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Determining of Growth and Yield Performance in some Olive Cultivars in Warm Conditions

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ABSTRACT: The present study was carried out for three successive seasons 2007, 2008 and 2009 on eight years old of 7 olive cultivars to understand yield performance and growth response to warm and dry environmental condition of Sarpole Zehab, Kermanshah, Iran. The obtained results showed that all measured characteristics were significant different between cultivars. Roghani had the highest height and canopy volume with fewer trunks cross sectional area, while Shenge had the lowest height and canopy volume. Sevillano and Koroneiki produced the highest cumulative yield over a 3-year period. The lowest alternate bearing index (ABI) was from Koroneiki and Sevillano but Baladi, Mari and Roghani had the highest. Fruit weight was from small to medium size in cultivars. The highest flesh to pit ration was observed in Sevillano. Cultivars with the higher fruit dry percent had the higher oil content like Roghani; all evaluated cultivars had low oil percent in warm climate except to Roghani. Generally Zard cultivar with relatively good yield and oil content will be recommended for dual purpose production.

Key Words: Olive (*Olea europaea* L.,); warm climate; oil percent; Iran.

INTRODUCTION

Olive (*Olea europaea* L.) tree is an evergreen native to the Mediterranean region. Some olive genotypes are grown as wild in different region of Iran like Kermanshah province in the west of Iran. There are more than 40 native olive standing genotypes in subtropical region of Kermanshah province like sarpole Zehab, Gilane Gharb and Paveh. In recent years, due to higher olive oil demand, the cultivation of olive has been expanded in various regions of Iran. However, the cultivation of olive tree is limited because of harsh environmental conditions and water scarcity in most of the new olive plantation areas (Arji and Arzani, 2008). The limitation of water as well as long hot summers in the regions lead to poor fruit and oil quality (Khaleghi *et al.,* 2015; Saadati *et al.,* 2013). Despite good vegetative growth, some of the olive varieties do not show good performance. This is due to lack of compatible and stable cultivars in such environmental conditions.

It is very important to know about pedo-climatic requirements and the physiological characteristics of new olive cultivar, before introducing it to an agricultural ecosystem (Bonofiglio, *et al.,* 2008). Some olive cultivars introduced to Dallaho Olive Research Station in Sarpole Zehab west of Iran to evaluate them for adaptability. Many researches were conducted in different regions of Iran to select suitable olive cultivars. Ajamgard and Zeinanloo (2013) investigate comparison of quantitative and qualitative yield of 21 Olive Cultivars in North of Khuzestan Province, Iran. Their results show that Konservolia, Abou-Satal, Koroneiki and X-D had the highest fruit yield than the others. They observed that only S-X variety had about 18% oil in fresh matter and the others had lower olive oil because of warm environmental condition. According to yield performance and table olive quality, Konservolia was introduced for dual purpose production.

Studied indicate that olive genotype show different responses in different regions, So that results of an experiment in two different environmental condition north and west of Iran during five years from 2006 till 2010 with 6 olive cultivars were different. Olive cultivars were Konservolia, Agouromanako, Patrini, Thiaki, Chalkidikis and Megaron. All cultivars had the higher plant height, trunk cross sectional area and plant wide in Sarpole Zehab (longitude: 45º 51´ E, latitude: 34º 30´ N, altitude: 570 m and 20.1°C annual mean temperature) in compare to Taroum (longitude: 50º 49´ E, latitude: 47º 36´ N, altitude: 300 m and 17.6°C annul mean temperature) but oil content and fruit yield was higher in Taroum. Generally, all cultivars had the better performance in Taroum region. Thiaki and Chalkidikis were introduced as oil and dual purpose production respectively in Taroum region (Arji and Norizadeh 2013). Ahmadipour and Arji (2012) report that olive cultivars respond differentially to different microclimate with different elevation where two main Iranian olive cultivars (Zard and Roghani) had the better fruit and oil performance in region with higher elevation. Oil and fruit yield were increased from 300, 570, 810 and 1000m above sea level.

