The effects of organic and conventional farming systems on selected soil properties of olive groves in central Greece

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Abstract
Olive tree cultivation is of great socioeconomic and environmental importance in the Mediterranean region. The maintenance of fertile soil is the basis on which a productive and sustainable agricultural system depends. In the present study a comparison between organic and conventional olive groves regarding the fertility of the soil in Magnesia Prefecture was conducted. In particular, soil samples were taken from two different farming systems (conventional and organic) of olive groves and analyzed for various soil parameters. A comparison between the mean values for soils under organic systems and their controls showed an overall improvement in the soil quality of the former, with increased contents of organic matter, available P, exchangeable K, NO_3, NH_4, CEC and pH values. Moreover, the organic matter, P and CEC were found to be correlated with the farming system and they are factors of distinguishing between the organic and conventional olive groves in the research area.

Key Words
Soil quality, olive groves, organic, conventional, Greece.

Introduction
Olive tree cultivation is of great social, economic and environmental importance in the Mediterranean region. Productive cultivated land is considered the land with good structure and drainage, having at the same time the ability to retain the suitable soil moisture and containing sufficient amounts of nutrients for the development of the plants (Stockdale *et al.* 2002). In assessing the fertility of a soil, not only its chemical properties but also its organic and physical characteristics should be taken into account, as these may be adversely affected by intensive soil cultivation practices over time (Werner 1997). This paper describes the characteristics of organic and conventional cultivated soils in an effort to investigate any changes in the soils of olive groves, resulted from applying the different farming practices. Here we present a preliminary analysis of selected soil properties.

Methods
The research was conducted in ten conventional and ten organic olive groves located in southwest Magnesia, Greece in 2009 (Figure 1). Olive trees planted in 1860 and were entered in organic management system in 1997. The soil texture was clay loam. The sampling was conducted in March by using a cylindrical sampler in depth of 0-30 cm. The number of samples taken was 10 for organic and 10 for conventional olive groves. Each sample consisted of 5 cores, well mixed on site, which were collected from different points in the field. The following characteristics of the soil were determined: soil texture (Bouyoukos 1951), organic matter (Nelson and Sommers 1982), ammonium nitrogen (Bremner 1960), nitrate nitrogen (Keeney and Nelson 1982), available phosphorus (Olsen and Sommers 1982), potassium (Thomas 1982), cation exchange capacity (Rhoades 1982b), pH (Mc Lean 1982) and $CaCO_3$ (Nelson and Sommers 1982). The fertilization applied in the area was that of calciferous nitric ammonia (26-0-0), 2 kg per tree, in the conventional olive groves and borax 200 gr per tree, potassium 1-1.5 kg per tree, and an amount of 50 kg per tree of digested manure originated from animals of organic farming were applied in the organic olive groves. Statistical analyses were performed using SPSS 18 Software. Mean comparisons were done using the one way ANOVA tests at a=0.05 level. Some of data ($CaCO_3$, K, NO_3, NH_4) were log (x + 1) transformed prior to analysis to obtain normality. Correlation analysis [Pearson] and Regression analysis (Binary logistic) were used to test relationships between variables.

Results
The soil texture was very variable in the two farming systems as shown in Table 1. Consistent differences in the percentage of sandy /clay particles were not observed amongst the two farming systems even though the

organic farmed soils tend to be heavier textured (SCL vs CL). The difference in clay content was not significant (F=3.11, p=0.09, df = 1) between the two treatments.

Figure 1. The study area.

Table 1. Soil texture of olive groves. (*)

Mean	**Organic**	**O1**	**O2**	**O3**	**O4**	**O5**	**O6**	**O7**	**O8**	**O9**	**O10**	**Mean**
25/51	%Clay/Sand	17/56	21/44	32/43	29/46	39/26	24/59	24/67	24/45	20/61	22/65	25/51
CL	Type	SCL	CL	L	CL	CL	SL	SL	CL	SL	SL	CL
Mean	**Conventional**	**C1**	**C2**	**C3**	**C4**	**C5**	**C6**	**C7**	**C8**	**C9**	**C10**	**Mean**
26/56	%Clay/Sand	17/56	25/54	39/40	26/59	29/58	26/47	30/59	32/53	24/63	16/69	26/56
SCL	Type	SCL	SCL	L	SL	SL	SCL	SL	SCL	SL	SL	SCL

