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INFLUENCE OF AGRO-CLIMATIC CONDITIONS ON FRUIT YIELD AND OIL CONTENT OF OLIVE CULTIVARS

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The influence of agro-climatic conditions on fruit yield and oil content of olive cultivars, i.e. Coratina, Pendallino and Leccino was investigated at two locations, Sangbhatti and Chakwal, during 2008 and 2009. Cultivars, Leccino had the highest number of fruits (7995 per tree), fruit yield (12.57 kg per tree) and oil content (7.04%), while cultivar Pendallino had the highest fruit set (12.67%) and cultivar Coratina had the highest fruit size (2.02 cm) at both locations. Pendallino ranked second to Leccino in number of fruits (5376per tree),fruit size (1.99 cm), and fruit yield (11.34 kg/tree) and oil content (6.53%). The number of fruits per tree, fruit set and oil content was higher at Chakwal location as compared to Sangbhatti. By contrast, the fruit size and fruit yield were higher at Sangbhatti location. Cultivar Coratina had the maximum fruit size but least oil content among the three cultivars studied. The interaction between C×L and C×L×Y significantly affected the fruit set, number of fruit, fruit size, fruit yield and oil content, while C×Y had significant affect on fruit set, number of fruit, fruit size and oil content. The interaction between L×Y also significant affected the fruit set and oil content. Cultivar Leccino is recommended for higher production of fruits and oil content at both the locations.
Keywords: Agro-climate, olive cultivars, yield, oil content.

INTRODUCTION

Olive (*Olea europaea* L.) is one of the ancient cultivated fruit crops that are domesticated about 6500 years ago (Loukas and Krimbas, 1983). The average annual olive production during 1998-2001 was above 15 metric tons around the world in which the Mediterranean region contributed more than 98% (FAOSTAT, 2003). Spain is the leading producer, accounting for 30% of total world olive production(Ashraf *et al.,* 2004). Olive is a medium sized to tall evergreen tree that can reach a height of 15 m or more. It is a robust tree capable of regenerating if cut or injured above ground and may live for centuries while maintaining good productivity (Pietro and Carlo, 2002). The monoecious olive tree produces small yellow-green flowers in inflorescences with 15-30 small flowers. The flowers are of two types, i.e. perfect flowers are hermaphrodite or bisexual flowers and staminiferous or male flowers. Fruits usually develop on the previous year shoots (Simmonds, 1976).Olive fruit is drupe or stone fruit which contains one seed surrounded by three main tissues, i.e. endocarp (pit), mesocarp (pulp or flesh) and exocarp (skin), collectively called the pericarp (Diego *et al.,* 2004). Since olive can grown on marginal and waste land, undesirable for other crops, cultivation of olive may contribute significantly to the economy of a country (Baloch, 1994) and may provide employment for rural peoples and help in poverty alleviation (Pietro and Carlo, 2002). Olive is commercially produced in belts between 30-45^{o} North and South of equator (Ehsan-Ullah*et al.,* 2012). Pakistan, being located in the same region has good potentials for olive cultivation in the subtropical mountainous region of Khyber Pakhtunkhwa and Balochistan provinces (Baloch, 1994).Olive is a subtropical evergreen tree that requires chilling for fruiting stage (Christakis *et al.,*1980). The selection of right cultivar is essential for yield and oil content (Fabrizia, 2012) because most olive varieties are self-fertilizing but some are self-sterile and need cross-pollination. Cross-pollination is increase the yield in olive (Lavee *et al*., 1996) but pollinizer variety should have overlapping bloom period with the main commercial variety (Lavee, 2006). Cutting length affects olive growth (Awan*et al*., 2012). In addition the flowering and fruit set also depend on the temperature during flowering Koubouris*et al.* (2010). Hence, the performance olive cultivars i.e. fruit yield, fruit size and oil content may vary in different locations (Lavee and Wodner, 2004; Padula*et al.*, 2008). The present experiment was, therefore, carried out to investigate the performance of three olive cultivars for yield and oil content of the olive fruit.

MATERIALS AND METHODS

The influence of agro-climatic conditions on fruit yield and oil content of three olive cultivars viz. Coratina, Pendallino and Leccino was investigated at two ecological zones, Sangbhatti (Mardan) and Chakwal, of Pakistan during two consecutive years i.e. 2008 and 2009. The experiment was laid out in a three factorial Randomized Complete Block design (RCBD) replicated three times. Three 7 years old

trees for each cultivar were randomly selected in each treatment at both locations.