Arji and Bahmanipour (2015) stated that 12 cultivars show different responses in a region like Ivan (longitude: 46º 5´ E, latitude: 33º 55´ N, altitude: 840 m) in Ilam provice of Iran. Zard cultivar was relatively suitable based on oil and fruit yield.

Several research were conducted on different olive cultivars in north (Ramazani Malekroodi *et al.,* 2013), central (Boland Nazar *et al.,* 2013), south east (Taslimpour and Zeinanloo, 2011) and north east (Faridoni *et al.,* 2011) parts of Iran.

The present study was carried out for three successive seasons 2007/2008, 2008/2009 and 2009/2010 on eight years old of 7 olive cultivars to understand adaptability of new introducing olive cultivars under warm environmental condition of Sarpole Zehab of Kermanshah, Iran.

MATERIAL AND METHODS

This experiment was conducted in Dalahv Olive Research Station of Sarpol-e-Zehab (longitude: 45º 51´ E, latitude: 34º 30´ N, altitude: 570 m) to understand adaptability of 7 Iranian and foreign new introducing olive cultivars under warm environmental condition. Cultivars were Roghani, Zard, Shenge, Mari, Baladi, Sevillano and Koroneiki. The trees were planted in 2000, with 6 × 6 spacing distance in a Randomized Complete Block Design with three replication and five trees in each experiment unit. Yield and growth characteristics were measured during 3 successive seasons 2007, 2008 and 2009.

Fruits were harvested in maturity stage and the total yield (kg/tree), fruit weight (g), fruit flesh to pit ratio was determined. Dry weight and moisture content was determined by oven-drying at 80±1°C for 48 h. Oil content was determined by Soxhlet method with 250 ml diethyl ether during 8 h. Alternate bearing index (ABI) was calculated During three successive years 2007 till 2009, using the following equation (Monselise and Goldschmidt 1982):

$$ABI = \frac{1}{n-1} \times \left\{ \frac{a2-a1}{a2+a1} + \frac{a3-a2}{a3+a2} + \bullet\bullet\bullet \frac{an-an-1}{an+an-1} \right\}$$

Where *n* = number of years, and a1, a2... an A, an = yields in the corresponding years.

Plant height, trunk cross sectional area and canopy volume were measured during the experiment. Plant height, trunk diameter and canopy volume were measured in the November of each year. Canopy volume (CV) was calculated based on the formula:

$CV = 4/3\ \pi ab^2$

Where *a* is canopy height/2, and *b* is canopy spread/2 (Westwood 1993).

Recorded data were analyzed by using SAS 13 software and means were compared by LSD ($P<0.05$).

RESULTS AND DISCUSSION

Results show that cultivars were significant for vegetative traits. Roghani and sevillano had the highest height whereas Shenge had the lowest height (Table 1). Canopy volume was higher for Roghani and sevillano and lower for Mari, Zard, Shenge and Koroneiki (Table 1). Mari and Sevillano had the largest trunk cross sectional area while Shenge, Roghani and Zard had the smallest (Table 2). First phase of vegetative growth occur from March to early of July and the second was in the late of September till late of November in our experimental condition. In general vegetative growth of examined cultivars was different and vigorous based of suitable environmental condition (precipitation and favorable temperature) for vegetative growth. According to Arji and Norizadeh (2015) finding, olive trees were vigor in sarpole Zehab condition than the Taroum north part of Iran. In agreement with previous studies conducted in Sarpole Zehab (Arji, *et al.,* 2013) and Arji and Bahmanipour (2015) olive cultivars were significant in growth traits.

Table 1: Olive vegetative growth traits during 2007 till 2009 in Sarpole Zehab of different olive cultivars.

