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INFLUENCE OF GEOGRAPHICAL FACTORS ON THE FATTY ACID PROFILE AND OIL YIELD OF *Olea europaea* L.

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Abstract

Olive tree is important oil sources for Mediterranean countries. For their excellent nutritional quality, olives and olive oil have always been essential component of the diet in many Mediterranean civilizations. Geographical factors such as slope, aspect, lithology, geology and elevation influence plant growth, development and subsequently main primary and secondary metabolite production, secretion and accumulation. Because of geographical factors and cultivated olive cultivars which indicate high genetic diversity in Turkey influence the fatty acid composition. This may result in a standardization problem in terms of olive production and their fatty acid composition. Geographical Information System (GIS) has been increasingly performed to analyze the influence of location on the growth and distribution of plants. In the present work changes in olive oil content and its fatty acid composition were discussed with the extent of varying geological and environmental factors. Herein, there was a weak relation between slope and major fatty acids except linoleic acid. Among the tested parameters, oil yield was more pronounced with varying slope percentage. There was a higher correlation with respect to the elevation than slope effect concerned with fatty acid compositions. With respect to the aspect and lithology, higher oil yields and fatty acid compositions were obtained in the south and southeast aspect and basaltic soils

Key words: *fatty acid, geographical information system, GIS, Olea europaea L., olive*.

INTRODUCTION

Geographical Information System (GIS) has a great concerned system of managing, analyzing, and displaying all forms of geographically referenced information. Since the disciplines of the plant sciences and geography are intertwined, GIS has been increasingly performed to analyze the influence of location on the growth and distribution of plants. The key role of GIS has gained an interest for the study of plants in fields ranging from agriculture to ecology (Morgan, 2011). Soil, topography and climatic factors are the nonliving components affecting plant growth and development and consequently the biochemical and physiological indices of plants at all levels as well as determine the extent where the genetic factors are up or down regulated or expressed (Bareja, 2011).

Traditionally, plants have been extensively used for medicinal, nutritional, flavoring, cosmetically and industrial purposes. Of those plants, *Olea europaea* L. (olive) belonging to the *Oleaceae* family is of the most important crops especially in Mediterranean countries. On plantation which they cover around 8 million hectares on the worldwide (Guinda et al., 2004) and its fruit and oil have a major agricultural importance in Turkey. Besides its fruits as table olive, its fatty oil is characterized with distinguished fatty acid composition, of which medicaly importance has been proven by a number of studies (Leon et al., 2004; Matson and Grundy, 1985). Moreover, the oil obtained from olive fruits have essential key roles for reactive oxygen species (ROS) which are associated with pathology of some diseases including diabetes, cardiovascular, cancer, age related, and neurological disorders has been well documented (Chacraborty et al., 2009; Ishii, 2007; Burhans and Weinberger, 2007; Polidori et al., 2007; Halliwell and Guteridge, 1999; Soholm, 1998).

Plant growth may be positively or adversely affected in growing area by a number of factors. Since the important property of olive oil and the odor as well as flavors association with oil quality have been found to be correlated with fatty acid composition (Maestro and Borja, 1990; Leon et al., 2004). In the present study, variation in the oil yield and fatty acid compositions was examined with geographical factors. Also, the size of variation by geographical conditions where the sampling done, and evaluations were compared based on the regression and linear trend analysis.

MATERIALS AND METHODS

Geographic Information System (GIS)

The sampling sites were mapped with the tools of geographic information systems (GIS). A GIS-based map can clarify and combine the geographical or environmental condition relation-effects on biochemical contents of a plant. In this context, slope, lithology, geology, aspect and digital elevation model (DEM) maps of the sampling sites were composed. Herein, the relatively experimental laboratory results were discussed applying the power of new technologies with the ever-increasing vast of geospatially- based data. Fatty acid changes, essential to human health, were under discussion with the extent of varying geological and environmental factors in the present work.

Sampling site and method

The olive fruits were sampled in the Kilis Yaglik cv. that approximately the same aged trees from Kilis district of southeastern part of Turkey. Fruits were also harvested in the same ripening period (mid-December 2012) from the same position on the sampled trees. The detailed information concerning the topographical and geographical data of experimental sites of the region is collectively present in Figure 1.

