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Preliminary Trials on the Reproductive Behaviour of Five Olive Cultivars Conducted in El-jouf Region (KSA)

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ABSTRACT

During the last 15 years, many olive cultivars have been introduced in the Kingdom of Saudi Arabia without any study on their biological and physiological behaviour and characteristics. This work aimed to determine the floral biology and the reproductive behaviour of five olive cultivars planted in Al-Jouf region and to choose the right cultivars adapted to the agro-ecological conditions of KSA. For each cultivar, floral biology in relation to phenological stages and flower quality and fertility behaviour under self and free pollination were determined for each cultivar. Notable significant differences between the cultivars were observed in all characteristics considered. Among the productive characters, all the olive cultivars showed a good productive behaviour with particular interest for 'Picual' and 'Sourani' cultivars. Regarding pollen characteristics, 'Sourani' and 'Picholine' reflected better pollen quality while the evaluation of flower quality and bloom showed good performance in all cultivars except for 'Zaiti' and 'Nabali' cultivars. In all cultivars, a positive response to open pollination was significantly consistent when compared with self pollination. The self-incompatibility index ISI was higher than 0.5 for all cultivars classified them as partially self incompatible cultivars. These results suggest that the five olive cultivars performed well in Al-Jouf conditions with a high phenological variability between cultivars for the parameters evaluated.

Key words: *Olea europaea*, pollen, pollination, self-incompatibility, phenological stages, floral biology, fruit set

INTRODUCTION

Olive industry has emerged as an important sector in KSA. Olive industry has emerged as an important sector in KSA where plantation of olive trees started in 1980. Since then, number of olive plantations have increased and were distributed in the northern parts. They cover now large areas in Al-Jouf (Sakaka, Quarait, Macon, Bousaita), Hail and Tabouk provinces. In 2011, the planted area of olive reached about 23245 ha of olive trees in KSA, out of which 22495 ha (96.77%) in Al-Jouf, Hail and Tabouk, 95% were at the young age of fruiting (less than 10 years) according to the statistics of the MoEP (2010) and Mehri *et al.* (2013). In KSA, olive cultivars have been introduced through the cuttings and the import of young trees from Jordan and Syria, without any study on floral biology and on compatibility relationships for production improvement. Many studies reported that the major factor affecting olive productivity and yield was the insufficient pollination due to self and cross incompatibility. Some olive cultivars such as 'Meski' (Tunisian table cultivar) failed to set satisfactory yields with low and irregular production, most likely due to self-

incompatibility (Mehri *et al.*, 2003). Essays on cultivar compatibility underlined the necessity of cross pollination to improve olive yield and to reduce the production of shotberries in olive cultivars (Griggs *et al.*, 1975). In olive trees, flower sterility appears to be due to gametophytic self-incompatibility as in the 'Manzanille' cultivar (Cuevas and Polito, 1997) and to morphological sterility (pistil abortion) as reported by Rallo *et al.* (1981).

This work aimed studying the floral biology of five olive cultivars planted in Al-Jouf region in order to choose the right cultivars adapted to the agro-ecological conditions of KSA and to elucidate compatibility relationships among the cultivars. For each cultivar, floral biology in relation to phenological stages was studied: bloom evolution, flowering period and flower quality (level of flowering, pistillate inflorescences, viability and germination rates of pollen grains. Also, fertility behaviour under self and free pollination was determined for each cultivar.

The study was conducted in a mixed olive orchard in Al-Watania private company over two successive growing seasons (2009 and 2010) on fifteen years-old trees of five olive cultivars planted in sandy soil. The cultivars concerned are Picholine, Picual, Nabali Mohassen, Sourani and Zaiti.

MATERIELS AND METHODS

Climatic conditions of Al-Jouf: The maximum and minimum temperatures, rainfall and wind speed were recorded for the bloom period (from February to June) of both the years 2009 and 2010.

Plant material: Three plants of each variety were used as three experimental blocks, selected for their uniform size and vigour with high flowering load. All trees received identical management practices (fertilizing, watering, etc.) with normal fertilization and cultural practices recommended in the orchard. Tree spacing was 6 m within rows by 7 m between rows. Irrigation was applied by in-line drippers. The used trees were nearly free from disease free, uniform in their shape and size as possible and in a good condition.

