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*Review*

# Organic olive farming

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**Organically managed agricultural land surface is widely increasing all over the world and organic olive farming in suitable environments as well. Both olive oil and pickled olive fruits demand is rising and organic products register an increasing tendency, mainly in the northern European and American markets. Scientific literature reports several studies about organic olive farming, but a comprehensive summary is lacking. Economic social implication represents a pivotal aspect in the passage from conventional to organic farming in olive and the price perception of organic productions in the market is a strong physiological threshold. Soil fertility maintenance through minimal soil disturbance, permanent soil cover and organic matter application helps to prevent soil erosion, increase organic matter availability and biodiversity reducing external input supply with higher autonomy for the ecosystem. A good organic matter cycle management allows a more efficient use of minimal amounts of organic fertilizers and an improved possibility to integrate plant nutrition with fertigation or foliar applications so that to reduce the leaching and the environmental pollution. As well, the use of olive oil by-products as amendment and source of nutrients has been studied and is advisable. The study and the selection of more resistant cultivars improve the effectiveness of the organic approach for pest and disease management in the vision of an integrated approach of the whole factors involved in the production process.**

**Key words:** *Olea europaea* L., soil fertility, conservative farming, nutrition, biodiversity.

## INTRODUCTION

Organic agriculture has developed rapidly worldwide during the last few years and is now practiced in approximately 120 countries of the world. Agricultural land organically managed in the world had exceeded at the end of 2008 the surface of 35 millions of hectares, with around 1,300,000 operators producing and processing according to certified standards. In 2011 the farmers were increased up to 1.8 million and the hectares were 37.2 million (IFOAM and FIBL, 2013).

In Table 1 is reported the agricultural land organically managed in the world according to Willer and Kilcher (2010). Australia accounts the largest certified organic surface, with 12 million hectares, followed by Argentina (4 million hectares), China (1.9 million hectares) and U.S. (1.6 million hectares).

In the European Union, about 7.5 million hectares are under organic management corresponding to 4.3% of the total agricultural area.

Globally, certified organic agriculture occupies about 1% of the agricultural land and 1-2% of agricultural sales by value (Willer and Yussefi, 2004). Europe and North America accounts for approximately 97% of the value of organic sales worldwide in 2005 (ISMEA, 2007), Europe has 52% of sales and North America has 45%.

## ORGANIC FARMING IN THE MEDITERRANEAN REGION

About one quarter of the world's organic agricultural land is in Europe (Willer and Kilcher, 2010). The country with the largest organic agricultural land surface is Spain with

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**Table 1.** Agricultural land organically managed in the world (Willer and Kilcher, 2010).

| | Organic managed surface (million of hectares) | Number of farms | World's organic land (%) |
|---|---|---|---|
| Europe | 8.2 | 220,000 | 23.4 |
| North America | 2.5 | n.a. | 7.4 |
| South America | 8.1 | 260,000 | 23.3 |
| Asia | 3.3 | 400,000 | 9.3 |
| Africa | 0.9 | 470,000 | 2.6 |
| Oceania | 12 | n.a. | 34 |

1.1 million hectares, followed by Italy with 1 million hectares, and Germany (0.9 million hectares). The country with the highest number of producers is Italy (more than 44,000 producers, IFOAM EU and FiBL, 2009).

In northern Africa, the first pioneer experiences about organic farming were made in Egypt (1977), where a biodynamic farm called Sekem with about 70 ha was created in the desert, and where medicinal plants and aromatic herbs were grown (Abou-Hadid, 2001). In the same decade, private initiatives were developed in Tunisia and Morocco, and organic farming developed in Turkey because of the growing market in Europe (Aksoy, 2002).

The development of organic agriculture and its importance differs from country to country. Generally, the EU Mediterranean countries are much further developed and organized than the Southern and the Eastern countries. Differences also exist among the countries located on the same shore. In the Mediterranean basin, there are more than 3 million hectares organically managed by almost 120,000 farms mainly located in Italy, Spain and France, but the statistics show that Tunisia, Turkey, Egypt and Syria are quickly increasing their organic agricultural land surfaces.

