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MORPHOLOGICAL AND BIOCHEMICAL ASSESSMENT OF EIGHT OLIVE GENOTYPES GROWING IN POTOHAR REGION OF PAKISTAN

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The present study was conducted to characterize eight olive genotypes (local and exotic) growing in Potohar region (Salt Range) of Pakistan. The genotypes "BARI Zaitoon-I", "Earlik I", "Earlik-II", "Frantoio", "Mariana", "Nocellara", "Naqvi" and "Sorani" were collected from different locations of Potohar. On the basis of morphological attributes, maximum leaf length was observed in genotypes "Mariana" (6.26 cm) and "BARI Zaitoon-1" (6.24 cm), while maximum leaf width was observed in genotypes "Frantoio" (158 cm) and "Naqvi" (153 cm). Regarding fruit weight, maximum fruit weight was measured in "Mariana" (5.41 g) while the minimum fruit weight (0.93 g) was observed in genotype "Earlik II". In biochemical assessment of fatty acids composition, palmitic acid (13.80- 10.12%), palmitoleic acid (2.08-1.03%), oleic acid (77.14-70.47%) and linolenic acid (1-0.21%) were found in mentioned ranges. Similarly, total polyphenols and peroxidase value found in selected genotypes were in following ranges 321-144 mg kg^{-1} and 15-3.03 meq of O_2/kg, respectively. The information from study revealed that biochemical profiling of olive genotypes could be helpful for olive oil processing industry and for breeders to conduct their future breeding programs.

Keywords: Oleaceae, genetic diversity, olive genotypes, Potohar Plateau, fatty acids, oil quality

INTRODUCTION

Olive (*Olea europaea* L.) is an evergreen tree originated from the Mediterranean area (Poljuha *et al.*, 2008). It belongs to family "Oleaceae" consisting of 30 genera and more than 600 species. It is an essential dietary part of the Mediterranean people. Olives are rich source of oils and fatty acids. Olive is a highly cross pollinated plant having a wide range of biodiversity, with more than 1200 genotypes (Bartolini *et al.*,1998). This huge diversity is an important source to develop modern olive genotypes which are enriched in oil (Hegazi *et al.*, 2012). Due to its diversity, olive is successfully cultivated in Mediterranean areas, Arabian peninsulas, temperate areas and subtropical regions of the world. Nowadays, its production is taken into geographical zones which were considered inadmissible areas for olive cultivation like Angola, South Africa, India, Australia, Pakistan and China.

Olive can play its essential role in our country's economy. It is evaluated that Pakistan's aggregate household edible oil use is around 2.9 million tons. Approximately, 67% of this consumption is met by imports. Annually 38 billion rupees are spent for this purpose. Thus, giving careful consideration to increase the olive cultivation in Pakistan can help saving foreign reserve. In Pakistan, domesticated olive is grown commercially on large scale. In Pakistan, it is locally known as Khat (Brahavi), Showan (Pashtu), and Kow (Sindhi, Saraiki and Punjabi) and Zaitoon (Urdu). In the recent decade, a few imported olive cultivars were effectively acclimatized in Peshawar, Kashmir, Swat (KPK), Fort Sandeman (Baluchistan) and in Potohar areas of Punjab. It is estimated that about 45 million olive trees are present in these areas, which showed the huge potential of this crop in Pakistan (Khaliq *et al*., 2019).

Potohar area is an arid region of Pakistan which is enriched with natural vegetation (Akram *et al.*, 2019). Potohar region (Salt range) is a sub mountainous area with arid subtropical climate. Its annual average temperature is 22.3°C while annual average rainfall is 519 mm (http://en.climate-data.org/location/1308/). A minimum and maximum temperature of 2°C and 43°C was recorded in the winters and summer season during this study, respectively. The olive cultivars growing in Potohar Region vary both physiologically, morphologically and variation exists among tree, endocarp, fruit, leaf, oil content, oil attributes, self-fertilizing ability, yield, vulnerability to specific diseases and so forth. However, there is ambiguity and confusion about the characteristics of olive trees developing in this area (Ozkaya *et al.*, 2008). So, the existence of wide hereditary patrimony in olive developing Potohar area requires specific and defined techniques for cultivar characterization and identification (Leva, 2009).