The three trees from each cultivar were selected and treated as a follows.

Flowering characteristics of the studied five olive cultivars

Flower morphology: The phenologic status of productivity for the five cultivars were recorded early for two consecutive years (2009, 2010). Three trees from each cultivar were selected and fifteen bearing shoots per cultivar were tagged. The average number of inflorescences and flowers/shoot, the percentage of perfect flowers was counted at anthesis. The indices level of flowering (number of days to full bloom, total duration of flowering, the starting and ending date of flowering were determined on the basis of phenological stages based on the BBCH scale system of Sanz-Cortes *et al.* (2005): First flowers open (BBCH 60, FO); Full flowering: at least 50% of flowers open (BBCH 65, FF); First petals falling (BBCH 67, PF). Pistillate flowers at Full Bloom (FB), fruit set percentages (fructification percentages 45 days after FB (June) until August were also recorded annually on at least 100 inflorescences of each cultivar. The inflorescences were collected at random throughout the tree, at white button stage, taken from the middle portion of fruiting shoots.

Pollen ability: Freshly pollen was collected from flowers having the same physiological stage (anthesis) from various inflorescences and shoot locations. The pollen of the five olive cultivars was collected from flowers soon after dehiscence of anthers and dried in the laboratory over night. Viability and germination percentages were determined as suggested by Mehri *et al.* (2003) on olive. Viability rate was determined with acetic carmine using five replicates of approximately

100 grains (Pinney and Polito, 1990). A pollen grain was considered germinated when the length of its pollen tube was equal to or exceed its diameter (Stanley and Linkens, 1974). The pollen grains of each cultivar were then cultured on solid medium with 0.7% agar, 20% sucrose, 100 ppm H_3BO_3 (Mehri *et al.*, 2003) at pH 5. All cultures were held in dark at 25°C for 24 h. Counted pollen grains were at least 100 per Petri dish. Pollen germination was determined after 24 h on 20 pollen grains/Petri dish chosen at random from various locations in the pollen sample.

Fertility behaviour of five cultivars: The self fertility behaviour and free pollination requirements of the five cultivars were investigated during 2009, 2010, in the region of Al-Jouf. For self pollination assays, three trees were used and before flower opening, five branches bearing about 200 inflorescences were tagged and isolated using paper bags. Before enclosing, the number of inflorescences per shoot and number of flowers per inflorescence were recorded. When flowers start to open the enclosed branches were hand-shaken to insure pollination. After petal fall and 2 months following, paper bags were removed from all the branches and the fruit counted. This counting was repeated at monthly intervals from June to August and the number of fruits per number of perfect flowers for the enclosed self pollinated and the open pollination ones was determined on each tagged shoot. For open pollination assays, five branches served as controls without using bags. Shoots were allowed to receive pollen from all cultivars present in the field. To evaluate the self fertility of each cultivar tested, the ISI index was calculated as the ratio between the number of fruits in self and open pollination.

For Nabali Mohassen and Zaity olive cultivars, normal fruits and shotberries under self pollination, were determined on each tagged shoots 45 days after bloom (initial fruit set) and before olive harvesting.

Picholine: It is grown in Southern France (Gard) and is the most French table olive industry. it is also known as Coiasses, Coliasse, Fausse. it is considered as a dual purpose cultivar. Picholine tree has notable resistance to drought and average resistance to cold, peacock spot and olive fly. Picholine is an early producer and adapts easily to varied climates and soils. Oil yield average is of 18-20 and 15-18% under non irrigated conditions.

Picual: It is originated from Spain and also known as Marteño, Lopereña, Morcona. it is one of the most cultivated varieties in the world, representing 50% of Spain's olives and trees. Picual is considered to be a rustic cultivar that adapts to diverse environmental conditions. its oil is considered to be of very good quality in Spain with a medium/high oil content (23-28%) and is excellent due to its fatty acid composition and the natural antioxidants Olive with low drought tolerance is tolerant of cold, salinity and excess soil moisture and it is sensitive to verticillium wilt and peacock spot.

Nabali Mohassen Synonyms Improved Nabali, Muhassan, Nabali, Nabali Mohassan, Raseei, Rasie, Rsa'si, Ras'i: It is a dual purpose cultivar largely diffused in the Middle East, having a high oil content (about 30%). The cultivar shows very high tolerance to drought and cold and has a low sensitivity to olive fly and medium tolerance to peacock eye spot.