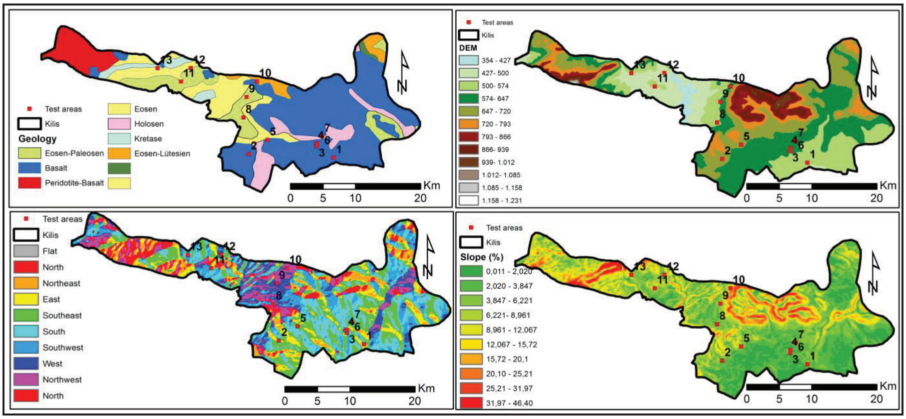

Figure 1. The topographical and geographical data of experimental sites of the region

Oil extraction and fatty acid composition analysis

The oils were extracted from olive fruits (each 10 g sample) with n-hexane for four hours using a Soxhalet Extraction Apparatus (Thermal). Then the solvent was evaporated under reduced pressure and temperature using a Rotary Evaporator (Heidolph). 0.5 g of olive oil was added 10 ml n-heptanes into a screw-capped tube for esterification. The fatty acid analyses were conducted according to the official method COI/T.20/Doc.no.24 2001. 0.1 g of olive oil was taken into screw-capped tube. 2 ml n-heptanes were added to it and shaken. After 0.2 ml methanolic potassium hydroxide was added for esterification, tubes were vigorously shaken for 30 sec. after the vials were closed. The supernatant of the solution was taken followed after one hour of incubation at room temperature. Then, the supernatant was put in 2 ml vials for injection.

GC-FID analyses of fatty acids methyl esters was carried out on a Shimadzu Gas Chromatography (GC-2010 series) equipped with an Supelco SP 2380 fused silica capillary column (100 m, 0.25 mm i.d., 0.2 µm film thickness). Helium was used as carrier gas, at a flow rate of 3 mL/min. The injection and detector temperature were 140 ºC and 240 ºC, respectively. The oven temperature was held isothermal at 140 ºC for 5 min, then raised to 240 ºC at 4 ºC /min and held isothermal at 240 ºC for 15 min. Injection volume of Diluted samples [1/100 (v/v) in n-heptanes] of 1.0 µL were injected automatically in the split mode (1/100).

The identification of the constituents was based on comparison of the GC-retention times with those of available analytical standards (Larodan Fine chemicals, mixture of 37 components of fatty acids methyl esters). Peak area was used to obtain the percentage of individual fatty acid.

RESULTS AND DISCUSSIONS

This study was designed to examine the effects slope, aspect, elevation and lithology of locations on the oil yield and some major fatty acid components of the oil of olive fruits collected from different orchards in Kilis province of Turkey. In this context, 13 locations for sampling were chosen and the numerical and geographical information concerned with sampling sites were represented and, the oil yields and their fatty acid components were numerically and empirically demonstrated in Table 1.

Table 1. Geographical and topographical properties, and oil yields with their fatty acid compounds for each location

Longitude	**Latitude**	**Location**	**Oleic acid**	**Linoleic Acid**	**Palmitic acid**	**Stearic acid**	**Oil yield**	**Slope (%)**	**Aspect**	**Elevation**	**Lithology**
37.21	36.68	1	67.45	11,02	13.28	4.32	22.14	2.93	East	528	Basaltic
37.06	36.69	2	69.96	9.19	12.84	4.06	26.88	1.86	East	673	Basaltic
37.18	36.70	3	67.17	11.18	13.95	4.47	21.63	2.95	South	560	Basaltic
37.18	36.70	4	68.86	10.17	13.16	4.09	22.53	1.84	South	580	Basaltic
37.10	36.71	5	66.24	12.69	13.17	4.29	30.16	4.25	Southeast	645	Basaltic
37.19	36.71	6	65.46	11.55	14.66	3.94	18.4	4.21	South	609	Basaltic
37.19	36.71	7	68.89	10.19	13.09	4.17	24.08	4.21	South	610	Basaltic
37.06	36.74	8	66.08	12.71	13.83	3.28	25.88	4.19	Southwest	557	Eosen Marn
37.06	36.77	9	67.29	11.55	14.44	2.99	25.78	7.41	West	586	Eosen Marn
37.08	36.79	10	68.72	10.50	13.45	3.41	28.75	11.8	Northwest	591	Eosen Limestone
36.95	36.79	11	68.96	8.75	13.53	4.36	14.62	8.96	South	460	Eosen Limestone
36.97	36.81	12	66.91	12.07	13.81	3.67	29.37	5.77	West	454	Eosen Limestone
36.91	36.81	13	67.88	10.67	13.16	4.34	18.23	8.97	South	513	Kretase Limestone