Globally olive cultivars are influenced by soil types and microclimates of an area. Moreover, different climactic and

non-climatic factors including growing practices, cultivars, handling and storing, processing and harvesting time influence the oil attributes of the olive genotypes. Keeping in view the above statements the objectives of the study were to (1) determine variation in olive genotypes based on phenotypic qualitative traits, (2) determine variation in olive genotypes based on morphological quantitative traits, (3) determine the biochemical profiling of olive genotypes (4) find correlation between the olive biochemical traits and (5) provide useful information to breeders about local and exotic genotypes for future breeding programs.

MATERIALS AND METHODS

***Plant materials and experimental sites*:** The study was conducted during year 2014-16, on 8 olive genotypes growing in Potohar region (Salt Range) of Pakistan. The details of these 8 olive genotypes along with their name, collection site, latitude, longitude and elevation are given in Table 1.

***Morphological qualitative parameter*:** For morphological parameters,8-12 years old trees were selected. The trees received custom horticulture practices like pruning, pesticide application and ploughing. Additionally, the trees received two irrigations of water every month. Phenotypic qualitative traits regarding tree, leaf and fruit were evaluated as per "methodology for primary characterization of olive varieties" prescribed by IOC (Barranco *et al.*, 2000).

***Morphological quantitative parameters*:** For quantitative analysis, the parameters like leaf length (cm), leaf width (cm), flowers in inflorescence (number), inflorescence length (cm), fruit weight (g) and pit weight (g)were measured.

***Fruit sampling for biochemical analysis*:** Olive fruits were used to extract oil samples (5 kg for each locality). After harvesting fruit was taken to citrus sanitation laboratory, Institute of Horticultural Sciences, University of Agriculture, Faisalabad through a well-ventilated vehicle on the same day for extraction process. The samples on arrival were stored at 4°C till analysis.

***Oil extraction process*:** The oil from fruit samples was extracted using the methodology defined by Pervez *et al.* (2013).

***Quality chemical indices determination*:** The basic oil quality parameters i.e. free acidity, peroxide value, UV absorptions at 232 nm and 270 nm) were determined as per methodology of European Community Commission Regulation (EEC, 2568/91).

***Total phenol determination*:** Total phenol contents of the olive oil extracts were evaluated according to methodology prescribed by Mateos *et al.* (2001).

***Fatty acid composition*:** Fatty acid composition of each olive oil sample was determined by the official method described by European Community Commission Regulation (EEC/2568/91).

***Statistical Analysis*:** In phenotypic qualitative data, ten fruit characteristics of each olive genotype were observed visually and their mean was taken. In olive quantitative traits, single olive plant genotype was used as an experimental unit and three olive plants were taken as replicates. The experiment was laid out according to Completely Randomized Design (CRD) and differences among means were calculated by Tukey HSD test. While the correlation analysis between olive oil quality characteristics was observed by Pearson Correlation using Statistix8.1 software.

RESULTS

***Morphological qualitative parameter*:** The genotypes showed notable differences in all the morphological quantitative characters (Table 2). In tree growing habit characteristics, the genotypes “BARI Zaitoon-I”, “Earlik-I”, “Nocellara” and “Naqvi” showed spreading habit while the “Earlik-II”, “Frantoio” and “Mariana” showed spreading erect growing habit. Regarding canopy density, “BARI Zaitoon-I”, “Earlik-II”, “Mariana” and “Sorani” exhibited medium tree canopy density as compared to all other genotypes which had medium-dense tree canopy density. Similar vigor (medium) was observed for genotypes “BARI Zaitoon-I”, “Mariana” and “Sorani” while “Earlik-II”, “Frantoio” and “Naqvi” had medium-strong vigor followed by “Earlik-I” and “Nocellara” which showed medium-weak tree vigor, respectively. Regarding leaf shape, “BARI Zaitoon-I”, “Earlik-I”, “Earlik-II”, “Mariana” and “Nocellara” had elliptic-lanceolate leaf shape while elliptic leaf shape was predominant in the remaining three varieties. Elliptic shaped fruit was observed in “Earlik-I”, “Earlik-II”, “Frantoio” and “Naqvi” followed by ovoid in “BARI Zaitoon-

Table 1. Description of genotypes along with collection areas and GPS data.