Cultivar	Plant Height (m)			Canopy Volume (m^3)		
	2007	2008	2009	2007	2008	2009
Baladi	3.39c	3.77ab	4.57ab	3.39c	3.77ab	10.54b
Roughani	4.2a	4.3a	4.70a	4.2a	4.3a	14.15a
Zard	3.77b	3.97ab	4.48ab	3.77b	3.97ab	7.26c
Sevillano	4.03a	4.17a	4.65a	4.03a	4.17a	13.21ab
Shenge	3.32c	3.45b	3.97b	3.32c	3.45b	8.6bc
Koroneiki	3.73b	3.99ab	4.10ab	3.73b	3.99ab	8.12bc
Mari	3.66b	3.77ab	4.20ab	3.66b	3.77ab	6.59c

In each column, means with the similar letters are not significantly different at 5% level of probability using LSD

Fruit yield at harvest significantly differed among the cultivars and years (Table 2). Sevillano, Koroneiki and Zard were more stable in fruit production and had the highest yield in compare to the others. The highest cumulative yields over the 3 years were in Sevillano (52.56 kg/tree), Koroneiki (44.4 kg/tree) and Zard (39.65 kg/tree). The lowest cumulative yields over the3 years were in Roghani (19.7 kg/tree) (Fig. 1).

Table 2: Olive Trunk Cross Sectional Area (cm^2) and Fruit Yield (kg/tree) during 2007 till 2009 in Sarpole Zehab of different olive cultivars.

Cultivar	Trunk Cross Area (cm^2)			Fruit Yield (kg/tree)		
	2007	2007	2007	2007	2008	2009
Baladi	138.7abc	142.7bc	175.8b	7.133c	4.500de	21.330a
Roughani	99.18bc	104bc	143.3c	4.500d	3.000e	12.200b
Zard	111.0 bc	120.1bc	150.5bc	8.230c	16.670b	14.750b
Sevillano	153.9ab	160.1ab	198.8ab	10.800b	20.480a	21.370a
Shenge	90.33c	100.3c	138.2c	6.400cd	7.130cd	14.280b
Koroneiki	133.4abc	144.4bc	177.5b	13.330a	16.700b	14.370b
Mari	187.3a	205.5a	230.9a	11.170ab	9.050c	6.930c

In each column, means with the similar letters are not significantly different at 5% level of probability using LSD

Table 3: Olive fruit weight and flesh/pulp ratio during 2007 till 2009 in Sarpole Zehab of different olive cultivars.

Cultivar	Fruit Weight (g)			Flesh/Pulp Ratio		
	2007	2008	2009	2007	2008	2009
Baladi	2.5c	2.2d	2.42d	2.62de	2.5d	3.44b
Roughani	2.48c	3.33b	2.46d	2.94cd	3.04c	4.28a
Zard	4.52a	3.46b	4.15a	4.42b	3.48b	4.33a
Sevillano	4.54a	3.73a	2.82c	5.33a	4.34a	4.31a
Shenge	3.15b	3.72a	3.42b	3.22c	3.55b	4.02a
Koroneiki	0.95d	1.08e	0.5f	2.11e	2.03e	1.43c
Mari	3.2b	2.96c	1.72e	4.48ab	4.41a	3.98a

In each column, means with the similar letters are not significantly different at 5% level of probability using LSD

