Environmental and ecological sustainability environmental sciences essay

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AbstractOlive is the most extensively cultivated fruit crop in the world counting 9, 2 million hectares of area harvested in 2009: 8, 3 million are in the Mediterranean countries. This paper explain why the development of organic olive cultivation (5% of the total olive cultivation) can increase the sustainability of the Mediterranean. Regarding the ecological aspects, organic farming has benefits on landscape, biodiversity soil, water and air. Regarding economic sustainability organic olive oil production can be viable if the correct marketing channel is found. Regarding social sustainability, the olive oil consumption have a positive impact on health related to Mediterranean diet effects. Olive cultivation in the Mediterranean

The Olive (Olea europaea L.) is the only species of the 600 belonging to the family Oleaceae to have a fruit that can be consumed directly or processed. It is native to the coastal areas of the eastern Mediterranean Basin, from Lebanon, Syria and the maritime parts of Turkey and northern Iran at the south end of the Caspian Sea. Its fruit, the olive, is of major agricultural importance in the Mediterranean region as the source of olive oil. Olive has contributed to the development of all the culture in the Mediterranean Basin. The plant is in the legend of and symbolism of major religions: Christianity, Judaism and Islam.

Olive is the most extensively cultivated fruit crop in the world counting 9, 2 million hectares of area harvested in 2009 (FAOSTAT, 2011) and its cultivation area has tripled in the past 50 years. This rising is mainly due to its great potential to improve socio-economic conditions in rural areas due to: recognized nutritional value and pharmacological properties of the oil and leaf extracts (antioxidants, tocofelori, vitamins, etc.); the property of the plant to adapt to adverse environmental conditions typical of the marginal areas (tolerance to drought and salinity and to different temperatures from -15 to +55 C); the ability of the plant to provide protection against erosion in sandy and desert environments.

Olive is cultivated in 9. 074. 000 hectares (FAOSTAT, 2011) in Mediterranean countries considered and the virgin olive oil production is 2. 872. 088 ton (tab. 1) with high differences in yield between countries varying from 0. 5 t/ha in Tunisia to 3, 1 t/ha in Spain (Egypt data regarding yields seems too high to be correct). In the 2004/2005 more than 98% of world oil production came from Mediterranean countries (IOO, 2006).

The cultivation of olives according to the methods of organic farming does not present major difficulties, except for the olive fly (Bactrocera olea), and this is why it is very common in all the countries of the Mediterranean. The organic olive in 2007 was cultivated on 362. 000 ha and it represented the 4. 9% of the total olive area and 11% of the total organic land in the Mediterranean countries (Santucci, 2008). Most of the organic olive cultivation is carried out in Italy (106. 938 ha), Spain (91. 485 ha), Tunisia (80. 016 ha), follows by Greece (39. 635 ha) and Portogallo (28. 152 ha).

Tab. 1: Olive area (000 ha), olive yield (t ha-1) and virgin olive oil production in 2009 in the main Mediterranean countries