*Symbols: *O*: Organic olive groves, *C*: Conventional olive groves, *SCL*: sandy clay loam, *CL*: clay loam, *L*: loam, *SL*: sandy loam

Sand, silt and clay particles bound together by organic matter is a vital component of soil, influencing fertility, soil structure, workability and water holding capacity, as well as carbon storage. In the organic olive groves a significantly (F=5.84, p = 0.02, df=1) higher percentage of organic matter was observed (mean = 2.98, SE=0.41) in comparison to the conventional ones (mean = 1.77, SE = 0.27) (Figure 2). This may be due to fertilization with the manure of the animals and the cutting of weeds in the organic olive groves. Both of them favor the availability of organic matter in comparison to the conventional olive groves. Jiao *et al.* (2006) found that the annual addition of manure in amounts exceeding 30 t/ha, increased the organic C in the organic olive groves. No significant differences in soil pH were found between organic olive groves (mean = 7.01, SE= 0.36) and conventional ones (mean= 6.25, SE= 0.27) (Figure 3).

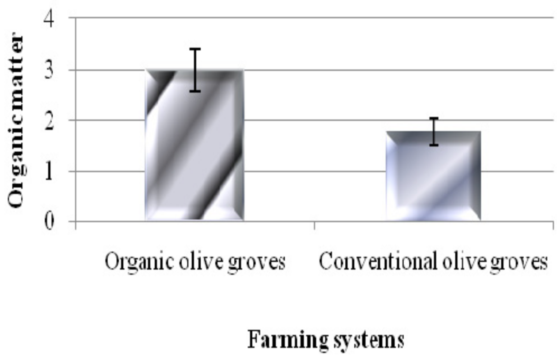

Figure 2. The effect of the farming system on the organic matter of the soil.

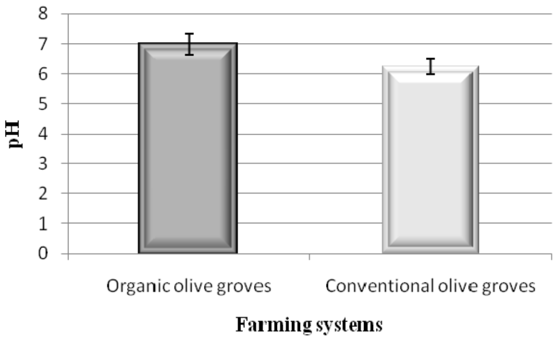

Figure 3. The effect of the farming system on the pH of the soil.

This may be due to the fact that the soil pH is mainly affected by the soil formation, the organic activity, the season of the year and the fertilization (Smith and Doran 1996). The mean concentration of K was higher in the organic olive groves (mean = 2.09, SE = 0.12) compared to the conventional ones (mean=1.98, SE=0.06). Regarding the mean concentration of K, no statistically significant difference was found (F = 0.65, p = 0.42, df = 1) between the two types of the olive groves. This may be due to the inorganic fertilization which was applied to the conventional olive groves and the organic fertilization which was applied to the organic ones (Schjonning *et al.* 2002). The mean concentration of P according to Olsen was significantly higher in the organic olive groves (mean = 3.95, SE = 0.58) than in the conventional ones (mean = 2.4, SE =

0.16) ($p<0.05$) ($F = 6.53$, $p = 0.02$, df = 1) (Figure 4). This might be attributed to the fact that the manure application in organic sites mainly as a means of nitrogenous fertilization of the crop, may lead to the accumulation of P in the soil (Schwartz and Dao 2005), because the as the ratio N/P of the most types of manure is smaller than the corresponding ratio of the majority of the conventional crops (Whalen *et al.* 2001).

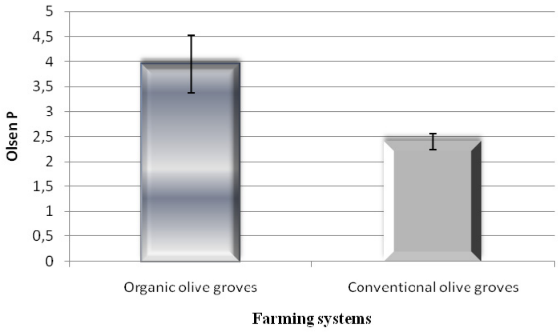

Figure 4. The effect of the farming system on the P according to Olsen.

