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Effect of Organic, Biodynamic and Conventional Farming Systems in Selected Soil Parameters of Various Crops

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Abstract. Growing concerns about the multifaceted harmful effects of conventional agriculture have led many farmers and consumers to seek alternative practices and systems, such as organic and biodynamic farming systems, that promote to improve the soil and product quality and will make agriculture more sustainable. In this research were determined in apple and wine grape crops for conventional, organic and biodynamic farming systems the following soil parameters: conductivity, pH, organic substance, soil mean weight diameter (MWD), organic C, total N, the percentage of mycorrhizal colonization rate and the number of earthworms in soil. It was also determined the qualitative characteristics of fruits in all these three farming systems and in case of apples are: fruit diameter, weight of fruit, color of skin and flesh firmness. While in the case of the wine grapes are: weight of 100 berries, peel weight of 50 berries, 100 pips weight, berries diameter and pH, acidity and sugars in the juice. The results indicated that, in the majority of all measurements the most positive effects were presented at the organic and biodynamic farming system versus conventional. Regarding the soil parameters, were found positive effects of biodynamic farming system on the following parameters: total N, organic C, mycorrhizal colonization rate , while for organic farming system were found positive effects on the following parameters: organic C and MWD. Between organic and biodynamic farming system, and for the fruit characteristics, more positive effects in the case of apples displays the biodynamic farming system whereas in the wine grapes the organic farming system.

Keywords: organic, biodynamic, conventional, soil parameters, farming systems.

INTRODUCTION

The term “sustainable agriculture” is increasingly included in the dialogue concerning food production around the world, especially considering the environmental, economic and social impacts of chemical-depended conventional agriculture. Sustainable management of agricultural land aims at maintaining or enhancing food production, reducing the level of production risk, protecting the potential of natural resources and preventing degradation of soils and water quality, while being economically viable and socially acceptable (FAO, 1993; Schjonning *et al*., 2004). Organic agriculture is contributing to most of the points listed and so as biodynamic agriculture. Like organic agriculture, biodynamic agriculture uses no synthetic chemical fertilizers and pesticides, and instead emphasizes building up the soil with compost additions and animal and green manures, controlling pests naturally, rotatingcrops, and diversifying crops and livestock. A major difference is that biodynamic farmer sad eight specific preparations to their soils, crops, and composts to enhance soil and crop quality and to stimulate the composting process (Koepf *et al*, 1976).

The foundation of sustainable agriculture is a healthy, fertile soil, on which the rest of the farm ecosystem depends. More than just a substrate for supporting root structure, the soil has it’s own complex ecosystem in which microorganisms are the dominant form of life and are responsible for performing functions vital to soil productivity, such as decomposition of organic matter and the cycling of major nutrients important to plant growth (Sylvia, 1998). Brady and Weil (2002) describe soil quality as the capacity of soil to function within its ecosystem boundaries to sustain biological productivity and diversity, maintain environmental quality, and promote plant and animal health; properties that can be measured quantitatively and adequately characterize the soil's ability to perform these functions are potential indicators for soil quality.

The quantitative assessment of soil quality is of great importance in determining the sustainability of land management systems. The selection of indicators considered necessary for the assessment of soil quality. Up operation on the soil involved a large number of physical, chemical and biological parameters. However, due to the fact that it is impossible to take into account all these parameters is necessary to make a choice. The parameters must satisfy a number of requirements: a) sensitivity to the largest possible number of factors degradation of soil quality, b) stable response to the change that takes place, and c) in response to a specific intervention capacity to reflect different levels of degradation (Elliott, 1997). Nortcliff (2002) emphasizes that the assessment of soil quality will have little or no value if the ratios are not selected based on strict criteria. These should serve as points of reference, to be able to record trends and patterns and to relate the soil quality with other system components. Relating to the choice of parameters used as soil quality indicators, Doran and Parkin (1996) consider that can be use a set comprising natural (structure, root depth), chemical (pH, total carbon, total nitrogen, electrical conductivity , nutrient levels) and biological (microbial carbon and nitrogen mineralization rates of nitrogen and carbon, soil respiration, activities of various enzymes) parameters. Alternatively for assessing soil quality given that most soil functions dependent on biological activities, biological indicators are more appropriate for assessing or monitoring the status / quality of the soil (Pankhurst *et al*., 1997). Generally, the physical and physicochemical parameters have limited use as they change only when the soil is subject to intense changes (Filip, 2002). In contrast, the biological and biochemical parameters are sensitive to small changes that soil may undergo in the presence of any degradation factor (Klein *et al*., 1985; Nannipieri *et al*., 1990; Yakovchenko *et al*., 1996).