Olive Area harvested (000 ha) in 2009 1

Olive Yield (t/ha) in 2009 1

Virgin Olive oil production (t) 1

Organic Olive area in 2007 (000 ha) 2

Albania

40

1, 2

1200

0, 07

Algeria

288

1, 6

56000

0, 4

Croatia

15

2, 1

5800

0, 027

Cyprus

12

1, 1

2014

0, 5

Egypt

110

4, 5

7300

0, 23

France

19

1, 6

6300

nd

Greece

646

3, 0

332600

39

Iran

31

1, 2

850

nd

Israel

17

1, 8

6000

0, 34

Italy

1190

2, 7

587700

106

Jordan

60

2, 3

16760

0, 01

Lebanon

57

1, 4

19700

0, 4

Libya

205

0, 8

15000

nd

Malta

0, 006

1, 1

1

0, 007

Morocco

550

1, 4

95300

0, 1

Palestine

92

0, 8

5000

0, 5

Portugal

380

0, 9

53300

28

Syria

635

1, 3

168163

5

Slovenia

0, 8

2, 1

300

0, 007

Spain

2500

3, 1

1199200

91

Tunisia

1500

0, 5

150000

80

Turkey

727

1, 7

143600

7

TOTAL/MEDIA

9074

1, 7

2872088

361510

Sources: 1) FAOSTAT; 2) Santucci, 2008

With appropriate management, olive farming can contribute to the conservation of natural resources. But the tendency in recent years has been towards environmental degradation as a result of bad farming practices, the expansion of intensive plantations and the marginalization of low-input farms. In 2002 the whole of 2, 250 million euros of the EU Common Agricultural Policy (CAP) budget for olives was spent on production subsidies, paying farmers according to the amount of olives they produce, a policy that encouraged intensification of production, irrigation and the expansion of olive growing. Today the growth in the main EU Mediterranean producing countries is uneven and influenced by the reform of the EU domestic policy for olive oil that led, in 2006, to the complete decoupling of support from production. Meanwhile, production has continued to grow in almost all non-EU producing countries at a high steady rate. Sustainability of the organic olive cultivation

Sustainability is a very popular but conflicting word. It is a multi scale concept and moreover it is a relative term and not an objective one: we can say " this farm is more sustainable compared to this other farm" or " more sustainable than 10 years ago". Methodologies to assess agricultural sustainability are many and use different matrices and indicators (Morse at al. 2001), at both regional and farm level (OECD, 2001; INEA 2008). Here can be mentioned MESMIS framework (Lopez-Riadura et al, 2002), Threshold Method (Nicholls, 2004), Prototyping and dissemination of Ecological Farming Systems (Vereijken, 1997; Vazzana and Raso, 1997; Kabourakis, 1998), Life Cycle Assessment (Ceuterick, 1996), Input/Output methodology (Tellarini and Caporali, 2000). Assessing agricultural sustainability is a very complex issues as agriculture is multifunctional (production of food, services, etc.) and multi scale (nation, region, farming systems, farm, field, plot). However, in the context of agriculture, sustainability basically refers to the successful management of resources of agriculture to satisfy human needs while at the same time maintaining or enhancing the quality of the environment and conserving natural resources. So sustainability in organic farming must be seen in its three main dimension: ecological, economical and socio-cultural aspects. According to IFOAM (Eyhorn et al. 2002) ecological sustainability is based on: recycling the nutrients instead of applying external inputs, no chemical pollution of soil and water, promote biological diversity, improve soil fertility and build up humus, prevent soil erosion and compaction, animal friendly husbandry, using renewable energies. Some important aspects of social sustainability are: sufficient production for subsistence and income; a safe nutrition of

the family with healthy food; good working conditions for both men and women; building on local knowledge and traditions. And economic sustainability includes: satisfactory and reliable yields; low costs on external inputs and investments; crop diversification to improve income safely; value addition through quality improvement and on-farm processing; high efficiency to improve competitiveness.

This paper analyse if the development of organic olive cultivation could have positive implication on sustainability of the Mediterranean basin.

Environmental and ecological sustainability

Environmental sustainability can be assessed by many indicators (Pacini et al, 2009) but classically it is composed by six environmental area: biodiversity, landscape, soil, water, climate, air and energy (tab. 2). Is it probably the most studied aspect of sustainability. Results from long term experiments comparing farming methods have shown that organic agriculture contribute more than conventional to ameliorate environmental sustainability (Leigh and Johonston 1994; Mader at al. 2002; Pimental et al. 2005; Migliorini and Vazzana 2006; Migliorini and Vazzana 2007; Raupp et al. 2006).

Tab. 2: Environmental sustainability area and indicators (OECD, 2001)

Area

Aspect/Indictor

Biodiversity

Genetic diversity

Spices diversity (Flora and Fauna)

Ecosystema-Habitat diversity

Landscape

Landscape structure and aesthetic value

Soil

Soil organic matter (SOM) and acidity (pH)

Biological activity

Soil structure

Erosion

Desertification

Water (ground and surface) quantity and quality

Water use indicator or Irrigation index

Nutrient use and balance

Nitrate leaching

Phosphorus

Agrochemical

Pathogens

Climate and air

Carbon dioxide (CO2)

Nitrous oxide (N2O)

Methane (CH4)

Ammonia (NH3)

Agrochemical

Energy

Intensity of energy use

Efficiency of energy use

Biodiversity and Landscape

Biodiversity can be divided in three main categories: genetic, specie and ecosystem diversity. Organic olive farming is expected to be more sensitive to biodiversity conservation and utilization, although this sector suffers from the same obstacles of conventional one. The use of compost, soil cover and green manure, minimum soil tillage, non use of chemical treatments and the introduction of ecological infrastructure are organic techniques directly correlated with the increase of soil, fauna, flora and ecosystems diversity.