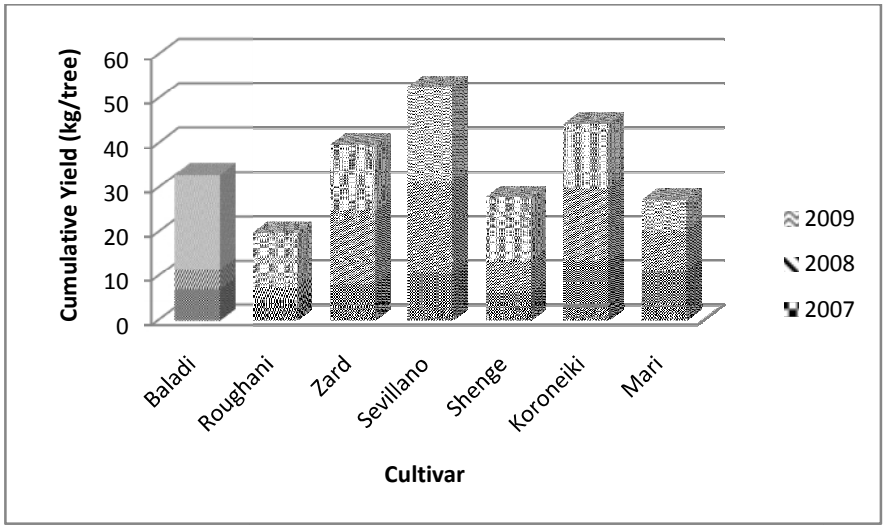

Fig. 1. Cumulative yield of cultivars during 2007-2009.

Arji *et al.* (2012) determined that Konservolia and Sevillano cultivars produced the highest yields in the Sarpole Zehab region. In different region of Kermanshah province, the highest yield was recorded in Zard cultivar in compare to Roghani (Ahmadipour and Arji 2012). Arji and Bahmanipour (2015) in Ivan report Zard cultivar had the highest yield in compare to 11 olive cultivars. Ajamgard and Zeinanloo (2013) in south of Iran reported that there were significant differences between cultivars in productivity and Konservolia, Abou-Satal, Koroneiki and X-D had the higher fruit yield in compare to the others. Several reports exist that there were significant differences between cultivars in fruit yield in different region of Iran (Ramazani Malekroodi *et al.*, 2013; Taslimpour and Zeinanloo, 2011 and Faridoni *et al.*, 2011). Different alternate bearing index (ABI) was recorded in the examined olive cultivars. The highest ABI values were recorded for Baladi, Mari and Roghani while the lowest were for Koroneiki and Sevillano (Fig. 2). The cultivars were higher cumulative performance, lowest alternate bearing index were recorded. This index is very important character in horticultural point of view. As all horticultural practices were the same in examined cultivars, this character is useful to select suitable cultivar in the tested region. According to this index and oil percent Zard were relatively suitable for dual purpose in sarpole Zehab environmental condition.

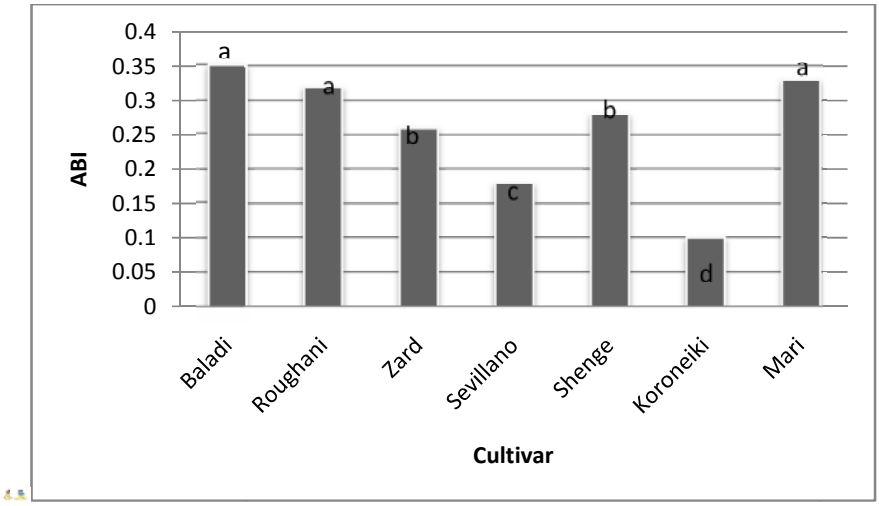

Fig. 2. Alternate Bearing Index (ABI) during 2007 till 2009 in Sarpole Zehab.

Mora *et al.,* (2007) reported that alternate bearing were different significantly among olive cultivars. They recorded mean alternate bearing index from 0.17 to 1 and describe that Coratina (0.18), Leccino (0.17) and Koroneike (0.23) had the lowest alternate bearing index in Illapel, Ovalle and Monte Patria, respectively. They also founded a strong association between fruit production and alternate bearing index. Our results were in agreement with their finding for ABI where Koroneiki had the lowest ABI in Sarpole Zehab. Rallo *et al.* (1994) and Toplu *et al.,* (2009) confirmed that several olive cultivars have different degrees of alternate bearing.