Effects of slope

The slope of the collections where we sampled olive fruits ranged from 1.86-11.88 %.

The inclination of land effects on oleic acid, linoleic acid, palmitic acid, stearic acid, which are the major fatty acid components of olive oils and oil yield were represented in Figures 2-6 with R^2=0.1356, R^2=0.018, R^2=0.1313, R^2=0.1313 and R^2=0.2872, respectively.

Even though weak correlation was obtained among slope effects on the mentioned parameters, we can deduce that linoleic acid comprising the essential portion of olive oil was not significantly found to be affected. Among the tested parameters, oil yield was more pronounced with varying slope percentage (R^2=0. 2872) (Table 2).

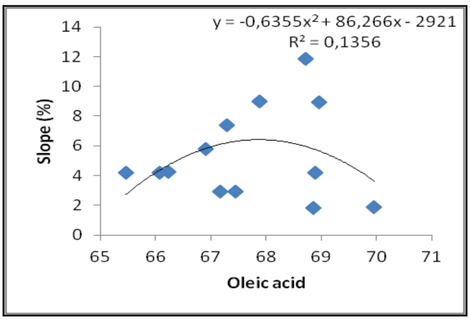

Figure 2. The effects of slope on oleic acid content

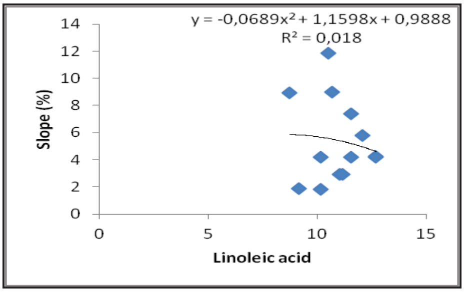

Figure 3. The effects of slope on linoleic acid content

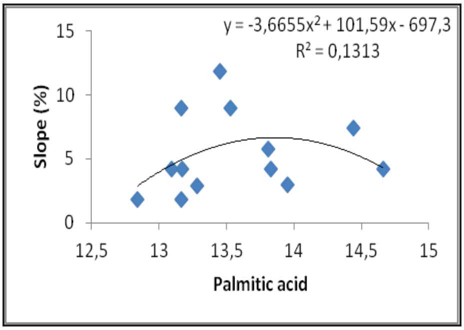

Figure 4. The effects of slope on palmitic acid content

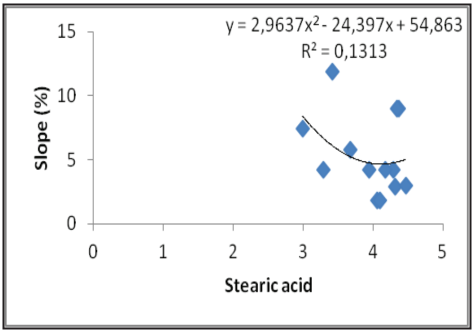

Figure 5. The effects of slope on stearic acid content

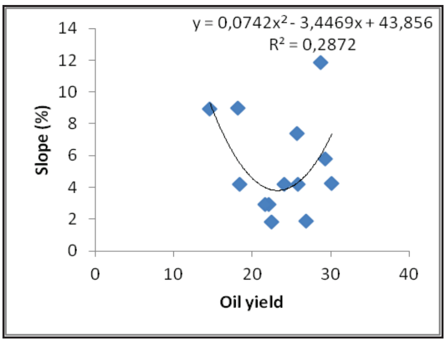

Figure 6. The effects of slope on oil yield

Effects of elevation

Locations ranged in elevation from 454 to 673 m herein. The altitude of location effects on oleic acid, linoleic acid, palmitic acid, stearic acid, which are the major fatty acid components of olive oils and oil yield were represented in Figures 7-11 with R^2=0.3342, R^2=0.0034, R^2=0.4977, R^2=0.0233 and R^2=0.2574, respectively. Herein, it was demonstrated that there was a moderate correlation between elevation and palmitic acid. However, the impacts of slope were attenuated with the elevation.