Biodiversity of olive trees (genetic diversity) is decreasing.

" Despite this large expansion, intra-specific diversity of olive is threatened by several factors including the abandonment of marginal soils, biotic and abiotic stresses, urbanisation, replacement of old groves with other species and substitution of rustic cultivars with more productive ones. For purposes of conservation and sustainable utilization, it is therefore very important to clearly identify true existing cultivars, their characteristics and the collections in which they are preserved." (Bartolini, 2011)

The Olive Germplasm Database was developed in 1997 by Prof. G. Bartolini and other scientists (G. Prevost, C. Messeri, G. Carignani) of the Istituto per la Valorizzazione del Legno e delle Specie Arboree (Trees and Timber Institute) of the Consiglio Nazionale delle Ricerche - CNR, Florence, Italy and published in collaboration with FAO Seed and Plant Genetic Resources Service (AGPS). In the 2005 edition, it contains information on more than 1 200 olive cultivars and has been compiled from more than 1 250 published sources. An updated list of olive cultivars with a short description of their characteristics and information on their geographical distribution are provided. A world-wide list of olive collections is also available. Since March 2008 un updated version of this database is available at http://www. oleadb. eu/.

The use of local varieties is required in the standards and regulations of organic farming and is contained in the agroecological principles that are the basis of organic farming techniques. Locally adapted varieties to the pedo-climatic environment are expected to be tolerant or resistant to pest and disease and so be productive with less inputs. Nevertheless, the organic olive sector uses the same varieties than the conventional one, as they are already the typical and well adapted to the regional environment since centuries. In Italy for example the olive tree variety available in the organic nursery plant register (ENSE, 2011) are the following: Agogia dolce, Ascolana, Bianchera, Cipressino, Frantoio, Itrana, Lazzero, Leccino, Leccio, Leccio del Corno, Leccio del Corno, Maurino, Mignolo, Moraiolo, Pendolino, Picholine. In new organic olive plantation, nursery plants of varieties not available in the ENSE list are provided by the conventional market and the period of conversion of three years is needed before selling the organic oil, that is also the period necessary for the plant to be productive. In Greece the main olive variety for oil production is Koroneiki, both in conventional and organic farming, although other varieties are grown locally in some regions (Minotu 2011).

For analysing species diversity we can consider the number of both cultivated and natural species, vegetable and animal, that are present in olive farms.

Some of the agro-chemicals used in conventional olive farming, such as Dimethoate and Fenoxycarb, have been found to cause a dramatic reduction in a wide spectrum of insect species, including several which have a beneficial role in controlling pests species (Cirio, 1997).

In the cropping systems of the organic farms a large number of cultivated and not cultivated species are expected. Vereijkein (1997) established in a European methodologies for prototyping ecological farms, a minimum thresholds of 50 species to be found in the Ecological Infrastructure as optimum level for Plant Species Diversity Index.

In a research in Apulia assessing sustainability of two olive farms (Vazzana et al. 2006) the Herbaceous Plant Biodiversity was higher in organic then conventional (200 vs 162, 44 score/ha) as well as the Arboreal Plant Biodiversity (7, 24 vs 6, 34 %) and the Ecological Infrastructure Index (896 vs 643 m/ha), although all the indicators were over the thresholds (> 48 score/ha, > 5% respectively > 60 m/ha).

One study conducted in Southern Italy (Iannotta et al. 2007) evaluated the side effects of compounds allowed in organic against the olive fly in open field on non-target arthropods fauna. The sprayed compounds showed few negative effects. This fact could be attributed to the grass cover which probably reduced the effects of active agents with short term efficacy. In definitive, the grass cover could play an important role in minimising the impact of sprayed compounds on non target arthropods, furnishing a shelter against the direct contact with active agents.