Location Sangbhatti is situated in district Mardan of Khyber Pakhtunkhwa province. The soil conditions of experimental site are described in Table 1. It has an altitude of 364 m with an average summer temperature around 45°C, and minimum winter of 0°C and mean relative humidity of about 65%. The Chakwal location has an altitude of 610 m, with average summer temperature of 40°C and the lowest winter temperature of -4°Cand 75% relative humidity. Average annual meteorological data is presented in Table 2.

Table 1. Soil physio-chemical status of Sangbhatti and Chakwal experimental sites

Type/Quantities	Unit	Sangbhatti	Chakwal
Texture class	---	Silt loam	Sandy clay loam
pH	---	7.00	8.00
Organic matter	%	0.55	0.56
Nitrogen	%	0.03	0.03
Phosphorus	ppm	5.52	11.40
Potassium	ppm	59.33	148
Electrical conductivity	dSm^{-1}	0.23	0.65

Source: Soil and Plant Nutrition Directorate, Agricultural Research Institute Tarnab (2008)

Table 2. Average annual meteorological data at both experimental locations during 2008 and 2009

Location	Max. Temp. (°C)	Min. Temp. (°C)	Rainfall (mm)	Relative Humidity (%)
Sangbhatti 2008	27.9	14.5	200.8	58.8
Sangbhatti 2009	26.1	16.1	220.9	70.7
Chakwal 2008	25.4	11.3	220.0	65.1
Chakwal 2009	23.3	10.7	240.8	73.1

The data were recorded on percent fruit set, number of fruits $plant^{-1}$,fruit size (cm), fruit yield $tree^{-1}$ (kg) and oil content.

***Fruit set (%)*:** The flower initiation in Chakwal was started in late March, while in Sangbhatti it was started in early March. The data for fruit set percentage was recorded by counting the number of flowers of each cultivar and the fruit set percentage was calculated by the following formula.

$$\text{Fruit set (\%)} = \frac{\text{Number of set fruit}}{\text{Total number of flowers}} \times 100$$

***Number of fruits per plant*:**The number of fruits per plant was estimated by counting the total number of fruits in the whole treatment and then average number of fruit per plant was calculated.

***Fruit size*:** Fruit size was recorded by randomly taking 30 fruits from each treatment and then their individual size was measured with the help of Vernier caliper and average fruit size was calculated, thereafter, by following formula as described by Mukhtar*et al*. (2004).

$$\text{Fruit size (cm)} = \frac{\text{Fruit length} + \text{Fruit breadth}}{2}$$

***Fruit yield per tree*:** The fruit yield per tree was estimated by harvesting all the fruits from each tree in each treatment, weighed and then average fruit yield tree was computed.

***Oil content (%)*:** The oil content was estimated by taking 15 kg fruits as a sample from each treatment and replications. Then oil from the fruit was extracted with an olive oil extraction unit and the percentage of oil was determined by the following formula:

$$\text{Oil percentage} = \frac{\text{Oil obtained (lit)}}{\text{Total number of fruits extracted (kg)}} \text{x}100$$

***Statistical analysis*:** The data were statistically analyzed using analysis of variance technique appropriate for randomized complete block design (Steel and Torrie, 1980). The significant means (main effects) were separated using Fischer's Protected LSD test. The interactions effects are represented graphically using MS excel.

RESULTS AND DISCUSSION

***Fruit Set (%)*:** Fruit set (%) was significantly affected by location (L), year (Y) and interaction C×L (Fig. 1a), C×Y (Fig. 2a), L×Y (Fig. 3a) and C×L×Y (Fig. 4a), whereas cultivars had no significant effect on fruit set percentage. The fruit set percentage was higher in year 2008 (12.81%) as compared to year 2009 (11.02%). The fruit set percentage was higher (13.01%) at Chakwal compared to (10.82%) at Sangbhatti (Table 3).

Table 3. Effect of different olive cultivars, locations and their interaction on fruit set (%), fruit $tree^{-1}$ and fruit size (cm)during years 2008 and 2009.