There was a higher correlation with respect to the elevation than slope effect concerned with fatty acid component herein however; the lower correlation was obtained in elevation effect than slope impact. Linoleic acid (R^2=0.0034) and stearic acid (R^2=0.0233) were determined to be less correlated to the varying elevation. (Table 2)

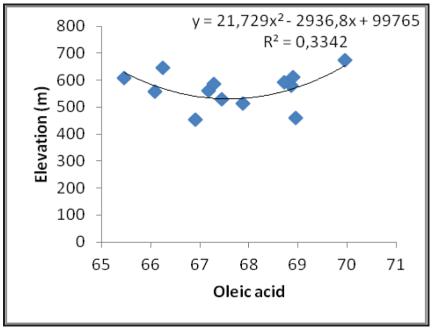

Figure 7. The effects of elevation on oleic acid content

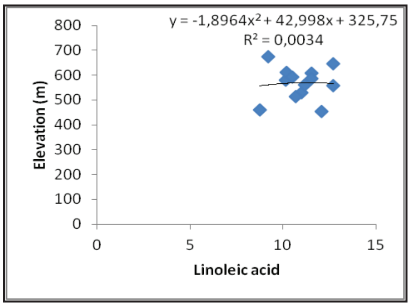

Figure 8. The effects of elevation on oleic acid content

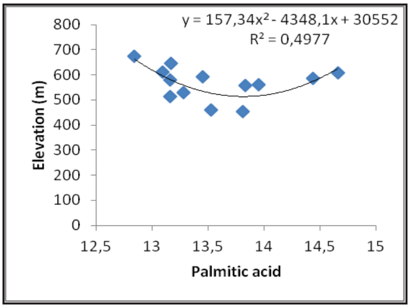

Figure 9. The effects of elevation on palmitic acid content

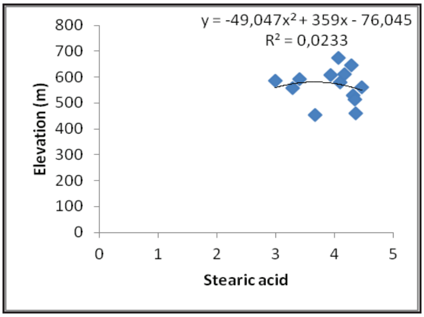

Figure 10. The effects of elevation on stearic acid content

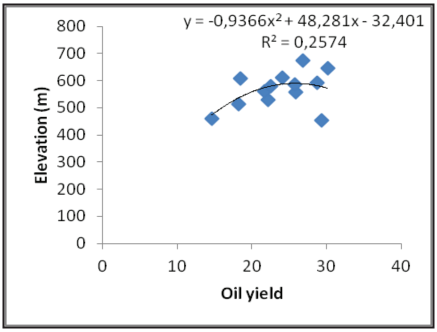

Figure 11. The effects of elevation on yield

Table 2. Relationship between topographical properties and oil yields and fatty acids

TP	Fatty acids and oil yield	RE	DC (R^2)
Slope	Oleic acid	$y = -0.635x^2 + 86.266x - 292$	0.1356
	Linoleic Acid	$y = -0.068x^2 + 1.159x + 0.98$	0.0180
	Palmitic acid	$y = -3.66x^2 + 101.59x - 697.3$	0.1313
	Stearic acid	$y = 2.963x^2 - 24.397x - 54.86$	0.1313
	Oil yield	$y = 0.074x^2 - 3.45x + 43.85$	0.2872
Elevation	Oleic acid	$y = 21.729x^2 - 2936.8x + 997$	0.3342
	Linoleic Acid	$y = -1.89x^2 + 42.99x + 325.7$	0.0034
	Palmitic acid	$y = 157.34x^2 + 434.1x + 305$	0.4977
	Stearic acid	$y = -49.047x^2 + 359x - 76.04$	0.0233
	Oil yield	$y = -0.936x^2 + 482x - 32.401$	0.2574

