultivar, while the lowest was in the Esek cultivar. In the cultivars used in our study, the hermaphrodite flower ratio ranged from 45.82% (Sarı Ulak-2017) to 62.67% (Domat-2019), indicating a moderate level of pistil degeneration.

### Monthly Fruit Set Ratios

Monthly fruit set levels were determined by counting the remaining fruits on branches each month until harvest. The values obtained from the counts were then calculated as monthly fruit drop percentages by comparing them to the initial total flower count. These values are presented in histogram form in Figure 1.

Data for the Domat cultivar were collected in 2017 and 2019, while no evaluation could be conducted in

2018 due to the cultivar exhibiting periodicity. Monthly fruit set levels for the Domat cultivar in 2017 are presented in Figure 1. Upon examining the graph, it can be observed that for the Domat cultivar in 2017, the highest fruit drop occurred in June for open pollination, self-pollination, pollination with Gemlik and Sarı Ulak cultivars, with a significant decrease in drop intensity in July. There was minimal drop in August and September. According to the 2019 data, severe fruit drop was observed in June, with minimal drop in July, August and September (Figure 1).

Since the Gemlik cultivar does not exhibit periodicity, fruit was harvested regularly over the three years. Upon examining the graph, it can be seen that in 2017 for the Gemlik cultivar, the highest fruit drop occurred in June for open pollination, self-pollination, pollination with Domat and Sarı Ulak cultivars, with no significant drop observed thereafter. According to the graph, the highest drop in 2018 also occurred in June. While fruit drop continued to some extent in July and August for open pollination, there was little variation in monthly fruit quantity after July for the other treatments. When examining the fruit drop levels for 2019, it was observed that severe fruit drop occurred in June, with no significant drops thereafter.

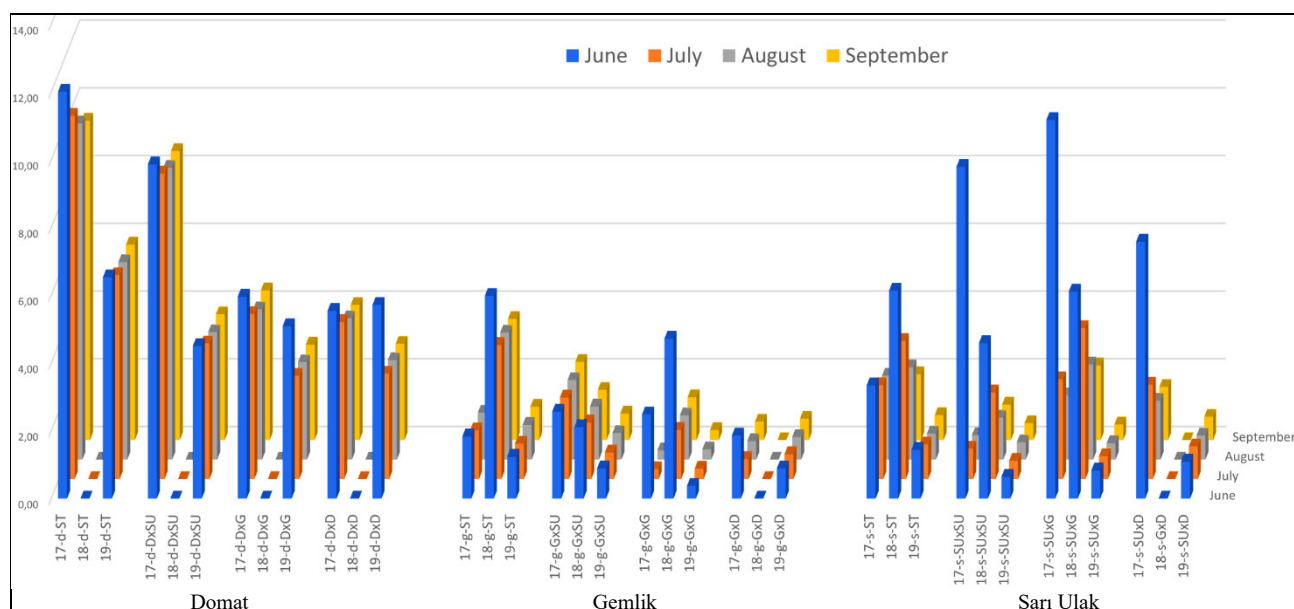


Figure 1. Monthly fruit drop levels for pollination treatments in Domat, Gemlik and Sarı Ulak olive cultivars (OP: Open Pollination, D: Domat, G: Gemlik, SU: Sarı Ulak)

Although the Sarı Ulak cultivar tends to exhibit periodicity, under regular maintenance conditions, it yields fruit annually. In this study, due to well-maintained conditions, fruit was harvested regularly for three years. Upon examination of the graph, it can be seen that for the Sarı Ulak cultivar in 2017, the

highest fruit drop occurred in June for open pollination, self-pollination, pollination with Domat and Gemlik cultivars, with fruit drop continuing in July and August and fruit numbers remaining constant in September. In the self-pollination treatment, there were almost no remaining fruits.