Sourani (also Maarri, Saurani, Savrani, Sorani Abo Shawki, Sourani) and Zaiti (also Asseel, Helkani, Houlkkani, Khilkhali, Kurdi, Zeiti): These are the main Syrian olive cultivars, covered, respectively 29.4 and 33.13% of total areas (Al Ibrahim *et al.*, 2007). Sourani

olives are used both for dual purpose (table olives and oil), Zaiti olives for oil of high quality. Their oil content was high; 27.3% in Zaiti and 26.3% in Sourani. In Syria, Sourani trees are grown in the regions of Aleppo, Dar'a, Hama, Idleb and Sweida while Zaiti cv. was found in the northern area of Syria (Aleppo).

Statistical analysis: Data from experiments were the mean of three replicates, subjected to analysis of variance to evaluate the differences between cultivars tested:

- For pollination assays, experiments were conducted with 3 replications and each tree was considered as a block and branches as experimental plot
- Data obtained were tested by analysis of variance to determine significant differences between cultivars and years on flowering and fruit set. Standard errors of each mean were calculated and presented in tables as±SE
- For pollen viability and germination, assays were conducted with 3 replicates

Cultivars: The cultivars under study are of different origin and concerned Picholine (from France), Picual (Spain), Nabali Mohassen, Sourani and Zaiti (Syria and Jordan). Olive germplasm (FAO, 2005).

RESULTS AND DISCUSSION

The climatic conditions of Al-Jouf were collected during the 2 growing seasons 2009 and 2010 (from February to June) and concerned maximum, minimum and average temperatures, humidity RH%, precipitation and wind speed (Table 1). The olive orchard, located at Al-Jouf province (North of KSA), is at an altitude of 684 m above sea level, latitude 29.8° N and longitude 40,1°E. The area of Al-Jouf has a semi-arid climate with an average total rainfall of 10.92 mm from February to June 2009 and 18.7 mm in 2010. The region received a very low quantity of rain. The range of maximum temperature minimum temperatures during the bloom period was similar in both years; the average monthly maximum and minimum temperature of 34.1 and 7.8°C in 2009 and 35.7 and 9.6°C in 2010, respectively (Table 1). Wind speed data during the bloom period

Table 1: Temperature, hygrometry, rainfall and wind speed recorded in Al-Jouf conditions from February to June during two seasons 2009 and 2010

	Temperature °C					
Season	Min.	Max.	Mean	Hygrometry (% H)	Rain fall (mm)	Wind speed (km h^{-1})
2009						
February	7.8	21.4	14.5	32.5	7.87	14.3
March	10.2	23.7	17.3	27.4	1.02	16.6
April	15.5	29.7	23	20.9	0.00	15.3
May	20.4	34.1	27.6	21.3	2.03	14.2
June	25.1	39.9	33	11.9	0.00	13.6
2010						
February	9.6	23	16.3	30	2.03	15.5
March	12.8	27	20.1	27	0.00	15.9
April	16.8	31.2	24.3	23	11.60	14.9
May	22.7	35.7	29.1	17	5.08	14.5
June	24.8	39.6	32.7	14.3	0.00	16.4

Source: Climate Al-Jouf-Historical weather

showed that the wind speed was of low intensity and similar in both years (about 15 km h^{-1}), thus ensuring adequate wind movement for pollen dissemination. In Al-Jouf province, the lowest temperature values were enregistered on March of the 2 growing seasons with 10.2 °C in 2009 and 12.8°C in 2010. Climate Al-Jouf-Historical weather (http://www.tutiempo.net/en/Climate/Al-Jouf/403610.htm).

Temperature, relative humidity and wind are the most important factors of olive pollination (Fabbri *et al*., 2004). During bloom period (from February to June) and under Al-Jouf conditions, the extreme cold temperature was 7.8°C and extreme heat temperature (35.7°C). The optimum temperature of 30 with 50% Relative Humidity (RH) was proposed for anther dehiscence in olive. A high temperature had a fast effect on pollen tube growth and stigma may get dry. The relative humidity during experiment varied from 20.9 to 32.5% in 2009 and 17 to 30% in 2010, a good value of RH enhances pollen germination (Fabbri *et al*., 2004). The annual average wind speed varied from 14.3 to 16.6 km h^{-1} during flowering. it is considered as an important factor for the anemophilous species; when wind is strong, pollen was transported away from the orchard and fertilization didn't occur.

