Determination of Self-Fertility of the 'Hayat' Olive Cultivar Obtained by Hybridization Breeding

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Geliş Tarihi (Received): 11.01.2016 Kabul Tarihi (Accepted): 17.05.2016

In this study, pollination biology of the 'Hayat' olive cultivar obtained by hybridization breeding was examined. For this reason, applications of free pollination, cross pollination, and self-pollination were performed for 3 subsequent years and self-compatibility and appropriate pollinators of this new cultivar were investigated. For three subsequent years, the highest rates of the fruit set were determined as 2,74%, 2,81%, and 2,14% respectively in free pollination. On the other hand, the lowest rates of fruit set were also determined as 1,53%, 1,79%, and 1,16% respectively in self-pollination. In addition, when self-fertility index and statistical analysis in data obtained from the study were taken into consideration, the 'Hayat' olive cultivar was classified as self-fertile. However, the data also indicated that cross pollination was effective in increasing fruit set. Therefore, it is thought that the use of pollinator cultivar in orchard establishment would be beneficial in terms of yield. Pollen viability and germination tests were performed by using 2,3,5 Triphenyl Tetrazolium Chloride (TTC) and agar in petri (15% sucrose + 1% agar + 100 ppm H_3BO_3) methods in the study. Accordingly, differences were determined between pollen viability and germination rates of examined olive cultivars in terms of both cultivar and years.

Keywords: Olive, fruit set, free- pollination, self- pollination, cross-pollination, pollen grain.

Melezleme Islahı İle Elde Edilmiş 'Hayat' Zeytin Çeşidinin Kendine Verimlilik Durumunun Belirlenmesi

Bu çalışmada melezleme ıslahı ile elde edilmiş 'Hayat' zeytin çeşidinin döllenme biyolojisi incelenmiştir. Bu amaçla 3 yıl süre ile serbest tozlanma, karşılıklı tozlama ve kendileme uygulamaları yapılarak yeni çeşidin kendine verimlilik durumu ve uygun tozlayıcıları araştırılmıştır. Üç yılda da en yüksek meyve tutum oranları sırasıyla % 2,74, % 2,81 ve % 2,14 olarak serbest tozlanmalarda saptanmıştır. Diğer yandan, en düşük meyve tutum oranları ise yine sırasıyla % 1,53, % 1,79 ve % 1,16 ile kendileme uygulamalarında belirlenmiştir. Bununla birlikte, çalışmadan elde edilen verilerde yapılan istatistiksel analizler ve kendine verimlilik indeks dikkate alındığında, 'Hayat' zeytin çeşidi kendine verimli olarak sınıflandırılmıştır. Ancak veriler, yabancı tozlanmanın meyve tutumunu arttırmada etkili olduğunu da göstermektedir. Bu sebeple bahçe tesisinde tozlayıcı çeşit kullanımının verimlilik açısından fayda sağlayacağı düşünülmektedir. Çalışmada, çiçek tozu canlılık ve çimlendirme testleri 2,3,5 Triphenyl Tetrazolium Chlorid (TTC) ve petride agar (% 15 sakkaroz + % 1 agar + 100 ppm H_3BO_3) yöntemleri kullanılarak gerçekleştirilmiştir. Buna göre, incelenen zeytin çeşitlerinin çiçek tozu canlılık ve çimlenme oranları arasında hem çeşit hem de yıllar arasında farklılıklar saptanmıştır.

Anahtar kelimeler: Zeytin, meyve tutumu, serbest tozlanma, kendileme, karşılıklı tozlama, çiçek tozu.

Introduction

Olive was cultivated in Eastern Mediterranean for the first time and has been spread from this region to whole of Mediterranean basin in time. Olive products that are generally used as table olive and olive oil are considered as one of the most important agricultural products of this geography. Olive orchards in Turkey are widespread in Aegean, Mediterranean, and Marmara regions under the influence of Mediterranean climate zone (Öztürk, 2006).

In Turkey olive is cultivated as mono-cultural and some deficiencies are observed regarding the use of pollinator cultivar. Most of the cultivars, which were examined in several studies conducted on self-fertility of olive cultivars, were determined as self-infertile or partially self-fertile. Some researchers also determined that the use of

appropriate pollinator cultivar even in self- fertile cultivars had a positive effect on yield. Regarding this subject, Ferrara et al., (2002) stated that the most important reason for low yield in olive orchards established by using one cultivar was self-incompatibility. In addition, the mechanism of self-incompatibility in olive has been reported to be under the effect of genetic factors and environmental conditions (Lavee et al., 2002). Several studies revealed that the use of pollinator cultivars increased fruit set and emphasized that having pollinator cultivars was necessary for orchard establishment (Lombardo et al., 2006; Vulletin Selak et al., 2006; Farinelli et al., 2008: Mete et al., 2012). 14 cultivars have been examined so far in studies conducted regarding pollination biology of olive cultivars in Turkey. In these studies, it has been determined that Edincik su and Samanlı cultivars are self-fertile; cultivars of Ayvalık, Çakır, Erkence, Gemlik, Memecik, Memeli, Yamalak sarısı, Uslu, and Domat are partially self-fertile; İzmir sofralık, Eşek zeytini (Ödemiş), and Kilis yağlık cultivars are self-infertile (Çavuşoğlu, 1970; Sütçü, 1980; Kaya and Tekintaş 2006; Mete and Mısırlı 2009; Mete et al., 2012).