Ecosystem and landscape diversity in olive orchard depend on the level of specialization and on how much is the olive cultivation intensive more than the type of management (organic vs conventional). Biodiversity tends to be high in traditionally managed olive plantations as their structural diversity (trees, understorey, patches of natural vegetation, dry-stone walls, etc.) provides a variety of habitats. We can distinguish three density in olive

cultivation: 1) traditional (200-300 p/ha) at 5x7m or 8x8 where is possible to grow between the row under the trees; ii) dynamic (> 500 p/ha) in monocone 3x6 that need to be thin out after 10 years iii) high intensive (1500 p/ha) at 1, 5x3 m the Spanish model where machine can prune and harvest 1 hectares in 2 hours!

The Agricultural Landscape Diversity in the study conducted in Apulia (Vazzana et al. 2006) was zero in both the farms showing very homogenous ecosystems as 100% of the field is covered by the same crops.

Soil

The evaluation of sustainability regarding soil involve many aspects/indicators (tab. 2): soil organic matter (SOM) and acidity (pH), biological activity, soil structure, erosion and desertification. These issues depend on climate and vegetation, topography, soil structure, soil cover and use of land. Organic agriculture considers soil as a living organism and has the goal to increase soil fertility. The use of chemical weeding (herbicide application) is forbidden, cover crops (vegetative strips between the tree rows or in form of mulching of the weeds or cover plants) and compost (animal and green) are used to protect soil from erosion and to increase organic matter.

Olive orchards are often on slope land and soil erosion is recognized as a serious problem causing environmental, economic and social repercussions. Soil erosion is one of the most serious and widespread environmental problems in the Mediterranean region. In intensified olive plantations, farmers usually keep the soil bare of vegetation all year round, by regular tillage. Intensive tillage not only exposes the soil to the erosive effects of rainfall, it also increases the soil vulnerability by reducing its organic matter content, especially when combined with the use of non organic fertilizers and herbicides.

Experimental data from research in Crete (Metzidakis et al. 2006) shown that the average soil loss is lower than in other countries due to: the presence of terraces in many olive plantations; soil is covered by spontaneous vegetation throughout winter and thus it is protected against rain and run-off water; tillage is usually practiced once per year at the end of winter. Especially in organic farming, soil erosion can be largely reduced if tillage operations are avoided or minimized.

The shift to organic farming in olive orchards in the province of Córdoba has been accompanied by increased protection of the soil and lowered erosion risk (Milgroom et al. 2007). The most important changes in soil management practices associated with the transition from conventional to organic agriculture were the reduction in tillage and the increase in management systems that incorporate a vegetative cover controlled either by grazing livestock or by mowing.

Soil organic matter content in Apulia organic olive farm is higher than in the conventional one (3, 13% vs 3, 06%) (Vazzana et al. 2006).

Water

The impact of the olive farming on water quantity is due over exploitation of ground and surface waters for irrigation that is a an enormous environmental problem in the Mediterranean region. Deep wells for irrigation have been installed in many fields especially in the plain and surrounding hills, converting what used to be dry olive trees cultivation to drip-irrigated cultivation. Water quantity can be assess with the Water Use Indicator or Irrigation index to measure the efficiency of the water use on the farm and the impact of farm activities on the water as a natural resource. Although the quantities used per hectare are relatively low compared to arable cropping, irrigated olive plantations cover an increasingly large area in some regions and their total impact on water resources is considerable. In south Italy (Vazzana et al. 2006), both conventional and organic olive orchards results with a Water Use much below the thresholds (< 1 mc/Ha AUU) but the conventional one was higher than the organic (0, 34 vs 0, 04 mc/Ha AUU).

While, the impact of the olive farming on water quality is due to pollution by run-off and leaching of fertilisers and pesticides to surface and ground waters and can be assess measuring the Nutrient use and balance, Nitrate leaching, amount of Phosphorus and Agrochemical, presence of Pathogens (tab. 2).

Herbicides are often used in intensive olive orchards to do the weeding in order to reduce water and nutrient competition and to clean the area for harvest the olive. Insecticide are sprayed to combat olive fly and run off and leaching pollute the ground water with residues. Nitrogen inputs can reach high levels (up to 350 kg per hectare in extreme cases), in the most intensive, irrigated olive farming. These can lead to problem of groundwater

pollution by eutrophication although few research is done in olive plantations related to ground water pollution. Climate and Air

The effect on climate by agricultural methods involve mainly the use of fertilizer (in particular the use of Nitrogen) and of farm machine related to the green house emission: Carbon dioxide (CO2), Nitrous oxide (N2O), Methane (CH4) and Ammonia (NH3).