The cation exchange capacity (CEC) of the organic olive groves was significantly higher (mean = 18.5, SE = 2.17) than the conventional ones (mean = 12.55, SE = 1.33), ($F=5.42$, $p = 0.03$, df = 1).This result is probably due to the fact that in the organic agriculture the increased application of manure increases the cation exchange capacity of the topsoil layers (0-30cm) due to the increase in the organic matter (Eghball 2002). Soil pH is important for CEC because as pH increases the number of negative charges on the colloids increases, thereby increasing CEC. The mean concentration of NO_3 showed no statistically significant difference between the organic and the conventional olive groves, as it is shown by the level of significance in these two cases ($p>0.05$) ($F=3.01$, $p=0.1$, df = 1). Similar results were obtained for NH_4 ($p>0.05$) ($F=0.55$ $p = 0.46$, df = 1). This parameter is related to a great extent to the concentrations of organic nitrogen and fungus biomass. Moreover, the mean concentration of $CaCO_3$ was not statistically significant different ($p>0.05$) ($F=1.03$ $p=0.32$, df = 1) between the organic olive groves and the conventional ones. This result may be due to the soil texture in the two farming systems which are applied in the olive groves of the southwest Magnesia (Table 1). Correlations were found between organic and conventional sites in respect to organic matter and farming system (sig.=0.05), CEC and farming system (sig.=0.05), P and farming system (sig.=0.05), pH and $CaCO_3$ [r=0.85(**)(highly strong positive linear), sig.=0.00], P and NO_3 [r=0.86(**) (highly strong positive linear), sig.=0.04], CEC and organic matter [0.79(**) (strong positive linear),sig.=0.00],K and organic matter [r=0.71(**)(strong positive linear), sig.=0.00], organic matter and NO_3 [r=0.71(**)(strong positive linear), CEC and K [r=0.62(**)(waist positive linear), sig.=0.00], P and NH_4 [r=0.61(**)(waist positive linear), sig.=0.00], P and organic matter [r=0.55(*)(waist positive linear), sig.=0.00], NO_3 and NH_4 [r=0.57(**)(waist positive linear), sig.=0.00]. In the organic olive groves significant correlations were found K and organic matter [r=0.90(**)(highly strong positive linear), sig.=0.00], CEC and organic matter [r=0.86(**)(highly strong positive linear), sig.=0.00], NO_3 and P [r=0.86(**) (highly strong positive linear), sig.=0.00], pH and $CaCO_3$ [r=0.85(**) (highly strong positive linear), sig.=0.00], P and NH_4 [r=0.82(**) (highly strong positive linear), sig.=0.03], NO_3 and NH_4 [r=0.83(*) (highly strong positive linear), sig.=0.00], CEC and K [r=0.78(**) (strong positive linear), sig.=0.00], K and NO_3 [r=0.76 (**) (strong positive linear), sig.=0.00)], K and P [r=0.68(*) (waist positive linear), sig.=0.03], organic matter and NO_3 [r=0.68(*) (waist positive linear), sig.=0.03]. It will be of interest to follow these relationships as the transition period to organic practices proceeds. As regards the conventional olive groves the correlation was observed in $CaCO_3$ and pH [r=0.85** (highly strong positive linear), sig.=0.00], P and the organic matter [r=0.73*(strong positive linear), sig.=0.01], NH_4 and organic matter [r=0.71(*) (strong positive linear), sig.=0.02] of the soil.

Conclusions

Based on the data collected on soil parameters, it seems that the conversion to organic farming for the conventional olive groves is progressing satisfactorily in southwest Magnesia Central Greece, with a gradual improvement in soil quality as organic fertilizers are applied. The organic matter, P and CEC were found to be correlated with the farming system and they are factors of discrimination between organic and conventional olive groves in the research area. $CaCO_3$, NO_3, NH_4, K and pH, although they showed higher mean values in the organic olive groves than in the conventional ones, the variance analysis showed that they are not factors of discrimination between the two farming systems.

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