Flowering characteristics: Data in Table 2 represents a mean value of 2 years 2009-2010 and showed that there were significant differences in both seasons among cultivars in No. of inflorescences/shoot, No. of flowers/shoot and sex expression (perfect flowers%) but this variation is not significant in perfect flowers rate. In this concern the Nabali Mohassen cv. had significantly values lower than all studied cvs, respectively with 7 flowers/ inflorescence and 1304 flowers/shoot. The highest number of flowers and of inflorescences per shoot were recorded for Sourani with 2688 and 217.4, respectively, but the percent of perfect flowers was the lowest (mean of 57%). The number of flowers per inflorescence was variable among the cultivars with the highest in 'Sourani' (12±2.6) followed by 'Zaiti (10±3.15), Picholine and 'Picual' (9±2.19) and the lowest in 'Nabali Mohassen' (7±1.88) (Table 2). Flower failure in olive trees which is related to pistil abortion, is recognized by small abortive pistils and staminate flowers. The amount of pistil failure was lower in 'Sourani' (57%) and higher in 'Picholine' cv. (69%) with small differences among the trees and the years of study. The effect of year affecting the development of perfect flowers is clear. For Picholine, the perfect flowers percent, ranged from 49.7% in 2009 to 88.31% in 2010 (data not shown). It is in agreement with Mehri and Mehri-Kamoun (2007) who reported that the percentage of fertile flowers differed greatly among cultivars, according to the position of the inflorescence on the shoot, as well as the position of the flower on the inflorescence.

Many studies conducted on olive flowering signaled the high effect of environmental factors during flower formation (Lavee *et al*., 2002) whereas, Freihat and Masadeh (2006) and

Table 2: Flowering characteristics of five olive cultivars during two growing seasons 2009 and 2010, planted in Al-Jouf conditions (KSA)

Cultivars	Mean No of inflorescences/shoot	Mean No of flowers/inflorescence	Mean No. of flowers/shoot	Perfect flowers (%)
Picholine	179.4±12.1	9±2.19	1614.6±9.8	69±7.1
Picual	253.0±7.49	9±4.20	2284±4.21	65±3.4
Nabali Mohassen	186.3±6.51	7±1.88	1304±7.05	65±3.7
Sourani	217.4±7.16	12±2.60	2688± 5.8	57±4.6
Zaiti	158.5±9.15	10±3.15	1575±7.23	59±3.9

Mean±SE: data represent mean values of 2 seasons

Taslimpour *et al.* (2008) consider that the number of flowers in inflorescence is affected by the cultivar and less by environmental conditions.

Several studies have reported the effect of environmental conditions on floral morphology of olive trees. Lavee *et al.* (2002) observed that the proportion of perfect and staminate flowers depends not only on climatic conditions but also on the level of olive production in the previous year. Fabbri *et al.* (2004) suggested that the percentage of perfect flowers in olive vary from year to year, tree to tree, shoot to shoot and inflorescence to inflorescence. While Rallo *et al.* (1981) and Rapoport and Rallo (1991) signaled the effects of environmental conditions on the number of flowers per inflorescence and the proportion of staminate flowers.

Bloom period: Dates of the start of bloom (FO), Full Bloom (FB) and End of Bloom (EB) for each cultivar were recorded for both years 2009 and 2010 in Al-Jouf (Fig. 1a, b). it was observed that most of the cultivars overlapped in their bloom time, although Picholine cultivar flowered late in both years. Bloom time dates for replicate trees of a cultivar were similar, but there were differences in the dates between cultivars. The cultivars 'Picual and Sourani were the earliest to bloom while 'Picholine' was the latest (eight days later). The flowering period of the five cultivars showed little difference between dates of the first appearance of flowers. The difference was about two days (Picual, Sourani) to ten days between Nabali Mohassen, Picholine and Zaiti cvs, in 2009. The flowering period of the five cultivars coincided fully with the bloom period where the onset of bloom period for the different cultivars varied between 18 and 22 days in 2009 and between 15-18 days in 2010. In view of flowering duration, it was observed that the studied