A significant difference was found among the cultivars for fruit fresh weight and flesh to pit ratio during the experiment. Fruit weight were grouped into three classes as follows: small (<2 g), medium (2-4 g) and big (4-6 g) (Anonymous 2008a). The biggest fruits were obtained from Zard and Sevillano whereas the smallest fruits were from Koroneiki with less than 1 g (Table 3). The highest fresh to pit ratio were found by Sevillano, Zard and Mari, while the lowest was determined for Koroneiki (Table 3). Fruit weight and flesh to pit ratio are important for either table or oil production. Oil variety with high fresh to pit ration and higher percent of oil content produce more oil than cultivar with low fresh to pit ratio. Several reports were in the literature on different fruit weight and pulp/pit in olive (Arji *et al.* 2012; Ramazani Malekroodi *et al.,* 2013; Taslimpour and Zeinanloo, 2011 and Faridoni *et al.,* 2011; Arji and Bahmanipour 2015; Arji and Norizadeh 2015).

Fruit dry matter and moisture content (%) were significantly different among cultivars. Roghani had the highest fruit dry matter and the lowest fruit moisture, whereas Sevillano and Shenge had the lowest fruit dry matter and the highest moisture content (Table 4). Lee *et al.* (1983) explained that there are a strong correlation between avocado dry matter percentage (% DM) and oil content. Such strong relationship was reported for some olive cultivars like Frantoio by Mickelbart and James (2003). In our studies this relationship were found for Roghani and Zard cultivars. Oil content can vary according to cultivar, agricultural management and environmental conditions. When oil content calculates on fresh weight basis, it divided into three groups as follows: Low (<18%), medium (18-22%) and high (23-33%) (Anonymous 2008b). Oil content based on dry or fresh weight was significantly different among cultivars (Table 5).

Table 4: Olive Fruit Dry and Moisture (%) during 2007 till 2009 in Sarpole Zehab of different olive cultivars.

Cultivar	Fruit Dry (%)			Fruit Moisture (%)		
	2007	2008	2009	2007	2008	2009
Baladi	**45.83ab**	**32.47e**	**44.49b**	**54.17de**	**67.53a**	**55.51c**
Roughani	**48.17a**	**46.37a**	**48.19a**	**51.83e**	**53.63e**	**51.81d**
Zard	**39.21c**	**44.38ab**	**44.54b**	**60.79bc**	**55.62de**	**55.46c**
Sevillano	**33.3e**	**36.67d**	**35.1d**	**66.67a**	**63.33b**	**64.9a**
Shenge	**35.5d**	**34.73de**	**39.67c**	**64.5ab**	**65.27ab**	**60.33b**
Koroneiki	**44.83ab**	**38.4cd**	**40.22c**	**55.17de**	**61.6bc**	**59.78b**
Mari	**42.17b**	**42.01bc**	**41.85bc**	**57.83cd**	**57.99cd**	**58.15bc**

In each column, means with the similar letters are not significantly different at 5% level of probability using LSD

Table 5: Olive fruit Oil% during 2007 till 2009 in Sarpole Zehab of different olive cultivars.

Cultivar	Fruit Oil in Dry Matter (%)			Fruit Oil in Fresh Matter (%)		
	2007	2008	2009	2007	2008	2009
Baladi	31c	34.07b	34.9c	13.96c	12.84cd	13.84cd
Roughani	42.83a	53.03a	49.1a	20.63a	19.75a	21.07a
Zard	41.43a	38.5b	41.34b	16.42b	16.38b	15.76b
Sevillano	37.17b	32.46b	33.59cd	12.39d	11.89d	11.67e
Shenge	24.33d	35.4b	39.34b	9.38f	12.32d	14.42c
Koroneiki	24.53d	36.83b	34.41cd	11.05e	14.2c	13.28d
Mari	25.27d	28.9b	32.53d	10.65e	12.1 d	13.56cd

Table 6: Meteorological data for Sarpole Zehab, Kermanshah, Iran during the trial period.