Factors	Varieties	Fruit set (%)	Fruits $tree^{-1}$	Fruit size (cm)
Locations	Sangbhatti	10.82b	4091 b	2.34a
	Chakwal	13.01a	7433 a	1.45b
	Significance			
Cultivars	Leccino	11.56	7995 a	1.68b
	Pendallino	12.67	5376 b	1.99a
	Coratina	11.51	3915 c	2.02a
	LSD	NS	350	0.05
Years	2008	12.81a	4985 b	1.92
	2009	11.02b	6539 a	1.86

The reason may be due to the difference in soil fertility, moisture availability, and management practices (Table 1) (Laveeet *al.,* 1996). Pendallino had higher fruit set percentage (12.67%), followed by Leccino (11.56%), whereas Coratina resulted in minimum fruit set percentage (11.51%). Fruit set percentage of olive may be used as

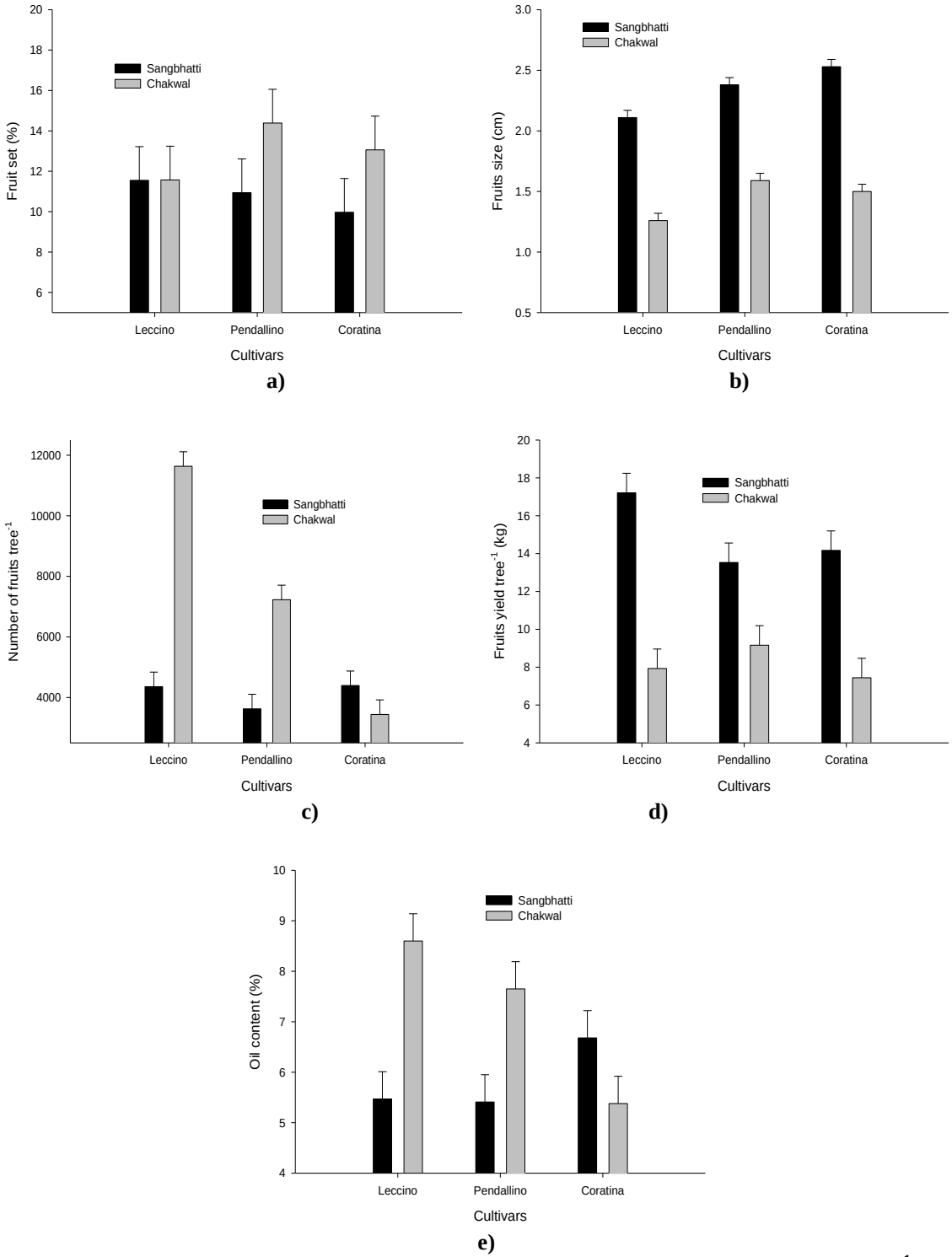

Figure 1. Influence of cultivars and locations (C×L) on a) fruit set b) fruit size c) number of fruits tree^{-1} d) fruit yield tree^{-1}(kg) and e) oil content (%) of olive.