The main objective of this study was to compare the conventional farming system with two sustainable farming systems, organic and biodynamic, concerning soil quality (chemical, physical and biological parameters). Additionally in the context of this study, was considered necessary to introduce some fruit analyzes so as to take place a more integrated approach to the differences in these three farming systems systems. The comparison held in two important for Greece and especially for the region of Arcadia crops, vine and apple.

MATERIALS AND METHODS

Farm selection and plant material

The study was conducted in the farmland region of Tripoli (37°30′30″N 22°22′30″E), Arcadia in Western Greece, during the period March - October 2012. A total of six fields were selected: three vineyards (organic , biodynamic and conventional) and 3 apple orchards (organic, biodynamic and conventional). The cultivated varieties of selected fields was the grape variety Moshofilero and the variety of apple spur type Red Delicious, Super Chief. The cultivation of wine grapes and apple constitute two of the main crops of the region, both in land area and in production.

In selecting the study area were taken into account:

- In recent years in the area of Tripoli have joined several dozen hectars in organic and biodynamic managment. So there was the possibility to choose neighbouring fields and compare organic, biodynamic and conventional vineyards and apple ochrads in the same soil type and climate conditions. Organic and biodynamic cultivation practices take place for more than five years in most rural parts of the region.
- The cultivated varieties in the region, regardless the farming system are mostly generic.
- The study area is located 157 km from Athens, which facilitated the conduct of sampling and transport of samples in a short time in the lab.

Soil sampling and chemical, physical properties analysis

Soil samples were taken, prior to growing period and application of treatments in the spring, at a depth of 25cm from 3 different sampling points in each field which is formed between eachother one diagonal. The soil samples from these three different sampling points in each field were mixed inside labeled plastic bags by hand to form a single soil sample as representative as possible for each field. In the laboratory After that the soil samples were transferred at the laboratory and a sub-sample left to air dry and then passed through a 5-mm sieve and placed in a disposable plastic bag to be used in subsequent measurements.

All soils were analysed for pH: Bates (1964) method – measured with a portable pH meter, electrical conductivity: Bates (1964) method– measured with a portable conductivity meter, total organic substance: Walkey-Black (1934) method, total Nitrogen: Bremmer (1965) method and MDW: was determined by using the oscillation apparatus Analysette 3, (Spartan, Fritsch Ltd, Oberstein, Germany) and for calculating Van Bavel (1949) eguation.

Soil sampling and biological properties analyses

Microbial soil respiration refers to CO_2 production due to the biological activity of microorganisms and soil organisms (Carlisle *et al*., 2006). The energy released amount of CO_2 for different soil samples was determined volumetrically by Isermeyer (Isemeyer, 1952).

To determine the rate of colonization of the root with arbuscular mycorrhizal, during the month of June soil samples with part of the root system were collected from the 0–35 cm layer by using a cylindrical auger (25 cm length, 10 cm diameter). The sampling point was performed on the line in the middle of the distance between two successive trees. After that roots were separated from the soil by soaking the samples overnight in 30 ml of a 0.5% solution of sodium hexametaphosphate. Afterwards, the root sample was stirred for 5 min and washed over a 5 mm meshsieve and were stained with fychine. Thereafter the root segments were placed in reticle and by using a stereoscope and Motic Image Plus 2.0 program (2009) (Giovannetti and Mosse, 1980), the rate of colonization was determined by measuring the root of intersections with reticle and the total number that is the root parasitized.