Genotype	Area	Location	Latitude	Longitude	Elevation
BARI Zaitoon I	Chakwal	BARI Research Station	32.55	72.43	521 m
Earlik-I	Talagang	Chinji National Park	33.04	72.48	386 m
Earlik-II	Balksar	Munday	32.59	72.40	496 m
Frantoio	KalarKahar	ManakPur	32.74	72.70	742 m
Mariana	ChoaSaidan Shah	DalelPur	32.43	72.50	733 m
Nocellara	PindDadan Khan	Sodian Gujjar	32.37	73.03	204 m
Naqvi	Lillah	Kandwal	32.33	72.39	217 m
Sorani	Chakwal	BARI Research Station	32.55	72.43	521 m

Table 2. Morphological qualitative characters of olive genotypes under study collected from Potohar region (Salt range) of Pakistan.

Genotypes	Growing habit	Canopy density	Vigor	Leaf shape	Berry shape	Berry surface	Groves	Purpose to use
BARI Zaitoon-1	Spreading	Medium	Medium	Elliptic-lanceolate	Ovoid	Smooth	Medium	Oil
Earlik I	Spreading	Medium-Dense	Medium-Weak	Elliptic-lanceolate	Elliptic	Smooth	Medium	Oil
Earlik II	Spreading- Erect	Medium	Medium-Strong	Elliptic-lanceolate	Elliptic	Smooth	Medium	Oil
Frantoio	Spreading- Erect	Medium-Dense	Medium-strong	Elliptic	Elliptic	Rugose	Medium	Oil
Mariana	Spreading- Erect	Medium	Medium	Elliptic-lanceolate	Elongated	Rugose	High	Oil
Nocellara	Spreading	Medium-Dense	Medium-Weak	Elliptic-lanceolate	Ovoid	Rugose	Medium	Table
Naqvi	Spreading	Medium-Dense	Medium-Strong	Elliptic	Elliptic	Smooth	Low	Oil
Sorani	Erect	Medium	Medium	Elliptic	Elongated	Smooth	High	Dual

I" and "Nocellara", and elongated in "Mariana" and "Sorani" respectively. Similar trend was obtained with stone surface. Fruit surface was predominantly smooth in five genotypes ("BARI Zaitoon-I", "Earlik-I", "Earlik-II", "Naqvi" and "Sorani") while the other three genotypes ("Frantoio", "Mariana" and "Nocellara") had rugose fruit surface. The groves on pit were medium "BARI Zaitoon-I", "Earlik-I", "BARI Zaitoon-I", "Earlik-II", "Frantoio" and "Nocellara" found in Potohar. For purpose to use six genotypes were suitable as oil purpose, except "Nocellara" and "Sorani" which served for table and dual purpose respectively.

Morphological quantitative parameter: The genotypes showed notable differences in all the morphological qualitative characters considered (Table 3). In leaf characteristics, maximum leaf length was observed in "Mariana" (6.26 cm) whereas minimum leaf length was observed in "Sorani" (4.57 cm). Leaf width was recorded maximum in "Frantoio" (1.58 cm) which was at par with "Naqvi" (1.53 cm). In flowers characteristics, highest flowers per inflorescence were recorded in "Frantoio" (19.16) and lowest in "BARI Zaitoon-I" (7.19) while maximum inflorescence length was recorded in "Naqvi" (3.70 cm) and minimum in "Sorani" (2.45 cm). In fruit parameters, maximum fruit weight was observed in "Mariana" (5.41 g), whereas minimum fruit weight was observed in "Earlik-II" and "Nocellara", having similar fruit weight (0.93 g). Regarding pit character maximum pit weight was recorded in "Bari Zaitoon-I" (0.63 g) followed by "Naqvi" and "Mariana" (0.62 g).

***Oil basic quality parameters*:** Peroxide value, free acidity, and UV absorptions reflect the basic quality parameters for olive oil samples under study (COI/T.15/NC No 3/Rev. 16, December 2016). The values range of peroxide value (11-3.2 meq. O_2 kg^{-1}), free acidity (0.2-0.3 %) and K232 (2.01-2.18 nm) and K270 (0.12-0.25), of the oil samples reveal their high quality and oxidative stability (Fig. 2, 3, 4 and 5**)**. Based on all legitimate quality parameters, it becomes possible to declare all olive oil samples as commercially "virgin" grade, having low peroxide value, free acidity, K232 and K270 values.

The data shown (Fig. 1) demonstrate the total phenolic (TP) compounds in olive oil samples were calculated using Folin–Ciocalteu colorimetric assay. The reported values (144-321 mg gallic acid kg^{-1}) depict a low to an average total phenolic content, inside the parameters defined for virgin olive oils, as reported by Servili and Montedoro (2002).