The effect on air by agriculture involve the use of agrochemicals. For the evaluation of this aspects Vereijken (1997) proposed the Environmental Expose to Pesticide (EEP) Index calculated for soil, air and water.

In olive orchards the only widespread pest causing economic damages is the olive fly, Bactrocera oleae. Conventional farmers spray with insecticides (Dimethoate, Deltamethrin, Phosmet) in order to increase quantity and quality of olive and oil yield. The dimethoate, organophosphorous insecticide, was the most widely used for its effectiveness and the relatively low cost. It is preferable because it would leave few residues in olive oil because, being water soluble, it would pass in the waters of vegetation. Due to the widespread use of this product in Italy are expected further restrictive measures which will involve the olives sector. Deltamethrin is a pyrethroids and its environmental impact is significant: is not very selective, so it is particularly harmful with regard to useful arthropods fauna and have negative side effects in Hymenoptera, Coleoptera and Neuroptera species. Its use should therefore be limited and confined to areas where the effect on useful arthropods fauna is low impact. It is harmful to aquatic organisms. The Phosmet is a organophosphorus of new generation. The environmental impact is significant: it has a harmful effect to useful arthropods fauna, particularly to the bees which show a high toxicity and against aquatic organisms. Spinosad seems to be significantly safer in the insect orders of Coleoptera, Neuroptera and Hymenoptera compared to pyrethroid and organophosphorous products.

Organic producers instead using chemicals can do a regular and frequent pruning of the trees and increase the soil quality and the biodiversity inhabiting olive agroecosystem that lead to a biotic control of many pest species. Biological control, carried out so far within the experimental launches of Opius concolor, offers only partial results and in any case is particularly costly. Bacillus thuringiensis have recently been used but in this case biological control has shown a lack of effectiveness, mainly because of the difficulty of reaching deep into the larva. For the control of olive fly organic farmers use mass trapping (based on food attractant, pheromones, pyrethrines and coloured surfaces) and treatments with organic and mineral origin inputs (rotenone, kaolin, copper, azadiractin and propolis).

Finally would be necessary to evaluate the air pollution from burning pruning residues. These practice in organic farming is strongly discourage as it have a negative impact on soil living organism and on carbon sequestration and all residues are willing to be incorporated into the soil to increase organic matter.

Energy and LCA assessmentEnergy efficiency measures the technical performance of the agrosystem. Are organic olive production systems more energetically efficient than conventional? In order to verify these question, methodologies and questionnaires were set up to investigate two farms management approaches (organic versus conventional) on the hills and on the plain of the Messara Valley, in Crete (Dessane 2003). It was found that the organic groves are twice as much efficient, in terms of energy, as the conventional ones. With the organic cultural practices, the average result obtained for the energy efficiency study is 6 Joules per Joule (J/J), compared

to 3 as an average for the conventional groves. Meaning that 1 non-renewable energy unit, in Joules (J), used in the organic production systems results in 6 J of olives. Life cycle analysis (LCA) a ‘ cradle to farm gate’ approach is a viable tools to determine efficient and ecologically sound cultural practices. Dessane (2003) applied it to the same organic and conventional olive farms in Crete when analyzing the environmental impact categories (eutrophication, acidification, global warming, erosion, biodiversity loss, energy and groundwater depletion). Results shown that organic production obtained a better score for the majority of the environmental impact categories. Nevertheless potential erosion was found to be really higher than tolerable ecological limit. Also, two cultural practices have been highlighted for being ecologically sound: cover-cropping and chopping, incorporation of pruning residues. Socio-Economic sustainability and quality

When analysing socio-economic sustainability of olive cultivation at farm level production, income, trade channel, labour condition, level of education and quality of production should be considered as explained in the second chapter.