Hayat is a new olive cultivar, which was obtained by hybridization of Memecik X Gemlik cultivars. The aim of the study was to determine pollen viability rates, pollen germination rates and appropriate pollinators for Hayat cv.

Material and Method

The study was conducted in olive orchard of Olive Research Institute located in Kemalpaşa. Ayvalık, Memecik, Çilli, Gemlik and Sarı Ulak cultivars were used as pollinator for Hayat cultivar. The Hayat olive cultivar is the first cultivar obtained by hybridization breeding in Turkey. It has high fruit weight (6,70 g) and oil content (25,60%).

Applications of free-pollination, self- pollination, and cross-pollination were performed in order to determine the fruit set rate of cultivars. Flowers on inflorescence were counted and labeled on days before anthesis. Labeled offshoots were left out for free pollination and were isolated with the help of sacs for self- pollination and cross-pollination. The number of flowers on the offshoots selected for the applications was not less than 400.

Pollen grains belonging to the cultivars used in cross pollination were obtained with the help of isolation sacs and when approximately 40-50% of flowers bloomed, the first pollination application was carried out by changing isolation sacs and the second pollination application was carried out when 70-80% of the flowers bloomed. Sacs used in isolation were shaken at certain intervals every day in order to increase the chance of pollination. Fruit counts were performed for approximately 150 days after full bloom. Fruit set levels in applications were calculated as % by proportioning the acquired number of fruits to the number of flowers counted at the beginning.

Self-fertility of the Hayat olive cultivar and efficacy of pollinators were calculated according to fertility index (R) formula. The obtained data were assessed by taking Table 1 into consideration (Moutier, 2002).

$$R = \frac{\text{Fruit set rate in self pollinations or cross pollinations}}{\text{Fruit set rate in free pollination}}$$

Table 1. Classification of self-compatibility and pollinators.

Self-fertility				
R	0,00	0,15	0,30	1,00
	Self-incompatible	Partially self-compatible	Self-compatible	

Cross pollination				
R	0,00	0,33	0,66	1,00
	Bad pollinator	Acceptable pollinator	Good pollinator	

After pollen grains required for pollen viability and germination tests were obtained, they were kept at -18 ºC until the tests were performed. The 2,3,5 Triphenyl Tetrazolium Chloride (TTC) tests were applied in order to determine viability level of pollen grains (Norton, 1966). 2 slides were used for each cultivar and randomly chosen 4 areas were counted for this purpose. Counts in TTC test

was carried out 2 hours after planting. Viable pollen grains were stained as red in this test based on staining of pollen grains. While those stained as light red and pink were called as semi-viable, pollen grains which were not stained were called as in-viable. The rate of red-stained viable pollen grains was presented in the study.

Pollen germination tests were performed by using the method of agar in petri. 15% sucrose + 1% agar + 100 ppm H_3BO_3 media were used in order to determine pollen germination rate of the cultivars (Mete et al., 2012).

The setup of the study was based on random blocks test pattern. Statistical analysis of the obtained data was performed by using Student's t test.

Results and Discussion

Pollen viability and germination tests:

It was determined that pollen viability rates of the examined cultivars showed no statistical difference in the first year, and while the lowest pollen viability was observed in the cultivar of Hayat (73,32%), the highest viability rate was observed in the cultivar of Sarı ulak (89,65%). A statistical difference at the level of $p<0.05$ was found in pollen viability rate in the second year and the cultivars were divided into two groups. Accordingly, Gemlik, Hayat, Sarı ulak, Çilli and Ayvalık cultivars were within the same group with pollen viability rates of 93,89%, 91,59 %, 90,97%, 89,56%, and 89,49%, respectively. Pollen viability rate was determined as 73,69% for Memecik cultivar.

There was a difference at the level of $p<0.05$ level in both years in terms of pollen germination rates of the cultivars used in the study. In the first year, the highest pollen germination rate was observed in Memecik cultivar at the rate of 60,74%, the lowest germination rate was determined in Çilli (42,13%), Ayvalık (40,85%), Sarı ulak (38,32%), and Hayat (37,44%) cultivars in the same group. Gemlik cultivar had a germination rate of 49,94%. In the second year, Çilli (77,75%), Sarı ulak (74,95%), and Hayat (72,97%) were found as cultivars with the highest pollen germination rate. These cultivars were followed by Gemlik (59,02%), Memecik (47,62%), and Ayvalık (40,94%).