## ORGANIC OLIVE

More than the half of the permanent crops surface in Europe is used for olives, followed by deciduous fruits, nuts, and grapes (Willer and Yussefi, 2007). International Olive Council (IOC, 2010) reported main areas of olive production are Spain (2.5 millions ha), followed by Italy (1.1 millions ha), Greece (1 million ha) and Portugal (less than 0.5 million ha).

According to the data released by IFOAM (Willer and Yussefi, 2007) and other concerned by this study, the organic olive would extend for about 362,000 ha, including those under conversion. This represents the 11% of the total organic surface and almost 5% of the entire olive surface of concerned countries. Overall, approximately 30% of the surfaces cultivated with organic olive is in Italy, followed by Spain (25%), Tunisia (22%) and Greece (11%, OPSAPM, 2008).

According to Diaz-Espejo et al. (2006), world demand for olive products, oil and fruit, is rising because of their nutritional properties, while organic products show an increasing trend, mainly in the northern European and American markets. Moreover, olive farming provides an important source of employment in many rural areas of the Mediterranean basin, including many marginal areas where productions can be combined with other activities such as tourism.

Olive planted areas are developing at international level, with estimated increases up to 100,000-120,000 ha/years. Due to this growth, olive growing surfaces are expected to increase up to 1-2 million ha in the next twenty years (ISMEA, 2007), and organic olive farming approach is consequently expected to rise, so that suitable inputs and techniques management is strongly required.

### Legislation

The relevant refereeing European legislation on organic farming and labelling of organic products (that includes also olive and olive oils) is the Council Regulation (EC) No 834/2007 and the Commission Regulation (EC) No 889/2008. According to the FiBL survey on organic rules and regulations (Huber et al., 2012), the number of countries with organic standards has increased to 84, only Kosovo among the non-EU European countries did not implemented a full regulation on organic agriculture, while northern African or middle-eastern countries usually have implemented national regulation based on the EU standards.

More over, the UE legislation for organic olive production covers all the field practices up to the harvest, but does not regulate the processing stage for which is required specific protocols linked to quality brands or certification bodies.

### Economic social approach

Ecologically-managed olive orchards are important both from an economic social and ecological point of view and also due to their potential for sustainability. Organic olive farming and olive oil are becoming abundant and few have dealt with the process of diffusion/adoption of the organic farming, even though this type of information is in great demand in the olive sector. Lampkin and Padel (1994) analysed the characteristics, motives and barriers to organic farming adoption from an international perspective. Diebel et al. (1993) analysed potential economic barriers to the adoption of low-input agriculture using mathematical non-linear programming.

Chinchilla (1999) used sociological techniques to analyse the role of the different parties involved in the diffusion of organic practices (from the research up to the extension level) among Andalusian olive growers. Parra López (2003) and Parra López and Calatrava Requena (2004) analysed the diffusion over time of organic farming as a technological innovation in Andalusian olive cultivation in three scenarios according to the yields of different olive orchards.

Organic and conventional farming practices and their environmental impacts have been also compared from an interdisciplinary perspective in some cases (Ardenclarke and Hodges, 1987, 1988; Mawampanga and Debertin, 1996; Berentsen et al., 1998; Clark et al., 1998; Conacher and Conacher, 1998; DEPA, 1999; Sánchez Jiménez, 1999; Stolze et al., 2000; Wells et al., 2000; Hansen et al., 2001; Rigby et al., 2001; Pacini et al., 2003; Parra López et al., 2004; Rasul and Thapa, 2004).

The adoption rate of organic olive-growing would appear to be closely related to the subsidies availability, especially in less productive regions (Parra López, 2003). Organic olive growing has a greater social value than conventional cultivation especially in less productive conditions: Greater generation of employment, greater contribution to social justice, and better performance in disadvantaged regions (Parra López, 2003; Parra López et al., 2004).