Organic olive production generally have a lower yield but it is more labour intensive if compared to conventional. Organic olive farms will tend to have less cost (inferior pest and disease management compared to conventional farming), high farm income and increase of the land value, although economic results depends on many aspects such as: the density of orchards, the intensities of management, the efficiency and quality of processing and the channel market as well as political support. An important contribution of the organic management is on the social sustainability in terms of revitalizing the rural area assuring farm successor; increasing local employment; resulting in high labour force per ha/year and labour employed for all ‘ year round’ with a relatively small percentage of abandonment, increasing demand for higher agricultural education. Finally the most important one is the high quality of olive oil (extra virgin).

A research in Crete (Metzidakis et al. 2006a) compared economic aspects of three different farming systems. Labour cost in organic was higher (up to 13 %) than intensive conventional and higher (up to 30 %) than semi-intensive. Output plus aid in organic was lower (up to 11. 5 %) than intensive conventional and higher (up to 26 %) than semi-intensive. Net revenue in organic was lower (up to 6 %) than intensive conventional and higher (up to 33 %) than semi-intensive. The production cost is high in organic farming due to: increased labour cost; difficulties in pest and disease management; lower yield due to deficiencies in fertilization. The net revenue can be lower than in intensive conventional and higher than semi-intensive conventional depending on the orchard and management.

A study conducted in Italy comparing 115 organic and 114 conventional olive growing farms (Cislino and Madau, 2007) showed that organic olive-growing farmers use their inputs more efficiently than conventional ones. In conventional farms Gross Production is significantly higher than the organic ones (9121 vs 3929 euro/ha), as the Net Margin, the Net Product and Costs. The average values on Total Labour Force instead shown that even if conventional farms still have higher results than organic ones, the distance become shorter: the Gross Production is 56037 euro/man-hours in conventional and 53200 euro/man-hours in organic. The organic farmers substantially achieve a similar overall economic efficiency with respect to the conventional ones due to a more rationale use of their own inputs rather than from a higher productivity.

In Turkey it has been determined (Artukoglu et al. 2010) with input/output methodologies that the economic efficiency of conventional olive oil farms is lower than in organic farms. Organic farm have a higher total cost due to higher labour, that is the most important cost (5371 vs 2491 Turkish Liras/ha), fuel (1600 vs 718 Turkish Liras/ha) and fertilizers (762 vs 486 Turkish Liras/ha). But the production was higher (4, 7 vs 3, 5 T/ha) and the unit price was higher (1. 69 vs 1. 32 Turkish Liras/ha).

Quality aspects of organic (extra-virgin) olive oil are related to the Mediterranean diet plus the added value of the higher quality of organic products.

Nutritionally, olive oil is rich in vitamins A, B1, B2, C, D, E and K, and in iron. It is the richest dietary source of monounsaturated fat available. Monounsaturated fat does not raise blood cholesterol levels the way saturated fat does. There are several types of olive oil that are heart healthy, but only extra virgin olive oil is used in the diet of the Mediterranean region. Olive oil is pressed from ripe olives after they are harvested. Oil from the first pressing is classified as virgin. Extra virgin simply means oil from the first pressing that is particularly low in acid — less than 1%. It is considered the finest oil, and is likely to have the fruitiest and most pronounced flavour.

Several epidemiological studies and some intervention trials suggest that the traditional Mediterranean diet may protect against chronic diseases and mortality. The most significant features attributed to this pattern are a high intake of vegetables, legumes, fruits, nuts, whole grains, and olive oil; a moderate-to-high intake of fish; a low-to moderate intake of some dairy products; a low intake of meat and saturated fatty acids, and a regular but prudent intake of wine. In recent years, however, food habits in the Mediterranean countries have tended to move towards the patterns typical of the northern countries.

Discussion and Conclusion

The analysis of literature show that organic olive cultivation have positive effects on ecological, productive, economic and social sustainability.

In particular the conversion to organic olive farming can increase the opportunity of the sector (Metzidakis, 2006b) with the production of organic meat, milk and other products aside olive oil, the establishment of strip cropping zones in vulnerable soils due to erosion; a better promotion of the high quality of organic products, a better trade and a better use/ function of agricultural cooperatives. Finally organic cultivation of olive can increase the cultural and traditional heritage value and higher agricultural education. Nevertheless the challenges for the future regarding the shortage of water for irrigation, the decline in labour availability and rural population, the reduction of EU subsidies.