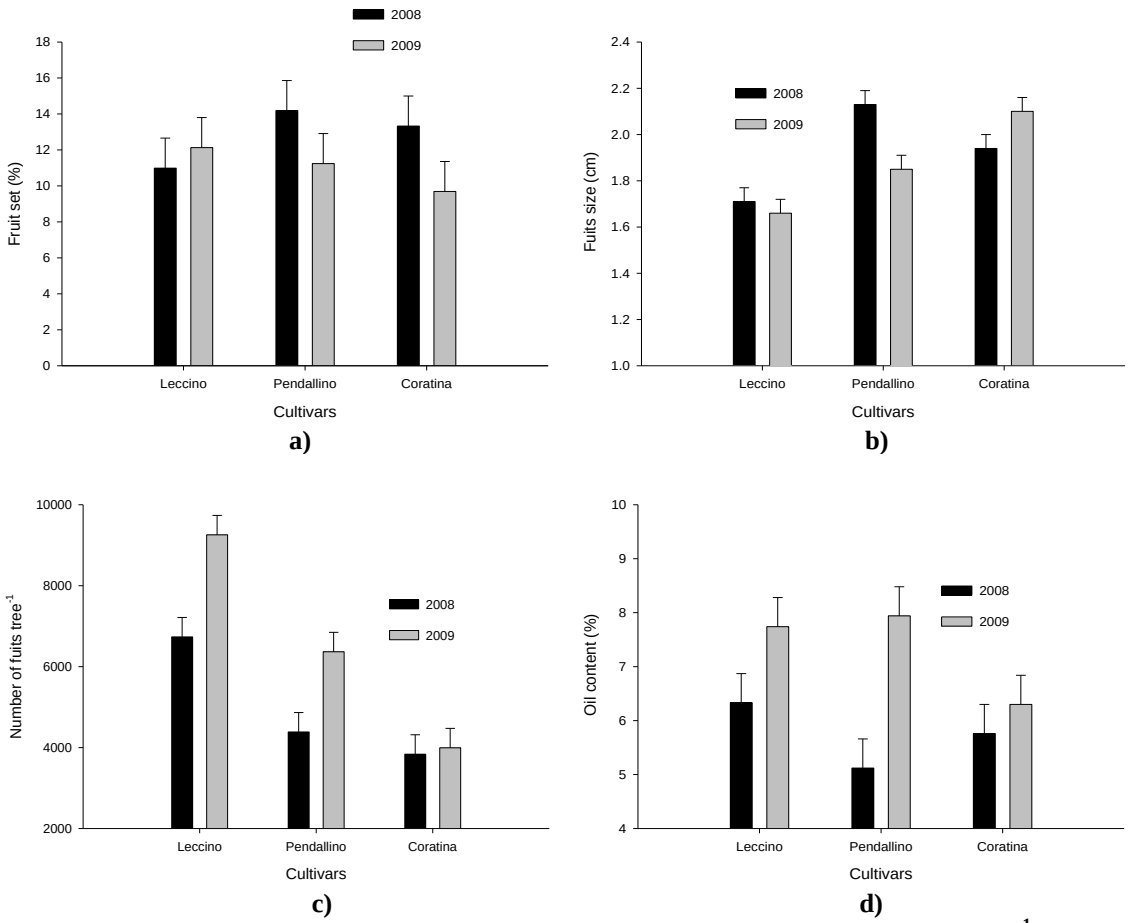

Figure 2. Influence of cultivars and year (C×Y) on a) fruit set b) fruit size c) number of fruits tree^{-1} d) oil content (%) of olive.