The fatty acid composition of the oil samples is given in Table 4. For all samples the values depict that distribution of fatty acids portrays standard ranges for virgin olive oil (COI/T.15/NC No 3/Rev. 16, December 2016). The data reveals that olive oil samples have an appreciable amount of oleic acid which was in range of 62-79% and significant levels of essential fatty acids i.e. palmitic (7-20%) and linoleic acid (6-16%). All fatty acids were in accordance with the standard

Table 3. Morphological quantitative characters of olive genotypes under study collected from Potohar region (Salt range) of Pakistan.

Genotypes	Leaf length (cm)	Leaf width (cm)	Flowers in inflorescence (No.)	Inflorescence length (cm)	Fruit weight (g)	Pit weight (g)
BARI Zaitoon-1	6.24 a	1.33 bc	7.19 h	3.04 b	3.05 c	0.63 a
Earlik I	5.72 b	1.31 bc	17.66 c	2.57 cd	1.97 e	0.40 b
Earlik II	5.47 c	1.25 c	17.84 b	2.50 d	0.93 f	0.39 b
Frantoio	6.15 a	1.58 a	19.16 a	3.67 a	2.56 d	0.42 b
Mariana	6.26 a	1.29 c	14.85 g	2.65 b-d	5.41 a	0.62 a
Nocellara	5.71 b	1.38 b	16.43 f	2.98 bc	0.93 f	0.39 b
Naqvi	5.87 b	1.53 a	17.08 e	3.70 a	3.73 b	0.62 a
Sorani	4.57 d	1.12 d	14.73 h	2.45 d	2.34 e	0.33 b

Table 4. Fatty acid composition of olive genotypes under study collected from Potohar region (Salt range) of Pakistan.

Genotypes	Palmitic acid	Palmitoleic acid	Stearic acid	Oleic acid	Linolenic acid	Arachic acid	Eicosenoic acid	Behenic acid
BARI Zaitoon-1	10.88 cd	0.55 f	2.08 d	77.14 a	0.81 b	0.34 d	0.21 c	0.11 c
Earlik I	11.33 c	1.25 d	1.95 e	73.04 bc	1.00 a	0.82 a	0.31 a	0.37 a
Earlik II	10.56 d	1.55 b	2.47 c	74.14 b	0.21 c	0.44 c	0.24 bc	0.04 c
Frantoio	13.39 a	1.03 e	1.95 e	74.83 ab	0.79 b	0.33 d	0.11 d	0.08 c
Mariana	12.53 b	2.08 a	2.79 a	74.02 b	0.76 b	0.54 b	0.28 ab	0.19 b
Nocellara	13.80 a	1.26 d	2.69 b	70.47 c	0.77 b	0.37 d	0.09 de	0.09 c
Naqvi	13.28 a	1.44 c	1.70 f	72.90 bc	0.76 b	0.22 e	0.03 e	0.08 c
Sorani	10.12 e	0.51 f	2.66 b	75.18 ab	0.86 b	0.49 bc	0.02 f	0.08 c