While monitoring monthly fruit numbers, a significant number of button-shaped fruits were encountered and their drop continued until the last month.

Domat cultivar's fruit development at specific intervals is depicted in Figure 2.

Figure 3 displays images related to the fruit development at specific intervals for the Gemlik cultivar.

Images related to the fruit development at specific intervals for the Sarı Ulak cultivar are provided in Figure 4.



Figure 2. Developmental stages of fruits belonging to the Domat cultivar. a. Fruits at 45 days with cartilaginous seeds, b. Fruits at 130 days ready for harvest



Figure 3. Developmental stages of fruits belonging to the Gemlik cultivar. a. Fruits at 30 days, b. Fruits at 45 days, c. Fruits at 70 days, d. Fruits at 90 days

In the trials conducted with the Domat, Gemlik and Sarı Ulak cultivars, it was determined that fruit drop was highest in the self-pollination treatments. In contrast, lower fruit drop was observed in cross-

pollination treatments, indicating a positive effect of pollinator use on fruit retention.

Rallo and Fernández-Escobar [13] reported that fruit drops are generally attributed to competition between the increase in ovary size occurring about 12 to 15 days after full bloom and the fertilized ovaries. In the samples examined, the rate of fertilized ovaries was 22% 8 days after full bloom, which increased to 62% 18 days after full bloom. Consistent with the findings of our study, the highest fruit drop occurred in June, mainly in the form of small fruit drop. During this period, fruit drop due to lack of pollination and nutrition deficiency was observed. It was also noted that during the period of flower drop, which is common in olives, mostly male flowers were shed.



Figure 4. Developmental stages of fruits belonging to the Sarı Ulak cultivar. a. Fruits at 30 days, b. Fruits at 45 days, c. Fruits at 70 days, d. Fruits at 90 days, e. Fruits at 110 days, f. Fruits at 125 days

Abscission is a term referring to the shedding observed in leaves, flowers and fruits. Kadioğlu (2016) states that despite successful pollination, abscission events can occur at different stages of fruit development. According to the researcher, these events can occur in three stages: immediately after

pollination in apples (post-blooming), shortly after general fruit growth (June drop) and during ripening (pre-harvest). In some plant species, periods of fruit drop coincide with decreases in the hormone (auxin) content in the fruit. When auxin levels are high, the fruit drop rate decreases. Among the cultivars in the trial, the highest fruit drops were observed in the Sarı Ulak and Gemlik cultivars. Additionally, in the Domat cultivar, both more and larger fruits were observed.

## CONCLUSION

•It was determined that the period from the opening of the cultivars flowers to the fruit setting stage lasted between 10 to 15 days.

While the ratios of perfect flowers showed similarity across years, the highest ratio was found in the Domat cultivar, followed by the Sarı Ulak and Gemlik cultivars.

•In the pollination trials conducted with the Domat, Gemlik and Sarı Ulak cultivars, it was found that fruit drop was highest in the self-pollination treatments.

•In cross-pollination treatments, less fruit drop was observed compared to self-pollination, indicating a positive effect of pollinator use on fruit retention.

•Among the cultivars examined in the trial, the highest fruit drops were observed in the Sarı Ulak and Gemlik cultivars.

•In the Domat cultivar, however, the fruit drop rate was significantly lower compared to the other two cultivars.

In the Domat olive cultivar, the highest fruit retention was observed in the 17-d-ST and 17-d-D×SU treatments. Generally, no significant difference was observed in fruit retention every 4 months in the Domat olive cultivar, indicating its good adaptation to the region. Despite the low fruit retention in pollination treatments, including self-pollination and hybridization with Sarı Ulak, Gemlik and Domat, no difference was observed in fruit retention among the four months.

In the Gemlik olive cultivar, very low fruit retention was observed in all pollination treatments. The lowest fruit retention was observed in the 19-g-G×G treatment. No difference was observed between the years and months in the Gemlik × Domat treatment.

In the Sarı Ulak olive cultivar, no difference was observed between treatments in 2019. The highest fruit retention in June was observed in the 17-s-SU×SU, 17-s-SU×G and 17-s-SU-D (Sarı Ulak × Sarı Ulak, Sarı Ulak × Gemlik, Sarı Ulak × Domat) treatments, which decreased in other months.

## CONFLICT OF INTEREST

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