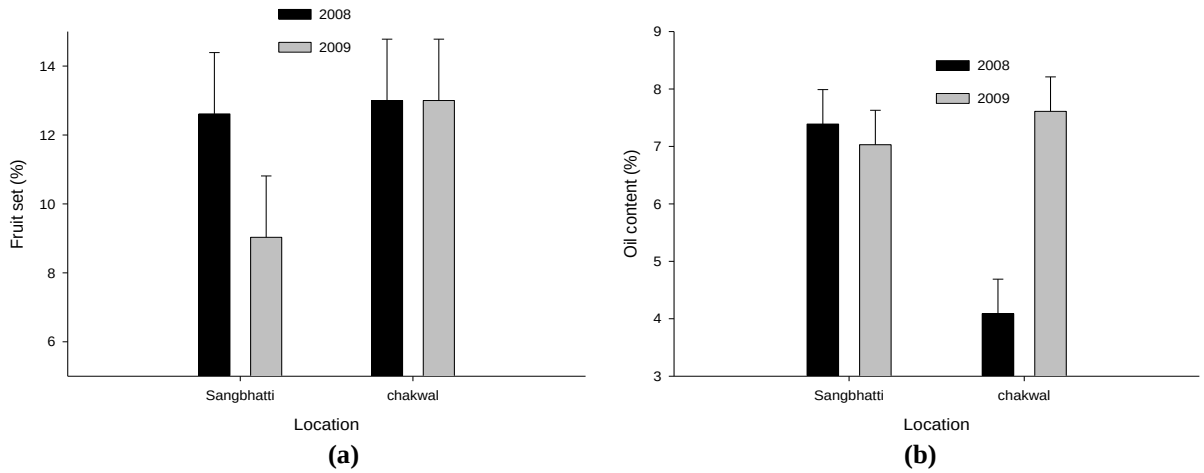

Figure 3. Influence of location and year (L×Y) on a) fruit set (%) and b) oil content (%) of olive.