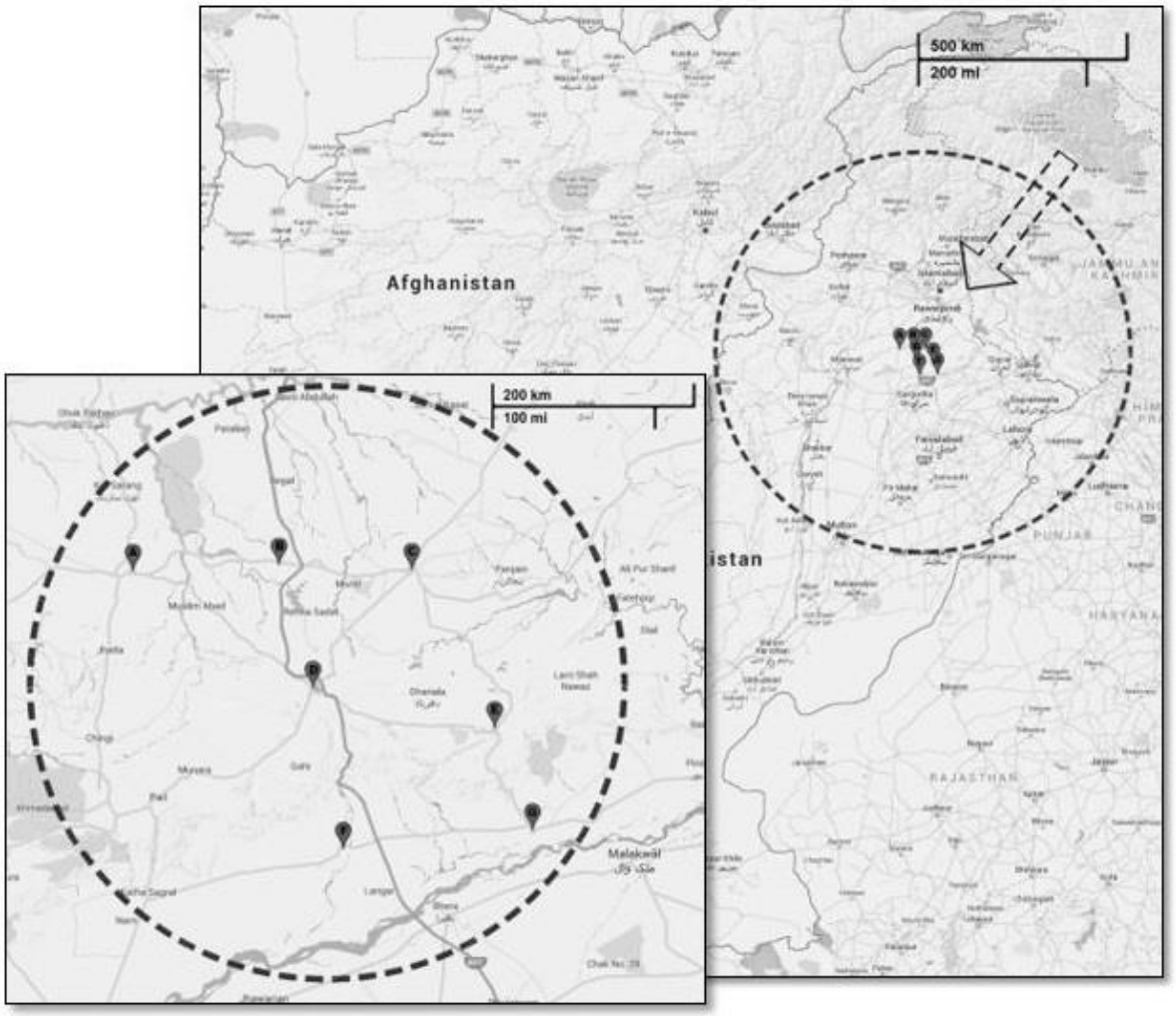

Figure 1. Map for sample collection in Pakistan. A–G locations (A=Talagang, B=Balksar, C=Chakwal, D=KalarKahar, E=ChoaSaidan Shah, F=Lillah and G=PindDadan Khan) are sites where wild olives were collected.

ranges of olive (*Olea europaea*) oils except linolenic acid which was above the fixed percentage (around 1.15% in Earlik I). (COI/T.15/NC No 3/Rev. 16, December 2016).

In our findings, significant correlation was observed in oil quality characteristics of olive genotypes collected from Potohar (Salt range) of Pakistan as shown in Table 5.

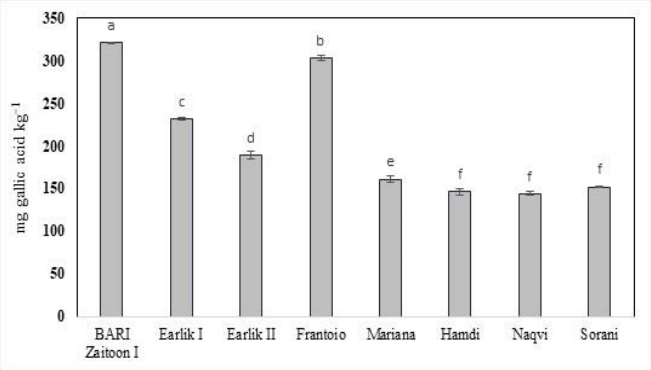

Figure 2. Graph showing total polyphenols in 8 genotypes collected from Potohar Region (Salt Range) of Pakistan.