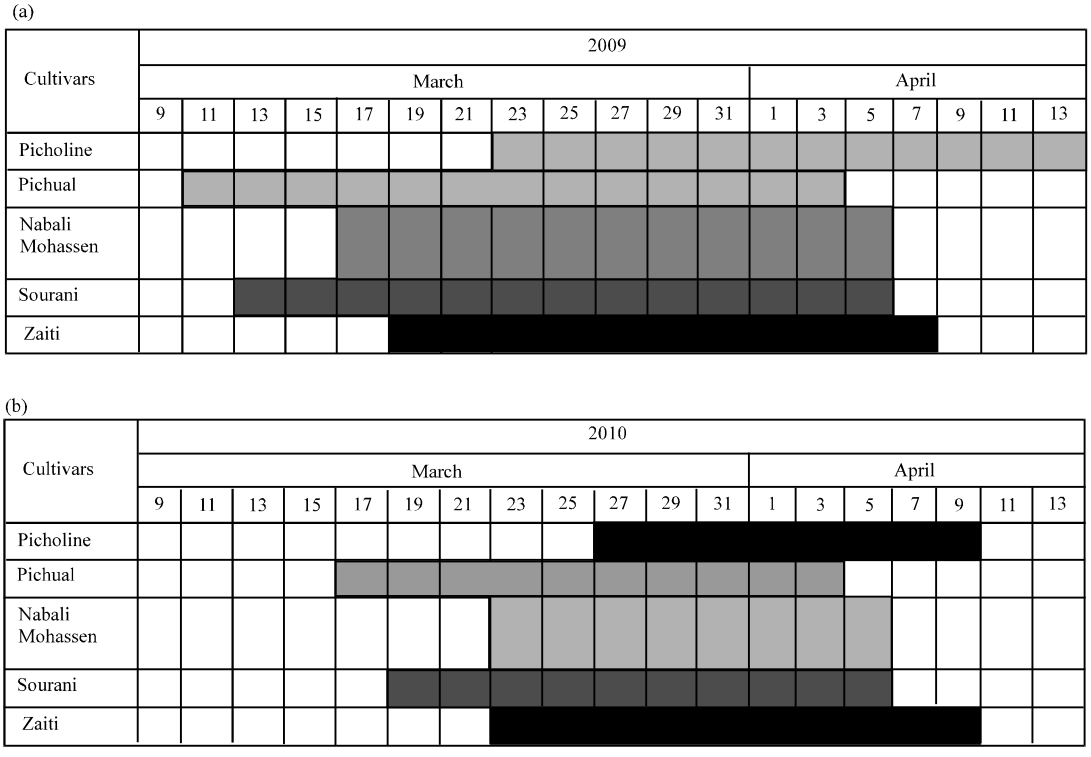

Fig. 1(a-b): Bloom period of five olive cultivars planted in Al-Jouf (KSA) during (a) 2009 growing and (b) 2010 growing season

cultivars overlapped in their bloom time and blooming lasts for about 2-3 weeks. it is in agreement with Griggs *et al.* (1975), who reported that olive blooming lasts for about 2 weeks.

Data illustrated in Fig. 1a and b, showed that blooming started from March 11th and ended at April 13th in the first season, while in second one blooming started from March 16th and ended at April 9th according to different cultivars. The earliest cultivar was Picual cv. followed by Sourani cv. while the latest cultivar was Picholine cv. in both seasons. Furthermore, full bloom of studied olive cultivars started from March 18th till 27th of March in the first season and from 27th March till April 4th in the second season. The earliest cultivar in full bloom was Sourani cv. in 2009 (Fig. 1a) and Picual cv. in 2010 (Fig. 1b) while the latest cultivar in this respect was Picholine cv. in 2009 and 2010 seasons. For Rallo *et al.* (1981), flowering in individual trees lasts for 10 days and in orchards for 20 to 30 days.