## Soil fertility and biodiversity management

Good soil fertility and biodiversity management is one of the pillars on which organic farming system is based on. This is why it is important to know the most common degradation processes (including biological ones) which decrease diversity (Guzman and Alonso, 2004) and the meaning of biodiversity for improving soil quality (Gangatharan and Neri, 2012) and the reasons behind the soil sickness (Zucconi, 2003, Neri et al., 2005, 2006).

Higher energy use efficiency, soil fertility and biodiversity are only some of the several agro-environmental positive effects reported on latest research outcomes obtained on organic horticulture (Raviv, 2010). Land maintenance systems in the organic olive orchard are based on the use of green natural mulching or cover crops among the rows to prevent soil erosion, increase organic matter availability and biodiversity. A periodical mechanical control with trimmers is applied and the vegetal residues (better if mixed with pruning material to balance the C/N ratio) left on the soil (Guzman and Alonso, 2004). Along the row during the early stages of plantation, the use of organic mulching systems (garden pruning chipped materials; compost, coconut fibre carpets, etc) is effective in reducing competition for nutrients and water between the olive and the natural ground cover. In adult olive groves a natural ground cover trimming or minimum tillage is effective (Lodolini and Neri, 2013; Giorgi et al., 2007a).

The efficiency of the cover crop practice in soil, water and nutrient conservation in the olive tree cropping of Southern Spain, were studied by using plots long enough to follow up the development of rills observed on hill slopes during several rainfall-runoff events and cropping seasons. Results showed that the cover crop, as compared to conventional tillage, efficiently reduced runoff and sediment yield down to tolerable levels, 5.68% of the rainfall being converted to runoff, and the soil loss reaching 0.04 kg $m^{-2}$ $year^{-1}$, as the average of four years. Additionally, in the cover crop treatment, the values of the nutrient export either dissolved in the runoff water or adsorbed in the sediment were lower than in the conventional tillage treatment (0.631 and 0.065 kg $m^{-2}$ $year^{-1}$ of organic carbon and nitrogen, respectively, 0.175 and 0.0333 kg $m^{-2}$ $year^{-1}$ of soluble K and P, respectively, and 0.010 and 0.002 kg $m^{-2}$ $year^{-1}$ of available K and P, respectively). The study concluded that the adoption of a cover crop as a soil management practice can be a feasible way to reach sustainability in many olive-cropped soils of southern Spain. Unfortunately, this method is not always easy to implement due to technical problems such as seed selection, its maintenance, and the choice of the correct killing date to avoid water competition (Gomez et al., 2009).

Soil fertility variation at olive orchard scale was studied in a rain-fed olive orchard located on a topographical sequence in the centre of Tunisia. Soil parameters such as pH, organic matter, gypsum, lime, N, P and K contents and soil electrical conductivity were determined in samples obtained at 1 m depth and used to characterize soil fertility. Leaf samples from olive trees (cv Chemlali) 80 years old and at squared spacing distance (24×24 m apart) were collected in mid-July 2005 to verify plant nutritional status. Each soil fertility component was analyzed statistically and geostatistically. Results showed that an important area is menaced by K deficiency. Indeed, in this area soil $K_2O$ content revealed to be under the threshold of 80 ppm. Another area, located in the higher part of the topographical sequence resulted to be affected by a high concentration of sulphates, carbonates and sodium. The study of the relationship between soil and plant concentrations for several nutrients did not allow singling out any correlation. Nevertheless, the carbohydrates allocation in the tree was influenced by soil fertility status. The hypothesis that to overcome stress caused by soil limiting conditions the tree concentrate assimilates in the active parts to increase osmotic pressure is discussed. Under these conditions, olive tree may develop a protection system leading to low reserve carbohydrates and yield (Gargouri et al., 2006).