Differences were found between years and cultivars in terms of pollen viability and germination rates of the cultivars examined in the study. Pinney and Polito, (1990); Wu et al., (2002); Palasciano et al., (2008), Mete et al., (2012) revealed that pollen viability rates were quite variable between olive cultivars. Ferri et al., (2008) reported that pollen viability and germination rates of olive could vary depending on genetic and environmental factors.

Fruit Set: Table 3 shows fruit set rates and fertility index values of different pollination applications performed on Hayat olive cultivar. The statistical analysis carried out on fruit set rates revealed no difference between applications. In addition, when Table 3 was examined, the highest fruit set rate was observed in free pollinations in all the three years. These rates were 2,74% in the 1st year, 2,81% in the 2nd year, and 2,14% in the 3rd year, respectively. Similar results were found in several studies indicating that the highest fruit set rates were obtained from free pollinations (Taheen et al., 1995; Lavee et al., 2002; Moutier, 2002; Farinelli et al., 2006; Lombardo et al., 2006, Mete et al., 2012). Taheen et al., (1995) associated this situation with adverse circumstances in humidity, temperature, and light exposure in isolation sacs or failure of choosing appropriate pollinators.

In the study, the lowest fruit set rates were obtained from self-pollination applications with 1,53%, 1,79%, and 1,16% respectively based on years. However, it was determined above 0,30 (0,56 in 1st year, 0,63 in 2nd year, and 0,54 in 3rd year) in all the three years in terms of self fertility index (R) values and the cultivar was determined to be within self-fertility class.

All of the pollinator cultivars used in the study had a value between fruit set rates obtained from self-pollination and free-pollination. R values of pollinator cultivars were found to be 0,66 and above, at which the class of good pollinator is involved, for all applications.

Self-fertility of the Hayat olive cultivar and effects of pollinators showed some differences by years. Some researchers studying on pollination biology of olive reported that self-fertility and cross pollination could vary based on the effect of environmental conditions (Bradley et al., 1961; Griggs et al., 1975; Androulakis and Loupassaki, 1990; Bartolini and Guerriero, 1995; Lavee et al., 2002). It is thought that this situation could be

arising from studies conducted in different ecological conditions and years. Farinelli et al., (2006) reported that the difference between years in terms of self-compatibility condition could be associated with cultivar, light exposure, temperature, and climate conditions during formation of flower bud and blooming.

Table 2. Pollen viability and germination rates of the Hayat olive cultivar and the other cultivars used as pollinators.

Cultivars	Pollen viability rate (%)		Pollen germination rate (%)	
	1st year	2nd year	1st year	2nd year
Hayat	73,32	91,59 a	37,44 c	72,97 a
Sarı Ulak	88,65	90,97 a	38,32 c	74,95 a
Memecik	84,60	73,69 b	60,74 a	47,62 c
Gemlik	79,78	93,89 a	49,94 b	59,02 b
Ayvalık	75,60	89,49 a	40,85 c	40,94 d
Çilli	74,35	89,56 a	42,13 c	77,75 a

Means were grouped based on Student's t test ($p<0.05$).

Table 3. Fruit set rates of different pollination applications on the Hayat olive cultivar.

Type of Pollination		Fruit set (%)	R	Fruit set (%)	R	Fruit set (%)	R
		1st Year		2nd Year		3rd Year	
	Free pollination	2,74	-	2,81	-	2,14	-
	Self pollination	1,53	0,56	1,79	0,63	1,16	0,54
Pollinators	Ayvalık	2,29	0,83	2,14	0,76	2,06	0,96
	Memecik	1,91	0,70	2,59	0,92	1,91	0,89
	Çilli	2,55	0,93	-	-	1,60	0,75
	Gemlik	2,59	0,95	2,58	0,92	1,47	0,69
	Sarı ulak	2,22	0,81	-	-	1,41	0,66

No statistical difference was found between fruit set rates.

Conclusion

The Hayat olive cultivar was thought to be self-compatible as a result of self-fertility index values and the statistical analysis carried out in the study. However, cross pollination was observed to increase the fruit set compared to self-pollination application. Besides, some researchers expressed the necessity of the use of appropriate pollinator even in the cultivars which are thought to be self-fertile (Lombardo et al., 2006; Mete et al., 2012). In this study, the efficacy of pollinator cultivars varied between years and all the pollinators were involved within the class of good pollinator. In the light of this information, it is thought that it would be appropriate to select one or several of the pollinators, used in the study for orchard establishment, according to preference of producer.

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