Data presented on flowering dates of 5 olive cultivars were recorded over 2 years (Fig. 1a, b). The duration of flowering for an individual cultivar ranged from 18 to 22 days, while differences were recorded between years, both in the onset and duration of flowering. The relative order of flowering time was maintained between the cultivars studied. Differences among cultivars in flower quality has been attributed to physiological and environmental effects but also probably reflect genetic differences as suggested by Bernad e*t al.* (1995) in almond and Cuevas and Polito (1997) in olive cultivars. Previous studies on olive, confirm the strong relationship between flowering periods and climatic trends (Lavee *et al.,* 2002; Orlandi *et al.*, 2010) and indicate that the most important parameter in flowering phenology is temperature (Galan *et al.*, 2001, 2005). Sanz-Cortes *et al.* (2005) found that the start of blooming differed for the cultivars and highlight the importance of recording bloom period to ensure the availability of pollen when the stigma are receptive. Griggs *et al.* (1975) and Ghrisi *et al.* (1999) observed that the bloom dates and duration vary among olive cultivars and between years. However, they observed that in most years the bloom time overlapped sufficiently for adequate pollination.

Pollen: Data presented in Fig. 2 showed that, there were significant differences in the studied cultivars for percentage pollen viability and germination in both seasons. All cultivars had a high degree of pollen viability superior to 50%. Percentage pollen viability observation ranged from 51.21±2.9% in Nabali Mohassen cv. to 88.63±3.8% in Picholine cv. it is clear from these results that Sourani and Picholine cvs. had the highest percentages of pollen viability and germination while Nabali Mohassen and Zaiti cvs had the lowest values. 'Picual' was intermediate. Pollen viability and germination were similar in Nabali Mohassen and Zaiti cvs; pollen viability as determined by acetic carmine test averaged 51.21±2.9% in Nabali Mohassen and 52.17±2.07% in Zaiti cv. whereas pollen germination *in vitro* averaged 18.17±5.6% in Nabali Mohassen and 13.72±5.31% in Zaiti cv. Fernandez-Escobar *et al.* (1983) signaled the importance pollen's ability to germinate: this characteristic appears to fluctuate (*in vitro*) between 12 and 60% in olive.

Generally, it could be concluded that the differences between the pollen vitality and germination of the five olive studied cultivars were highly significant. The viability and germination pollen abilities proved satisfactory for all the tested cultivars except for 'Nabali Mohassen and Zaiti'. These results agreed with those reported by Hegazi (1970), who mentioned that the differences between olive pollens viability were highly significant in different olive cultivars. But other factors must be considered such as the manner of collecting, the effect of pollen conservation and weather conditions during collection.

Many methods have been tested on viability and germination of olive pollen, both to provide a source of pollen for possible yield enhancement by cross-pollination (Griggs *et al.*,1975;

Fernandez-Escobar *et al*., 1983) or for use in research (Pinney and Polito, 1990). This work showed a difference in the performance of the pollen of the five tested cultivars Pollen incompatibility has often been found to be the cause of poor performance of olive crops (Ghrisi *et al*., 1999; Sibbett *et al*., 1992). Under Saudian conditions, 'Nabali and Zaiti cvs.' present the lowest pollen viability and germination (Fig. 2).

Fertility behavior of the five cultivars: Data in Table 3 showed that fruit set in self pollination under Al-Jouf conditions and 45 days after full bloom, was highest in Zaiti cv. (5.1% in 2009 and 5.44% in 2010) and lowest in Nabali Mohassen cv. (less than 1% in the 2 seasons). The average fruit set of Picual under self-pollination in Al-Jouf was 3.99% in the first season and 4.3% in the second season as expressed by the number of perfect flowers.

Compared to self pollination, fruit set under open pollination treatment led to increase in fruit set of all cultivars, during both seasons 2009 and 2010. For each cultivar, fruit sets calculated as the number of fruits per the total number of perfect flowers were different between cultivars and were higher under open pollination than under self pollination. Open pollination enhanced fruit set 2 times in Sourani cv. and 1.5 times in Picholine, Picual, Zaiti cvs. more than self pollination treatment. For Nabali Mohassen cv., fruit set was improved under open pollination but less than 1%. Results achieved in the current study relative to self pollination and to increase in fruit set