Studies for developing a soil degradation index (SDI) in organic olive orchards have been carried out in Southern Spain as an assessment and certification tool and also to have the final goal in the evaluation of the soil degradation risk in commercial farms by field technicians with a minimum number of soil measurements and costs. The results derived from the assessment of organic olive groves in the province of Cordoba indicated that 55% of the organic olive farms (OF) in the study area were not found to be in a state of soil degradation. This is according to the conventional standards established for agricultural production, with most deficiencies being in soil nutrients, partly due to low fertility of some of the soils on which the plantations were established. Only 7% of the OFs had a large number of poor soil property values, and thus would be considered to be degraded soils. This is explained by the low, or moderate, intensity of the farming systems used in the OF considered in this study. There was a large variability in soil degradation status within the same soil management system, indicating the difficulty of screening soil conditions in organic olive orchards based on the soil management used. Finally, concerning the results obtained it is concluded that the study could contribute to improve soil protection initiatives in Southern Spain (Gomez et al., 2009).

To provide a description of the organic olive production systems, a research study was carried out in four EU olive-producing countries in the frame of the OLIVERO project. The goal of the project was to evaluate the feasibility of organic farming in the different target areas providing economically viable indications for olive groves management according to local socio-economic and environmental conditions and in order to preserve natural resources.

The study results indicated that the Soil Management according to Organic Production Systems (SMOPS) provides ecological, economic and social benefits to the regions in which they are located, although most of these benefits are not strictly limited to the organic production systems. The analysis of the reasons for the beneficial effects of olive cultivation in the studied areas indicates that in most cases soil management techniques adopted or recommended for organic production systems could provide similar benefits in other production systems as well. Erosion control and organic matter balance remain significant issues and subsidy support should be conditional on the implementation of additional soil and water conservation measures. In some of the studied areas, such as Western Crete (Greece) and Basilicata–Salerno (Italy), the potential for organic olive production expansion remains great, even though organic olive farming showed a lower profitability compared to non-organic olive production systems.

Efficacy of different management systems with respect to that of tillage systems used in semiarid, continental environments was studied through field experiments in an olive orchard (Sta. Olalla, Toledo, Central Spain) to establish the most appropriate herbaceous cover in terms of reduced competition for water; and to assess the efficacy of different strategies aimed at increasing soil N, OM, and biochemical fertility and controlling erosion. The data derived from the plant covers were highly satisfactory in terms of soil erosion control, given that during most of the year the naked soil area never reached 50%, and from the autumn of the third year of this study, values as low as 17% bare soil were recorded for plots sown with clover and 12% for plots with a natural plant cover. The management strategy used favored the presence and abundance of spontaneous legumes in the natural cover. The beneficial effect of the subterranean clover cover on the soil included more available water in the fifth year and also the study highlighted that the plant covers used did not compete, or scarcely competed, with the olive crop for water during these first 5 years, since although soil moisture values were the greatest for plots subjected to tillage and, on occasion, for those with a natural cover, these differences were mostly not significant and neither were most olive yields significantly affected by the management strategy (Hernandez et al., 2005).

## Nutrition

The role of inadequate nutrition and or nutritional imbalance in yield loss in organic olive orchards was evaluated by a comparative analysis of soil fertility and leaf nutrient status of both organic and conventional olive orchards (Vemmos et al., 2006). The study revealed that the leaf N level in organically grown olive trees was at the lower end of the optimum range recommended in the literature or even marginal (Jones et al., 1991; Reuter and Robinson, 1986; Gavalas, 1978; Lodolini et al., 2009, 2011). The lower production experienced by organic farmers may be due to insufficient N supplied. The higher P and K concentration in organic farms is related to the fact that P is more available because of organic matter additions; moreover organic matter is generally a good source of K. In both organic and conventional farms, K was found to be lower than the optimum (0.9-1.20% d.w., Jones et al., 1991). The soil pH in both farming systems was below 7.00 and K deficiency is reported to occur more often in acidic soils (Gavalas, 1978).