Earthworms were measured during June. Soil areas of 50x50 cm^2 (using a metal quadrat) were treated with 20 L of water Then, hand sorting was used in the same quadrats, with 3 samplings per plot for each replicate. The samples were not separated for adult and juvenile. For the total earthworm abundance all earthworms across species were calculated.

Fruit sampling and analysis

All the wine grapes and apples samples were collecting during ripening(at technological maturity). The fruit samples were representative and were randomly taken from differend parts of every field and processed in the same day into laboratory.

Regarding wine grapes were measured the: weight of 100 berries, 100 pips weight, peel weight of 50 berries: determined by using precision scales and 20 berries diameter: determined by using digital caliper. Futhermore after having collected a total of 100 ml of must have taken place also the following measurements: pH: determined by using a pH meter, total acidity: determined by titration and sugars: determined by using a portable refractometer.

Regarding apples were measured the: diameter: determing by using a digital caliper, weight:determing by using precision scales, flesh firmness: determined by an electronic penetrometer and the skin color (L *, C *, h^o): determined by using differential reflectance colorimeter.

Statistical analyses

The study is based on non-factorial measurements. All data were analyzed by using the Tukey test and the computer program eazANOVA ver 0.98.

RESULTS AND DISCUSSIONS

Soil properties

For the presentation of the results of the effect of farming system on soil properties was used the average of measurements from both crops (apple and wine grape) to give a holistic approach to the interpretation of results.

As concerns the chemical soil properties there were no statistically significant differences in pH, electrical conductivity and total organic substance values among the three farming systems (Tab.1). Difference was observed only the percentage of total N that was significally greater in biodynamic farming system compare to conventional (Tab.1), something has been reported in other studies (Forman, 1981; Koepf 1993; Reganold *et al*, 1993) and may be due to the specificity of fertilization in biodynamic production system.

The organic farming system enhanced the mean weight diameter of soil aggregates (MWD) compare to conventional farming system while were not observed statistically significant difference among the organic farming systems with the other two systems (Tab.1). This may be due to the different way of use and frequency of cultivation techniques. Cultivation techniques determine the presence of soil binding agents of soil particles, leading to the formation or decomposition of aggregates (Jiao *et al*., 2006).

Regarding the biological prorerties there were no statistically significant difference in the number of earthworms among the three farming systems (Tab.1). Contrary concerning the percentage of organic C and AM colonization the highest prices recorded in organic and biodynamic farming system compared to conventional (Tab.1.). Reduced treatment (Ryan and Graham, 2002; Bilalis and Karamanos, 2010) presented in organic and biodynamic farming as well as better aggregation (Bilalis and Karamanos, 2010) have resulted in an increase of the percentage parasitism of root system with mycorrhizal.

Tab.1

The effect of farming system on soil properties in vine cultivation

Farming system	Soil properties							
	pH	Conductivity (mS/cm^3)	Total organic substance (% w/w)	Organic C (mg/100g soil)	Total N (%w/w)	MDW (mm)	Earthworms average (No/m^2)	% AM colonization
Conventional	5.86a	0.1a	1.24a	17a	0.13a	8.77a	3a	14.6a
Organic	7.29a	0.36a	1.85a	67b	0.19ab	14.91b	15a	29ab
Biodynamic	6.45a	0.29a	1.84a	66b	0.22b	11.13ab	11a	31b

*Values in the same column followed by different letters are significantly different at $p \leq 0.05$