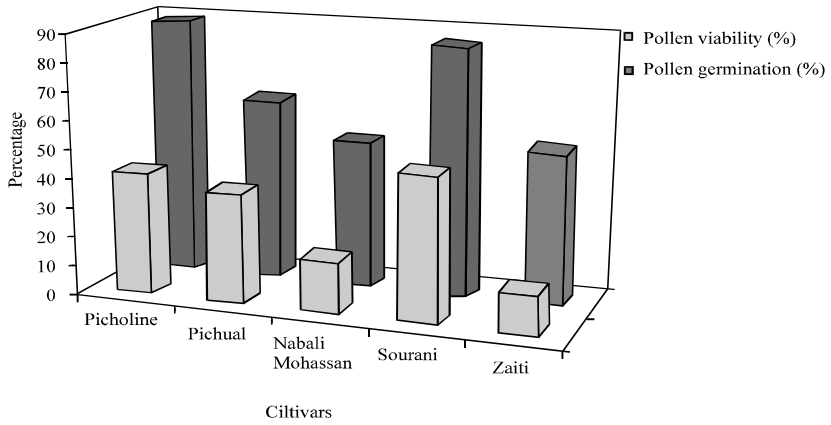

Fig. 2: Pollen viability and germination percentage of five olive cultivars grown in Al-Jouf conditions

Table 3: Fruit set percentage per perfect flowers of 5 olive cultivars planted in Al-Jouf conditions after 20 days of full bloom and during 2 growing seasons

	Fruit set under self-pollination (%)			Fruit set under open pollination (%)			Index of self compatibility (ISI)		
Cultivars	2009	2010	Mean	2009	2010	Mean	2009	2010	Mean
Picholine	4.15	4.05	4.10	5.6	5.76	5.6	0.74	0.70	0.72
Picual	3.99	4.3	4.15	6.95	6.83	6.19	0.55	0.62	0.58
Sourani	2.2	3.1	2.6	4.76	5.45	5.1	0.46	0.56	0.42
Nabali Mohassen	0.45	0.68	0.56	0.76	0.97	0.86	0.59	0.7	0.64
Zaiti	5.1	5.44	5.25	6.5	6.41	6.45	0.78	0.64	0.71

under open pollination confirmed the reports with other olive cultivars (Sibbett *et al.*, 1992; Bini, 1985; Fernandez-Escobar and Gamez-Valledor, 1985; Cuevas and Rallo, 1990; Cuevas and Polito, 1997).

The Self-incompatibility Index (ISI) was calculated to assess the level of SI in the five olive cultivars. The mean values of SI index were different indicating the compatibility at different level between cultivars; it was 0.72 in Picholine, 0.58 in Picual, 0.64 in Nabali Mohassen and Zaiti (0.71) cultivars and lower in Sourani (0.42) (Table 3). Values of ISI low and close to zero, has been suggested by Zapata and Arroyo (1978) to be an indication of completely self-incompatibility. The ISI values between 0.2 and 1, classified the olive cultivars studied as relatively self-incompatible under the Al-Jouf conditions.

For Picual cv., the two-years mean of fruit set percentage under self pollination was 4.15% and the mean average of the self-incompatibility index ISI was 0.58 suggesting being partially self-incompatible under Al-Jouf conditions. While Cuevas *et al.* (2009) advanced that Picual cv. behaved as strongly self-incompatible cultivar in Southern Spain conditions with reduced fruit set under self-pollination (mean ISI of 0.21). This may be due to differences in temperature between Saudi Arabia and Southern Spain at the time of flowering. it is in line with studies on olive compatibility relationship conducted by Sibbett *et al.* (1992) and Caruso *et al.* (1995). They signaled conflicting results, as the same cultivar was found self-compatible in some researches and self-incompatible in others. For Androulakis and Loupassaki (1989) and Lavee *et al.* (2002), pollen-incompatibility is influenced by temperature and varies from environment to environment and from year to year.

The results presented suggest that 'all the cultivars were relatively self-incompatible under the arid-type climatic conditions of Al-Jouf, KSA. More studies are needed to investigate the sexual compatibility relationships between 'Picholine, Picual, Sourani, Nabali Mohassen and Zaiti' by cross pollination assays. More studies are needed to investigate the sexual compatibility relationships between 'Picholine, Picual, Sourani, Nabali Mohassen and Zaiti' by cross pollination treatments.