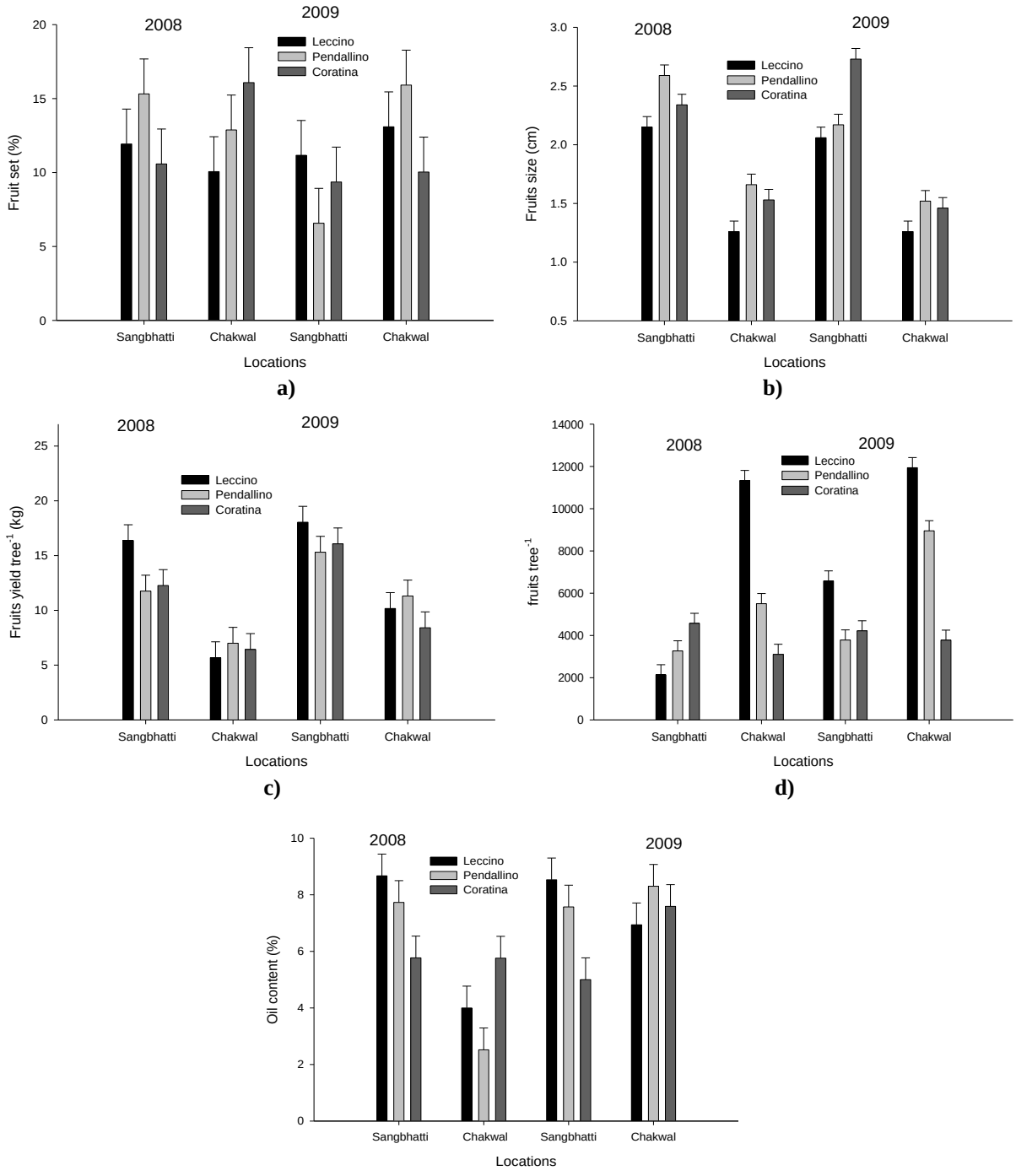

Figure 4. Influence of cultivars, location and year (C×L×Y) on a) fruit set (%) b) fruit size c) number of fruits tree^{-1} d) fruit yield tree^{-1}(kg) and (e) oil content of olive

indicator for determination of commercial crop and thus is an important characteristic for improving productivity of olive (Ahmed *et al.,* 2004). The fruit set depends on cultivar (Palliotti*et al.,* 1996), location (Padula*et al.,* 2008) and also by the genotype and environment interaction (Cantini*et al.*,1999), the higher fruit in Chakwal might be due to soil fertility and climatic conditions (Table 2), because final fruit set depend on nutritional and environmental conditions (Koubouris*et al.*,2010).

***Number of fruits per tree*:** Number of fruits tree^{-1} was varies significantly with cultivars, locations, years and interaction between C×L (Fig. 1c), C×Y (Fig. 2c) and C×L×Y (Fig. 4c). The number of fruits tree^{-1} varied considerably among the different olive cultivars. The cultivar Leccino produced higher number of fruits (7995), followed by (5376) in Pendallino (Table 3),whereas Coratina resulted in less number of fruit set (3915). The number of fruits was higher in 2009 (6539) as compared to 2008 (4985). The differences in fruit might be associated with deviation in temperature, rainfall and other factors affecting that plant growth and development. The number of fruit was higher (7433) at Chakwal compared to Sangbhatti (4091). Number of fruits tree^{-1} is an indicator of final fruit yield (Webster, 2002). Generally, the higher the number of fruits/tree, the higher will be the final fruit yield (Ahmed *et al.*,2004). The average rainfall, soil fertility and optimum temperature was more genial for the tree growth at Chakwal as compared to Sangbhatti (Table 1).The orchards have been developed in rainfed area, therefore the main source of irrigation was rain and it was noted that in year 2009 the rainfall was comparatively more than in 2008 at Chakwal (Table 2).

***Fruit size (cm)*:** Statistical analysis of the data showed that fruit size of olive differed significantly by cultivars, locations and interaction between C×L (Fig. 1b), C×Y (Fig. 2b) and C×L×Y (Fig. 4b) were found significant. Cultivar Coratina had larger fruit size (2.02 cm), followed by Pendallino (1.99 cm), while fruit size of cultivar Leccino was 1.68 cm. The fruit size was 2.34 cm at Sangbhatti as compared to Chakwal (1.45 cm) (Table 3). Fruit size is an important quality and marketing parameter which significantly influences the economic value of olive fruit (Webster, 2002). Optimal yield and good financial returns depend on high fruit set and optimal fruit size. Among the cultivars under study, Coratina and Pendallino had significantly larger fruits as compared to Leccino. The olive cultivars differ considerably in genetic makeup and hence the fruit size and yield (Palliotti*et al.*, 1996; Ahmed *et al.*, 2004). Generally the fruit size is negatively related with the number of fruit per tree so that higher number of fruits results in smaller fruit size (Miranivi, 1990). Since cultivar Leccino had higher number of fruit tree^{-1}, hence smaller fruit size (Table 1). There was no significant effect of the years on the fruit size of different cultivars. However, the location significantly affected the mean fruit size. The fruit size in Sangbhatti was more than that in Chakwal. The difference in fruit size due to location can be attributed to variation in soil and climatic condition (Miranivi, 1990)**.**