Fruit characteristics
Apple

As for the diameter and weight of apples the highest values recorded in apples of biodynamic production system against the conventional and organic one (Tab.2). The fruit size depends directly on the plant nutrition, which also dramatically affects post-harvest quality. The lower weight of apples, probably due to the smaller size of cells and intracellular spaces, reflecting the nutritional status of the plant and especially the availability of N (Amarante *et al*. 2008). Although the evaluation of soil parameters confirms the superiority of biodynamic farming system in the amount of total nitrogen and hence the size of the fruit, nonetheless because the role of micronutrients such as Mg and Ca is important can not be attributed to this increase in size only the availability of N. As regards the flesh firmness of the apples, the biodynamic production system present a higher value of flesh firmness compare to conventional one (Tab.2), while the organic production system does not display differences with the other two. The content of soils in nitrogen plays an important role also in flesh firmness, the greater availability of nitrogen greater flesh firmness on the condition the concentration of Ca in the fruit is equally high. The lower value has the ratio N: Ca the greater value displays the flesh firmness (Peck *et al*, 2006).

The measurements in the colorimetric characteristics of the apples indicated that brightness value L* is higher at the conventional production system compare to biodynamic one while the organic does not display differences (Tab.2.) and the value of hue h^o is higher at the conventional apples compare to biodynamic and organic (Tab.2.). Therefore, the biodynamic and conventional production system lower values are associated with darker color in the skin which is desired by consumers.The values color parameter C* were no statistically significant differences among the three production systems.

Tab. 2

The effect of farming system on fruit characteristic in apple cultivation

Farming system	Fruit characteristics					
	Weight(g)	Diameter(mm)	Flesh firmness(lb)	Skin L*	Skin h^o	Skin C*
Conventional	189.31a	72.44a	28.91a	43.94a	32.00a	31.45a
Organic	212.90a	76.27a	30.99ab	41.36ab	25.77b	31.11a
Biodynamic	310.42b	86.97b	31.81b	38.43b	22.72b	32.97a

*Values in the same column followed by different letters are significantly different at $p \leq 0.05$.
Each column represents the average value of 10 apples.

Wine Grape

The organic production system had a significant superiority over conventional and biodynamic indicating higher values in weight of 100 berries, in diameter of 20 berries in 50 peel berries weight in and weight of 100 pips (Tab.3). These characteristics are linked since the greater number and size of pips, the greater is the berries volume and lower concentrations of sugar and nitrites and less acidity.

Regarding the content of the must sugars biodynamic production system (Tab.3) was the greatest value (Reeve, 2003). Generally, the more sugar the greater the alcohol content in wine will be generated. In the other two parameters of must characteristics there were no statistically significant differences between the three farming systems (Tab.3).

Tab. 3

The effect of farming system in fruit characteristics in wine grape cultivation

Farming system	Fruit characteristics						
	100 Berries weight(g)	100 pips weight(g)	50 peel berries weight(g)	20 Berries diameter(mm)	Sugars (°Brix)	l aci cidity(g/lt)	pH
Conventional	151.09a	4.21a	19.89a	1.35ab	11.8a	5.58a	3.45a
Organic	213.27b	5.81b	25.88b	1.39a	11.8a	5.3a	3.48a
Biodynamic	191.56c	4.73c	23.45c	1.3b	12.4b	5.48a	3.37a

*Values in the same column followed by different letters are significantly different at $p \leq 0.05$.

CONCLUSION

The present study is the first attempt in Greek literature to compare soil and fruit properties under biodynamic, organic and conventional management and generally to record the biodynamic farming system with any other system of production. The results from the present study showed that the biological and physical parameters of soil quality were generally significantly greater in organic and biodynamic farming systems as compared to conventional. While concering the chemical parameters weren't observed differences between the three farming system except the percentage of total N that was significally greater in biodynamic farming system. This superiority of organic and biodynamic farming system compare to conventional take place also in fruit quality characteristics that were analyzed. Between organic and biodynamic production system, and for the fruit characteristics, more positive effects in the case of apples displays the biodynamic farming system whereas in the wine grapes the organic farming system.

Taking into consideration what has been mentioned, the data indicate that the principles and practices of biodynamic and organic farming can contribute significantly to our goal of achieving a more sustainable agriculture and environment.

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