The leaf Zn concentration in organic farming was found to be lower than in conventional ones whereas Fe and B were higher. In general, metallic cations like Fe, Mn, Zn, and Cu can be bound to chelates in organic matter. However, some micronutrients may be bound so tightly to organic matter that crops suffer from their deficiencies

(Marschner, 1997); in particular, Zn and Cu are often unavailable and deficient in organic soils, in contrast to Fe availability, which increases. The higher level of B may be due to the fact that organic matter enriches soils with Boron. Regardless of the type of cultivation, B level, like K, was found to be below optimum (Jones et al., 1991; Reuter and Robinson, 1986; Gavalas, 1978). Given that B and K deficiencies adversely affect vegetative growth and reduce yields, it is important that these elements be closely monitored in olive orchards. The total nutrient balance (S=N+10P+K) was lower than optimum in 3 of the 4 organic farms, whereas it was slightly higher than optimum in all but one of the conventional trees. The N/S ratio was lower in all organic farming systems compared to conventional ones.

The significant decrease in olive fruit yield of the organic orchards included in the study would seem to be related in particular to inadequate N fertilization, but may also be a result of inappropriate cultivation practices generally.

Effectiveness of a plant guard biofertilizer (commercial liquid materials containing spores of *Trichoderma harzianum* fungi) and felspar (silicates of alumina together with potash, soda, or lime) as a natural source of potassium combined with compost on vegetative growth and nutritional parameters were studied on olive seedlings and rhizosphere micro flora in the root regions. The experiment revealed a significant increase in the height of the main stem, branch stem length, number of branches, main stem diameter and leaf area of olive seedling treated with compost fortified with plant guard and felspar at two recommended levels compared with the control treatment. Application of olive seedlings with compost fortified with highest level of plant guard 1% and felspar 25 g increased the plant height from 43.1 cm in the control to 72.2 cm (67.52% increase). Also, application of olive seedlings with compost fortified with the highest level of plant guard 1% and felspar 25 g increased the chlorophyll a and b content. The same trend was also observed concerning the application of compost, plant guard and felspar on micro and macronutrients content in the leaves of olive seedlings (Elham et al., 2009).

To study the response of different concentrations (0, 16, 32 and 48 g/tree) of two fertilizers (20:20:20 NPK and 20 N-ammonium sulphate), experimentations on two-year-old rooted cuttings of four olive cultivars (Nabali, Grossa di Spagna, Nabali Mohassan and Manzanillo) were carried out under greenhouse and field conditions.. The greenhouse experiment results indicated that different fertilizer treatments increased leaf nitrogen content, shoot length and shoot dry weight, but negatively affected phosphorus content and root dry weight and had no effect on potassium content. However, Nabali had the highest leaf NPK content. Grossa di Espana had the shortest shoot length, while Manzanillo had the highest shoot length, dry weight and root dry weight. Results of field experiment indicated that different fertilizer treatments had no effect on leaf nitrogen content and adversely affected phosphorus leaf content, they also negatively affected potassium content but not the 48 g NPK/tree and 16 g N/tree, however, they improved shoot length and shoot dry weight but did not affect root dry weight except 32 g N/tree treatment. Nabali Mohassan and Manzanillo had the longest shoot (Nawaf et al., 2006).

The effect of poultry manure with or without nitrogen fixing bacteria namely Biogein (biofertilizer recommended to enhance vegetative growth and flowering) was compared to a mineral nutrition in an adult olive trees (cv. Picual) in a private orchard at Egypt-Alex. Desert Road during two following seasons (2005 and 2006). Results showed an increase in vegetative growth when organic fertilizer was applied. N and K leaf contents increased significantly by applying poultry manure, but no significant differences were observed on P leaf content in both seasons. Poultry manure increased Fe contents in leaf in both seasons and Mn in the second season, while leaf Zn content increased in the second season when mineral fertilization was used. No significant difference was observed between treatments on the leaf chlorophyll *a* content, even though leaf chlorophyll *b* content was enhanced in the second season (Hegazi et al., 2007).