***Fruit yield (kg) per tree*:** Fruit yield per tree was significantly affected by cultivars, locations and years. The interaction between C×L (Fig. 1d) and C×L×Y (Fig. 4d) also had significant effect on the fruit yield tree^{-1}. The fruit yield of olive is influenced by various physiological and reproductive processes such as floral induction, flower differentiation, fruit set and growth (Webster, 2002). The highest fruit yield of cultivar Leccino (12.57 kg) was followed by Pendallino cultivar (11.34 kg), whereas Coratina had least (10.80kg) fruit yield fruit yield (Table 4) which can be attributed to variation in yieldpotential of different cultivars (Padula*et al.*, 2008). Generally, cultivars which had higher number of fruits had higher yield (Martin, 1990). The findings of this study showed that the fruit yield tree^{-1} was directly proportional the fruit size (Padula*et al.*, 2008; Sweeney *et al.*, 2002). Thus, cultivar having higher fruit size also had superior yield. Significant variation in yield tree^{-1} existed between the years. Fruit yield tree^{-1} was higher during 2009 (13.22 kg) as compared to 2008 (9.93 kg). The significant variation in years could be attributed to climatic variations in years, the crop load and alternate bearings (Miranivi, 1990). Similarly, yield in both locations was also significantly different which may be due to the variation in soil and climatic conditions (Miranivi, 1990). As a whole the fruit yield was better at Sangbhatti (14.97 kg) as compared to Chakwal (8.17 kg) which could be attributed to variation in fruit size of both locations (Padula*et al.*, 2008; Sweeney *et al.*, 2002).

Table 4. Effect of different olive cultivars, locations and their interaction on fruit yield (kg) and oil content (%) during two consecutive years2008 and 2009.

Factors	Varieties	Fruit yield (kg) tree^{-1}	Oil content (%)
Locations	Sangbhatti	14.97 a	5.85 b
	Chakwal	8.17 b	7.21 a
	Significance		
Cultivars	Leccino	12.57 a	7.04 a
	Pendallino	11.34 ab	6.53 b
	Coratina	10.80 b	6.03 c
	LSD	0.76	0.34
Years	2008	9.93 b	5.74 a
	2009	13.22 a	7.32 b

***Oil content in fruits (%)*:** Cultivar, location and year significantly affected oil content. The interaction between C×L (Fig. 1e), C×Y (Fig. 2e), L×Y (Fig. 3e) and C×L×Y (Fig. 4e) was significant. Among cultivars, Leccino showed higher oil content (7.04%), followed by Pendallino (6.53%) whereas Coratina had low oil content (6.03%) (Table 4). Generally fruits bigger in size contain less oil and are, therefore, fit for pickles etc, while cultivars characterized by small fruit size, produce more oil (Lumaret*et al.*, 1997;Besnard *et al.*, 2000). The final oil content of the fruits is the output of environmental factor and genetic makeup of cultivars (Lavee and Wodner, 2004).Greater oil content in olive fruit was recorded in year 2009 (7.32%) as compared to year 2008 (5.74%). This may be due to the variation in climatic conditions, the crop load and alternate bearing

behavior of the varieties (Miranivi, 1990). And as a whole, the fruits in Chakwal had higher oil content as compared to Sangbhatti. The oil content depends on the fruit size with small size fruit having more oil content (Lumaret*et al*., 1997). Thus, the higher oil content at Chakwal location may be due to the smaller fruit size at Sangbhatti. Since, the oil content of olive fruit is higher at higher altitude (Chunfang*et al*. (1996), the high oil content at Chakwal location may be due to its high altitude.

***Conclusion*:** Olive cultivation at Chakwal resulted in higher number of fruits per tree, fruit set percentage and oil content percentage, whereas higher fruit size and fruit yield was recorded at Sangbhatti. Cultivar Leccino was higher in number of fruit per tree, and higher fruit yield and oil content percentage. Pendallino resulted in higher fruit set percentage. Coratina produced fruits of bigger size with poor oil content.

REFERENCES

Ahmed, M., A. Iftikhar, H. Rehman, K.M. Khokar and M. Tariq. 2004. Study on floral biology and fruit setting in olive cultivars. Sarhad. J. Agric. 20: 377-79.

Ashraf, T., B. Adriana, and T. Francis. 2004. Growing of olives and other tree species in marginal dry environment. International center for agricultural research in the dry areas. pp 17-19.

Awan, A.A., E. Ullah, S.J. Abbas, O. Khan and S. Masroor. 2012. Growth response of various olive cultivars to different cutting lengths. Pak. J. Agri. Sci. 49:315-318.

Baloch, A. 1994.*Hort. Phases of plant growth*. National Book Foundation Islamabad.pp. 633.

Besnard, G., B. Khadari, P. Villemur and A. Berville. 2000. A cytoplasmic male sterility in olive cultivars (*Oleaeuropaea L.*): phenotypic, genetic and molecular approaches. Theor. Appl. Genet. 100:1018-1024.