Effects of aspect

Aspect have a strong and significant influence on temperature through the affecting the angle of sun-lights reaching and contacting with the ground. Consequently, microclimates of the regions are strongly influenced by the aspect of a slope. Of 13 test areas in the present work, east (2), south (6), southeast (1), southwest (1), northwest (1) and west (2) aspects were determined (Table 1). Aspect as a climate factor is significantly influenced by temperature and precipitation elements. In fact, plant species diversity and frequency in Turkey differ on the slopes of the mountains overlooking the sea than on the slope overlooking the mountains inland. This is an important aspect factor of influence on the vegetation. The highest oil yield was determined in the southeast aspect orchids above 600 m elevation having basaltic soils. Interestingly, eosin-limestone soils at different aspects also gave higher oil yield with major fatty acid compositions. However, of tested 13 areas, oil yield and its major fatty acid compositions varied significantly depending aspects correlatively elevation and soil type.

Effects of lithology

Marly surfaces are composed of easily friable rocks. Therefore, erosion severely occurs on bare surfaces, causing decline in mineral content and soil thickness. In the present study, olive trees locating on different rock types were determined higher oil yields and fatty acid components were obtained in basaltic soils. Volcanic rock basalt has rich mineral content. Basalt rock reacts are dissolved and physically disintegrated after reaction with water. Then basaltic soils are formed from the rocks. Nevertheless, lithology ought not to be considered lonely for oil yield and its fatty acid composition variation. The slope or inclination of a land can be defined as the percentage change in its elevation over a certain distance (Bareja, 2011). Plant growth and consequently biochemical indices of a plant are influenced by the steepness of a slope through differential incidence of solar radiation, wind velocity and soil type (Bareja, 2011) and availability of water and nutrients (Casado et al., 1985; Montalvo, 1992; Maggi et al., 2005) and therefore on each slope, *Olea europaea* L. faces different environmental challenges as a heterogeneous environments resulted from slope habitats (Maggi et al., 2005). Biology of organisms at all levels was reported to be affected with the varying the microclimatic conditions on the slopes (Nevo, 1997, 2001; Auslander et al., 2003). Herein, it was addressed that sharp microclimatic differences may stress plants (Moller and Swaddle, 1997; Auslender et al., 2003) and consequently production and release of secondary metabolite between slopes. Slope positions were associated with less variability in previous reported papers (Maggi et al., 2005). Plant biomass was significantly correlated (r=0.65 and 0.70) in the report by Kapolka and Dollhopf (2001). However, up to our best knowledge, no data have been proposed concerned with biochemical components of oils and oil yield.

The elevation or altitude of the land affects plant growth and development primarily through temperature effect (Bareja, 2011). Altitudinal gradients effects on plant growth through photosynthetic rate have been of interest to plant physiologists and ecologists (Billings et al., 1961; Körner and Diemer, 1987; Friend et al., 1989; Terashima et al., 1995; Bowman et al., 1999; Sakata and Yokoi, 2002; Kumar et al., 2005). In considering the impacts of elevation on plant growth and related parameters, altitudinal gradients affect not only temperature gradients but partial pressure of carbon dioxide in air and its effect on photosynthesis, resulting variations on plant phenology and growth (Heegaard, 2002; Fernandes-Calvo and Obeso, 2004; Fujimura et al., 2010).

CONCLUSIONS

The consequences of the study reveal that oil yields and fatty acid profile of the oils were influenced by the different ecological and topographical conditions, supplying additional information about the climatic conditions and its impact on the oil quality. Herein, there was a weak relation between slope and major fatty acids except linoleic acid.

Among the tested parameters, oil yield was more pronounced with varying slope percentage. There was a higher correlation with respect to the elevation than slope effect concerned with fatty acid compositions. With respect to the aspect and lithology, higher oil yields and fatty acid compositions were obtained in the south and southeast aspect and basaltic soils.

Ever increasing need for productive uses of land and natural resources under global climate changings directed researchers to assess to find new computer based technologies or agricultural techniques for sustainable crop production and higher yield regarding with desired secondary and primary metabolite content.

In the light of the present study, this information may help to understand topography and to predict the best plantations for crops.

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Terashima I., Masuzawa T., Ohba H., Yokoi Y., 1995. Is photosynthesis suppressed at higher elevations due to low CO_2 pressure? Ecology 76: 2663-2668. Figure 3. View from a Dairy Farm in the NE part of Romania.