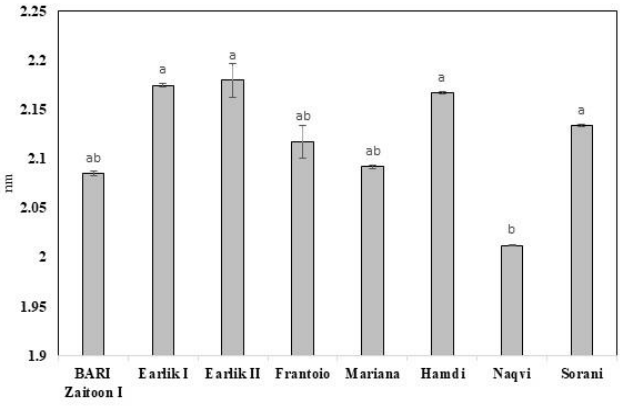

Figure 3. Graph showing spectrophotometric absorption at K232 in 8 genotypes collected from Potohar Region (Salt Range) of Pakistan.

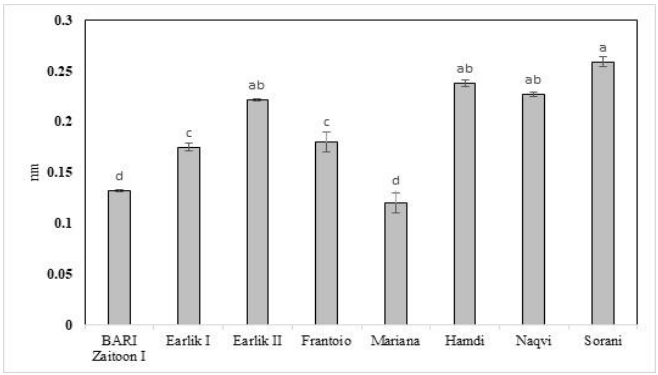

Figure 4. Graph showing spectrophotometric absorption at K270 in 8 genotypes collected from Potohar Region (Salt Range) of Pakistan.

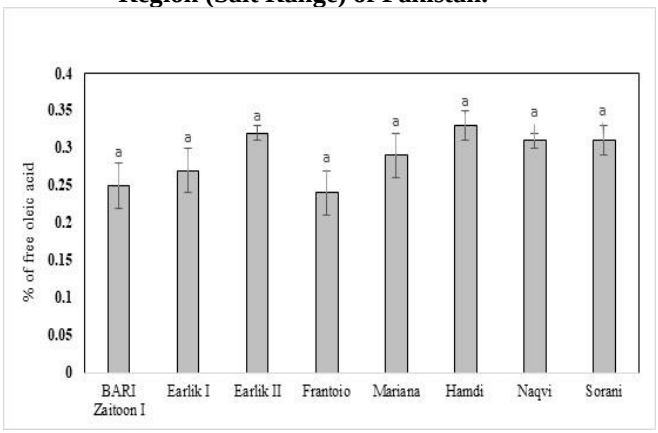

Figure 5. Graph showing free acidity in 8 genotypes collected from Potohar Region (Salt Range) of Pakistan.

Table 5. Pearson's correlation coefficients of oil quality characteristics in 8 grapes genotypes form Potohar region (Salt range) of Pakistan.

	Arachic acid	Behenic acid	Eicos. acid	Free acidity	K232	K270	Linolen. acid	Oil %age	Oleic acid	Palmitic acid	Palmit. acid	Peroxide value	Total polyph.
Behenic acid	0.7153												
Eicosenoic acid	0.4578	0.6042											
Free acidity	0.1908	0.0574	-0.1210										
K232	0.5834	0.1511	0.1959	0.2404									
K270	-0.0388	-0.3892	-0.7736	0.5177	0.2928								
Linolenic acid	0.2013	0.4514	-0.2005	-0.1204	-0.1305	-0.0474							
Oil percentage	-0.0568	0.1065	0.2317	0.2396	0.1435	-0.2672	0.2039						
Oleic acid	0.0239	-0.0423	0.2342	-0.4973	-0.1810	-0.4666	0.1003	0.2509					
Palmitic acid	-0.4093	0.0135	-0.1001	0.1546	-0.2484	-0.0061	0.0256	-0.0454	-0.7075				
Palmitoleic acid	0.0835	0.2771	0.3594	0.3774	-0.1091	-0.1526	-0.3744	-0.2302	-0.5680	0.6105			
Peroxide value	0.2345	0.0347	-0.2420	0.7499	0.1815	0.4740	-0.0200	-0.0225	-0.5949	0.2253	0.4924		
Total polyphenol	-0.1190	0.1022	0.4658	-0.6729	-0.0767	-0.6940	0.1022	0.3677	0.6724	-0.2121	-0.4344	-0.8968	
Stearic acid	0.5294	0.0241	0.0840	0.4500	0.6178	0.2125	-0.0776	0.2153	-0.1709	-0.2426	0.0832	0.6773	-0.4314