Cantini, C., A. Cimato, and G. Sani. 1999. Morphological evaluation of olive germplasm present in Tuscany region. Euphytica 109: 173-181.

Christakis, G.F., M.K. Fordyee and C.S. Kurtz. 1980. Proc.3rdIntl. Cong.on Biological Values of Olive Oil held in Greece, pp.85.

Chunfang, G., Z. Jian and L. Qiu. 1996. The influence of climatic factors on the composition of lipid acids in sunflower. Proc. 14th Intl. Sunflower Conf., Beijing, China. pp. 559-564.

Diego, B.F., E. Ricardo and R. Luis. 2004. Olive growing. Departmento de Agronomia. Escuela Tecencia Superior de Ingenieros Agronomos Y Montes Universidad de Cordoba.Pp.41-42.

Ehsan**,** U., A.A. Awan.S.J. Abbas, F.Ullah, S. Masroor and O. Khan.2012. Growth response of various olive cultivars to different cutting's length.Pak. J. Bot. 44: 683-686.

Fabrizia, L. 2012. Olive: A Global History. Reaktion Books, pp.106–110.

FAOSTAT. 2003. Food balance sheet. Available online with updates at http://apps.fao.org/lim500 M./wrap.pl.Food balance sheet and language.

Koubouris, G.C., I.T. Metzidakis, and M.D. Vasilakakis. 2010. Influence of cross pollination on the development of parthenocarpic-shotberries-olive (*Oleaeuropaea L.*) fruits. Expl. Agric. 46: 67-76.

Lavee, S. 2006. Biennial bearing in olive (*Oleaeuropaea* L.).Olea 25: 5-13.

Lavee, S. and M. Wodner. 2004. The effect of yield, harvest time and fruit size on the oil content in fruits of irrigated olive trees, cvs. Barnea and Manzanillo.Sci.Hortic. 99: 267-277.

Lavee, S., L. Rallo, H.F.Rapoport and A. Troncoso. 1996. The floral biology of the olive: I. Effect of flower number, type and distribution on fruit set. Sci. Hortic. 66: 149-158.

Loukas, M. and B. Krimbas. 1983. History of olive cultivars based on their genetic distances. J. Hort. Sci. 58: 121-127.

Lumaret, R., N.Ouazzani, H. Michaud and P. Villemur. 1997. Cultivated olive and oleaster, two very closely connected partners of the same species (Oleaeuropaea): Evidence from enzyme polymorphism. Bocconea 7: 39-42.

Martin, G.D. 1990. Olive flowers and fruit population dynamics.ActaHort.286: 141-153.

Miranivi, K. 1990. Oleographic studies on some introduced table olive cultivars grown in the Montenegero. Hort. Absts. 60:8571.

Mukhtar, A., A. Iftikhar, H.Rehman, K.M. Khokhar and M. Tariq. 2004. Studies on floral biology and fruit setting in olive cultivars. Sarhad J. Agric. 20: 377-379.

Padula, G., E.Giordani, E. Bellini, A. Rosati, S. Pandolfi, A. Paoletti, G. Pannelli, V. Ripa, F. De Rose, E. Perri, A. Buccoliero and C. Mennone. 2008. Field evaluation of new olive selections and effects of genotype and environment on productivity and fruit characteristics.Adv. Hort. Sci. 22: 87-94.

Palliotti, A., A. Serafini and P. Preziosi. 1996. Productive characterization and analysis of some agronomical traits of auto-chthon "San Felice" olive cultivar. Annali della Facolta di Agraria, Universita degli Studi di Perugia 50: 261-267.

Pietro, R.D and B. Carlo.2002. Aphytosociological analysis of abandoned olive-grove grasslands of Ausoni mountains. Lazaroa 23: 73-93.

Simmonds, N.W. 1976. Evolution of Crop Plants.Longman Group Ltd. London.pp.219-221.

Steel, R.G.D and J.H. Torrie. 1980. Principles and procedures of statistics, 2nd Ed., pp.172-177. McGraw Hill Book Co, Singapore.

Sweeney, S., K. Butler, D. Conlan, R. Correll, G. Jones, P. McClure and R. Taylor.2002. A survey of selected oil composition and fruit characteristics in different olive varieties across Australia. Adv. Hort. Sci. 16: 253-258.

Webster, A.D. 2002. Factors influencing the flowering, fruit set and fruit growth of European pears. Acta Hort. 596: 699-709.