**By-products**

Olive oil by-products have an important fertilizing value due to their organic matter and nutrients content so that they represent a good solution for organic fertilization in olive groves, but they also possess a phytotoxic effect due to high polyphenols concentration. Some experimentation were carried out in Italy to study the reaction of olive roots and potted plantlets vegetative growth in presence of different patches husks distribution and increasing concentrations (Giorgi et al., 2007b, 2010; Paolasini, 2011). Olive roots avoided husk substrate if a husk-free section was present, while toxic effect was mitigated and root growth allowed when hay residues were mixed to the growing media. Positive effects on root and shoot growth were registered with husk concentrations up to 8% (corresponding to 80 $cm^3$ $ha^1$) once the toxic effect during the initial stage was overcome, while reduced development of the plantlets were shown for 40 and 20%.

Experiments were carried out in Italy and Spain to transform olive mill by-products into organic fertilizer by composting those products under aerobic and anaerobic conditions (Calvet et al., 1985; Estaun et al., 1985). These processes reduce the volume of wastes, remove its phytotoxicity and improve its organic values. The composted olive mill by-products obtained from the processing were used as soil amendments and showed no phytotoxic effects but beneficial effects on soil fertility, particularly enhancing N2-fixers, ammonia producing bacteria, nitrifying bacteria, cellulosic and ligninolitic bacteria (Hamdi, 1993; Boari et al., 1984). An increase in water retention properties and ion-exchange capacity of soil and a general improvement in the soil properties were also recorded. Olive mill by-products were also mixed with lime prior to application in the field and the sludge obtained was found to be suitable to be used as fertilizer for field crops (Tomati and Galli, 1992). Finally the olive mill residues were found to be effective on saprophytic growth and disease incidence of foliar and soil borne plant fungal pathogens (Bonanomi et al., 2006).

## Carbon exchange

Measurements of the daily net ecosystem exchange flux rate (FNEE) of an irrigated olive orchard along its growing period were executed to assess the variation of FNEE with tree size and quantify the water use efficiency (net $CO_2$ assimilated per unit of water employed) of the system. Researchers suggested that drip irrigated orchards in general, and olive in particular, deserve specific carbon exchange and carbon budget studies and cannot be easily included in other biomes. The behaviour of soil respiration or the strong effect of the canopy conductance on the carbon assimilation, suggest that the knowledge obtained in forests or herbaceous crops does not necessary apply in the context of irrigated orchards, where more specific work should be undertaken (Testi et al., 2008).

Microbial biomass, basal and cumulative respiration (and consequently the $qCO_2$) seemed to be mainly influenced by the presence of the green manure in the soil (Ponzio, 2012). Thus, it was confirmed the findings of several authors on the effects of organic amendments on soil microbial activity (Widmer et al., 2002; Treonisa et al., 2010).

## Pest and disease management

Biological control options have been investigated as methods to manage pests and diseases and can be very effective when used as part of an integrated management program. Investigations about the olive fruit fly (*Bactrocera Oleae* Gmelin) control have included new parasitoids (Kapaun et al., 2010) and finding new enemies (Argov et al., 2009).

Biocontrol agents are also being investigated to reduce the severity of diseases such as olive knot and *Verticillium* wilt (Prieto et al., 2009; Rokni Zadeh et al., 2008). Muller et al. (2008) reported that the application of *Serratia plymuthica* bacteria in the nursery reduced disease severity from *Verticillium*, while other authors (Castillo et al., 2006; Lima et al., 2008; Porras et al., 2006) investigated the suppressive effects on diseases of mycorrhizal fungi and composts. Several non-conventional pesticides or biopesticides have been investigated: Kaolin, for example, is used for olive fly control with minimal effects on the oil quality (Perri et al., 2007) but significant negative effect on the natural enemy arthropod community (Pascual et al., 2010).