Self pollinated Nabali Mohassen and Zaiti flowers produced the most shotberry fruits and the lowest number of seeded fruit (Table 3). The fruit set percentage in self pollination of Nabali Mohassen was very poor less than 1% and it is accompanied by an abundance of the parthenocarpic and commercially unless fruit: shotberry. In Zaiti cv., fruit set percentage under self pollination was 5%, 45 days after full bloom, it declined from 5% to 1.9% before harvesting, about 2 months after full bloom, due to falling of shotberries. According to Ayerza and Coates (2004), the production of shotberry fruits may be related to high air temperature reached during anthesis period (41%) or to the low pollen viability. The lowest pollen viability and germination percentages of Nabali and Zaiti cvs. obtained in this experiment can explain the formation of shotberries.

Further work is needed to establish the effect of cross pollination on shotberries production of Nabali Mohassen and Zaiti cultivars under the conditions of Al-Jouf and to determine the most suitable pollinator cultivar to reduce shotberries. Cross pollination has been recommended to improve normal olive fruit set (Lavee and Datt, 1978; Cuevas *et al.,* 2001) and to reduce the production of shotberries in olive cultivars (Griggs *et al.*, 1975). Koubouris *et al.* (2010) signaled the impact of different pollination treatments (self, open and cross pollination) on the degree of shottberry formation of Koroneiki, Kalamata, Mastroidis and Amigdalolia olive cultivars. The number of shottberries declined when other pollen cultivars fertilized Manzanillo cultivar (Sibbett *et al.*, 1992).

This can be explained by the high average maximum temperature in Al-jouf during flowering (35.7°). High temperature during anthesis decreases self-fertilisation by inhibiting pollen tube growth in the style, while cross-fertilisation is considerably less affected (Lavee *et al.,* 2002).

The cultivars Picholine, Picual, Nabali Mohassen, Sourani and Zaiti were described in this study have shown considerable adaptability to local microclimate conditions of Al-Jouf (KSA). They showed a good performance and a good reproductive behaviour with some differences between cultivars. The results of these surveys provided encouraging information for developing all the cultivars except for Zaiti and Nabali Mohassen which present the shotberry phenomenon under self-pollination and a low pollen viability and germination.

Pollination and fruit set parameters in five olive cultivars following self and open pollination were investigated. The latest resulted in a more than 1.5 and 2-fold increase in fruit set over self pollination. But it is important to determine the fruit set associated with cross pollination of one cultivar using pollen grains of the others cultivars present in the experimental grove in order to elucidate compatibility relationships among the cultivars.

The survey of the five olive cultivars under study showed that Sourani olive cultivars recorded the highest values of No. of inflorescences/shoot, No. of flowers/shoot, pollen viability and germination in the two growing seasons 2009 and 2010, respectively. This cultivar can be suggested as pollinator for self-incompatibility olive trees according to its data of flower characteristics and pollen quality in the two growing seasons. 'Sourani' cultivar showed a good performance as pollenizer. The greater viability and germinability of this cultivar coupled with the concordance of the flowering period with the others cultivars; make it more effective as pollinizer. These results suggest that under Saudian conditions, interplanting olive cultivars with 'Sourani' trees or using pollen in a supplementary pollination program can enhance olive productivity in orchards. But the low percentage of perfect flowers of 57% in Sourani can be a negative characteristic in the evaluation of this cultivar as pollinizer because the size of olive crop depends on viable pistillate flower. Bini (1985) considers this morphological sterility due to inadequate development of ovary as a reason of self incompatibility in olive.

CONCLUSION

This study has revealed much about the performance of five cultivars Picholine, Picual, Sourani, Nabali Mohassen and Zaiti under KSA conditions and can be profitably exploited in an olive breeding program. The information derived from this work will be available to improve management of current olive orchards for the development and management of future plantings in Saudi Arabia. This results may resolve the confusion in cultivar identity and may assist olive farmers in cultivar choices. However, more data is required on total yields, on adaptation to mechanical harvesting and resistance to stress environmental factors to have a full data on the cultivar production potential.

The productive characteristics of the five olive cultivars studied showed a good productive behaviour with particular interest for 'Picual and Sourani cultivars. They were described as very suitable in those areas and has shown considerable adaptability to local microclimate conditions of Al-Jouf. Regarding pollen viability and germination, 'Sourani and Picholine reflected better pollen quality while the evaluation of flower quality and bloom revealed the good performance of all cultivars except for 'Zaiti and Nabali Mohassen'. The self fertility behaviour is nearly self compatible with good pollen behaviour which can be used as pollinizer for other olive cultivars which may be self-incompatible in Al-Jouf conditions.

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