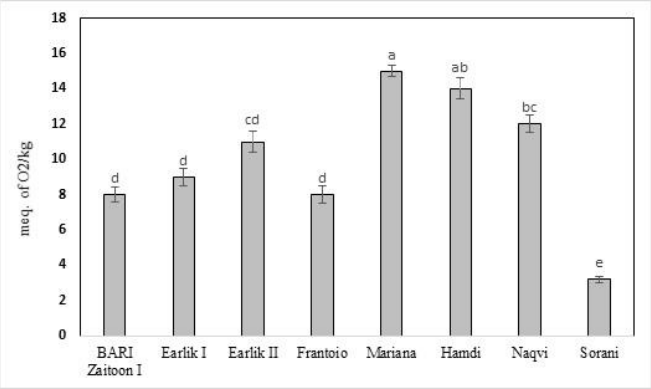

Figure 6. Graph showing peroxide value in 8 genotypes collected from Potohar Region (Salt Range) of Pakistan.

In these olive oil traits, free acidity showed a strong positive correlation (r = 0.7499) with peroxide value. Similarly, behenic acid also showed strong positive correlation (r = 0.7153) with arachic acid. However, total polyphenols showed its positive correlation (r = 0.6724) with oleic acid while it showed its highest negative correlation (r = -0.8968) with peroxide value. The other highest negative correlation (r = -0.7736) was observed between ficosenoic acid and K270.

DISCUSSION

There are numerous distinguishing techniques that are used in olive trees to evaluate its diversity. Among them morphological and biochemical techniques are of great concern. In morphological techniques, there are certain qualitative and quantitative traits that can be assessed only through physical observations like agronomic traits (Kareem *et al*., 2018; Nafees *et al*., 2015, 2017, 2018, 2020; Sharief *et al*., 2019). These traits are of great significance as they are used for breeding programs to improve existing genotypes (Haider *et al*., 2015; Naqvi *et al*., 2015; Akram *et al*., 2019). In fruit plants, the climatic conditions like rainfall, temperature and humidity play their significant role in fruit qualitative and quantitative attributes (Haider *et al*., 2018; Akram *et al.*, 2020), and in olives, climatic condition affects its oil composition (Qarnifa *et al.*, 2019; Romero *et al.*, 2016). All the olive genotypes grown under Potohar region of Pakistan showed significant variations in qualitative traits like growing habit, canopy density and tree vigor. In our study, the genotype "Sorani" showed erect growing habit while all others genotypes "BARI aitoon-I", "Earlik-I", "Nocellara" and "Naqvi" showed spreading while genotypes "Earlik-II", "Frantoio" and "Mariana" showed spreading erect growing habit.As far as tree canopy density and vigor characteristics are concerned most of the genotype had medium to medium dense canopy density and had medium weak to medium strong vigor. These characteristics depend upon the genetic makeup of an organism as similar in olive trees. Our findings were in consonance with those of Ebiad and Abu-Qaoud (2014) who found most of the olive genotypes had medium vigor, spreading growth habit and medium canopy density in his study.

The leaf shape commonly observed in olive genotypes growing on Potohar region of Pakistan had elliptic-lanceolate and elliptic shapes. The results are in league with the outcomes of Al-Ruqaie *et al.* (2016) who reported similar results in 8 olive genotypes grown in Saudi Arabia. However, berry shape was the great varying trait of olive genotypes grown in this area. The genotypes 'Earlik-I", "Earlik-II", "Frantoio" and "Naqvi" growing in this region had elliptic while genotypes "BARI Zaitoon-I" and "Nocellara" had ovoid elliptic and "Mariana" and "Sorani" had elongated shapes. This characteristic is considered most suitable character for discriminating genotypes. These morphological results were also in consistent to other investigators (Hannachi *et al.*, 2008 and Poljuha *et al.*, 2008). The results were like those of Fayek *et al.* (2014) who reported similar results while comparing Egyptian olive clones with the international genotypes. A smooth fruit surface with medium grooves on pit was predominantly found in most of studied olive genotypes. Similar differences in seed of olive genotypes were also reported by Hartmann and Papaioannou (1971), Fouad *et al.* (1992), Del Rio and Caballero (2008) and Fayek *et al.* (2014). However, some stone characteristics can fluctuate due to external environmental factors (Poljuha, 2008) and the fruit maturity characters varies with climatic conditions, cultivation practices and with cultivation zone (Gharbi *et al*., 2015).