Month													
Year	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Agu**	**Sep**	**Oct**	**Nov**	**Dec**	**Mean**
Average of Minimum Temperature (^oC)													
2007	1.5	4.9	6	10	16.8	20.4	23.9	22.6	17.6	14.1	6.8	3	12.3
2008	-0.2	3.1	8.4	12.4	15.6	20.3	23.1	24.2	20.6	14.9	8.8	3	12.8
2009	1.4	5.7	6.7	9.7	15.7	22.1	23.7	21.2	17.5	13.4	8.8	6.4	12.7
Average of Maximum Temperature (^oC)													
2007	13.2	15.5	19.3	23.6	35.1	40.5	41.6	42.1	39	32.9	23.3	16.4	28.6
2008	10.4	16.1	25.8	30.4	33.5	40.1	42.5	43.1	37.6	30.2	21.3	16.9	29
2009	14.6	17.4	20.4	24.4	33.3	39.1	40.6	40.9	34.9	31.5	20.7	17.2	28
Mean Temperature (^oC)													
2007	7.3	10.4	12.6	16.8	26	30.4	32.7	32.4	28.3	23.5	15	9.7	20.4
2008	5.1	9.6	17.1	21.4	24.6	30.2	32.8	33.6	29.1	22.6	15	10	20.9
2009	8	11.8	13.6	17.1	24.5	30.6	32.2	31	26.2	22.5	14.7	11.8	20.3

In each column, means with the similar letters are not significantly different at 5% level of probability using LSD

Table 7: Meteorological data for Sarpole Zehab, Kermanshah, Iran during the trial period.

Month													
Year	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Agu**	**Sep**	**Oct**	**Nov**	**Dec**	**Mean**
Average Relative Humidity %													
2007	71	74	63	61	45	28	26	28	29	38	48	64	48
2008	71	57	50	36	31	22	22	24	32	46	66	57	43
2009	61	65	60	60	39	22	25	25	37	41	71	75	48
Average Precipitation (mm)													Sum
2007	66.5	66	33.8	80.5	22.5	1	0	0	0	0	0	23.3	293.6
2008	81.7	48.7	14.3	1.9	1.9	0	0	0	0.2	90.7	43.4	6.5	289.3
2009	22.7	44.2	30.8	52.1	1	0	0	0	9.6	52.4	86.3	63.5	362.6

The highest oil content based on dry or fresh weight recorded for Roghani and Zard cultivars Oil content varied significantly between cultivars ranging from 9.38% to 21.07%. The highest oil contents were in Roghani (21.07%) whereas the lowest were in Shenge (9.38%) based on fresh weight (Table 5). According to oil content scale all cultivars were located in the low oil content except to Roghani. The olive oil accumulation results from a multivariate interaction in which genotype, environment, and agronomic-dependent factors are involved. The genotype controls genetic traits accounting for the rate pattern of fruit growth, oil accumulation and fruit ripening, while the genotype ×environment interaction changes the rate of fruit growth, oil accumulation and fruit ripening pattern.

Environmental factors, such as temperatures during fruit growth and ripening, water availability and other agronomy practices had influence on fruit growth, oil accumulation and ripening patterns. Arji and Norizadeh (2015) reported that oil content strongly were under environmental conditions. They recorded higher oil content (>48% based on dry matter) for 6 olive cultivars in north part of Iran than the west part (<35% for all cultivars). In this experiment mean maximum temperature were higher than 40°C during Jun, July and August for three successive years (Table 6).

This high temperature coincide by low relative humidity (Table 7) had negative impact on fruit growth and oil accumulation in such environmental conditions. Low oil percentage in all cultivars strongly depends on environmental conditions.

In general based on fruit yield, alternate bearing index and oil content Zard variety was relatively suitable for dual purpose production.

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