In quantitative attributes, huge variations were observed in leaf length, leaf width, flowers in inflorescence, inflorescence length, fruit weight, and pit weight parameter of selected olive genotypes. The variations in these traits may be due to exogenous factors including environmental (temperature, light, humidity & precipitation) or may be due to cultivation technology (fertilizers and cultural practices) (Shahzad *et al*., 2013; Mahmood *et al*., 2014). The variations in fruit weight and pit weight are of extreme importance as the traits are the agronomic traits and are required for breeders to improve genotypes production.

In the world, olives are grown for oil, table or for dual purpose. In Potohar region of Pakistan, "Nocellara" was the only genotype which was used for table purpose while another genotype "Sorani" was used for both table and oil (dual) purpose. The remaining all genotypes in this area were growing for oil purpose. In the world, the increasing trend of growing oil genotypes is for oil consumption due to increase in consumption pattern and higher consumer demand for oil usage. Trentacoste and Puertas (2011) also reported that in Mendoza province of Argentina 61 olive accession were grown by farmers, most of which were used for oil purpose and least of them were used for dual purpose.

Sensory characteristics bitterness and pungency mainly depends upon the phenolic compounds present in the oil. The intensities of pungency and bitterness in the cultivars varies with the concentration of phenolic compounds in cultivars (Pedan *et al.*, 2019). Olive genotypes are classified as extra virgin olive oil as per classification parameters cited by Boskou (2006). The parameter values (acidity, peroxide value, absorbencies in ultra-violet, fatty acid composition) are used to evaluate oil quality were within the IOC trade standards. The total polyphenols recorded in olive genotypes grown in Potohar were in range of 144-321 mg gallic acid kg^{-1}. The results were in resemblance with the findings of Del Carlo *et al.* (2004) who pointed out that virgin olive oil stability against oxidation is due to the presence of phenolic substance. The results were comparable to the finding of Ocakoğlu *et al*. (2009) who reported that the origin of plantation effects the phenolic contents even in oils of that variety.

Similarly, the fatty acid profile of the cultivars revealed that oleic acid and palmitic acid are most abundant fatty acids followed by linoleic acid, palmitoleic acid, stearic acid. Similar findings were observed by Talantikite and Aitamas (1998) who reported that oleic acid was the most abundant monounsaturated fat present in olive genotypes and its concentration varies with genotypes. It contributes in maintaining oil quality and stability. The variation in oleic acid is affected with fruit ripening stages and with the geographical location (Qarnifa *et al.*, 2019). Moreover, genotype is one of the main factors affecting the composition of fatty acids in olive oil instead of sampling site, maturity and various other factors. The concentration of saturated and unsaturated fatty acid is also affected by ecological factors like genotype, temperature and precipitation (Esmaeili *et al.*, 2012). The difference in oil composition may be due to the different fruit ripening stages (Inglese *et al.*, 2009).

All the oil characteristics studied in olive genotypes grown in Potohar region of Pakistan were in accordance with trade standards of IOC. Similarly, good number of flowers in inflorescence were observed in the selected genotypes which indicates that these genotypes had high ability to produce commercial profitable crop (Mehri and Mehri, 2007; Hannachi and Marzouk, 2012). In Potohar climate of Pakistan, the genotype "Mariania" showed highest fruit weight and oil content of Mariana confirm its suitability to be used for oil purpose cultivars. The high fruit weight, pit weight and fatty acids concentration which confirms its suitability that it can be used as oil purpose.

Conclusion: Results of this study has provided important information about olive germplasm grown in Potohar region of Pakistan. The morphological agronomic traits observed in this study are helpful for breeders to evaluate and develop elite olive genotypes. Moreover, a detail biochemical profiling including fatty acid composition of olive genotypes will be helpful to promote Pakistan olive oil industry. Overall, the genotype "Mariana" showed highest fruit weight and maximum fatty acid composition which showed that this genotype has a great future potential and is performing very well under semi-arid climatic condition of Potohar.

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