The influence that different styles of olive-orchard management (conventional, integrated, and organic) exert on the predator *Chrysoperla carnea* has been studied to strengthen this insect's role in the integrated management against pests. The results showed that the chrysopid populations increase significantly during some months in the integrated and organic olive orchard. The most abundant species in all the zones was *C. carnea*, representing 95% of all captures in the conventional olive orchard. It was found that the larvae from the integrated olive orchard took longer to develop, while the pupae from the organic orchard evolved most rapidly to adulthood. The highest mortality rate was for larvae in the conventional olive orchard. The fecundity of the females from the organic orchards was significantly greater, presumably due to their greater longevity and shorter pre-oviposition period. These results of the study can be used to improve conservation strategies and to increase *C. carnea* populations and their predatory activity (Corrales and Campos, 2004).

## Cultivar selection

More over, in organic olive cultivation farming the selection of less susceptible cultivars to pests and diseases is strongly recommended.

Some studies have reported a different susceptibility of the cultivars to olive fruit fly. Rizzo and Caleca (2006) compared Sicilian cultivars according to the dimension of the fruits and confirmed that larger fruit ones (that is, Nocellara del Belice) are more susceptible to the attack of the fly. Also Pannelli et al. (2001) reported higher susceptibility to *Bactrocera Oleae* (Gmelin) for Ascolana tenera than Mignola among the olive cultivars in Marche Region.

Cristizio et al. (2011) compared 4 different olive cultivars (Caiazzana, Leccino, Coratina and Itrana) to check susceptibility to *Spilocea oleagina* (Cast.) Hugh in the province of Caserta. Results showed that Caiazzana and Leccino cultivars are resistant, while Coratina and Itrana are very sentitive.

The resistance of 23 olive cultivars to Verticillium wilt (*Verticillium dahliae*) has been tested under controlled conditions by Lopez-Escudero et al. (2004). Results grouped cultivars according to different susceptibility ranges: Cornicabra and Valanolia resulted extremely susceptible, Arbequina, Hojiblanca, Picual and Leccino showed moderate susceptibility, while Manzanilla de Sevilla, Empeltre, Frantoio and Oblonga resulted the most resistant cultivars.

The authors concluded that the Spanish cultivar Empeltre can be considered a valuable genetic source for inclusion in breeding programs for Verticillium wilt resistance.

## Oil quality

Few studies have tested the influence of organic olive farming on the quality parameters of the produced oils and results are often discordant.

Gutierrez et al. (1999) reported the type of cultivation have an influence on the quality parameters of the oil. In particular, oils from organic cultivation showed lower acidity and peroxide value and higher stability to oxidation (Rancimat) and sensorial analysis scoring when compared to conventional systems. More over, highly significant differences were recorded for the *α*-tocopherol content, being 1.3 times higher in the organic oils. No significant differences between conventional and organic management were found for the total sterol content in the oil.

The impact of integrated cultivation technique has been studied in southern Spain on the cultivar Hojiblanca (Cayuela et al., 2006). Results showed that only tocopherol and sterol contents were significantly higher in the oil samples from integrated olive orchard management when compared to those one from conventional approach. No differences were found for the other chemical-physical and organoleptic parameters tested.

Ninfali et al. (2008) compared the oil quality characteristics from organic and conventional farming for Leccino and Frantoio cultivars over three years in Central Italy. Results reported higher free fatty acidity and peroxide values for Leccino in conventional cultivation oils in 2 of the 3 years of experimentation, while no significant differences were found for the same parameters in Frantoio. Not clear trends or differences were indentified during the experimental period for phenols, tocopherols, volatile compound concentrations and antioxidant capacity. The final assumption of the authors is that organic cultivation practices do not affect the quality of the extra virgin olive oil when compared with conventional farming and that genotype and pedo-climatic conditions seem to have more marked effects.

## CONCLUSION

The increasing demand for olive organic products in the market pushed researchers to supply more indications to enlarge knowledge and orchard management. Organic olive farming does not represent a simplistic approach where agricultural management is more “natural” with trees grown up in marginal lands or with less care to the production process, but requires a higher technical approach to integrate all the factors involved and to select the most suitable technical solutions according to the specific pedo-climatic and farm conditions. Even in the olive grove, soil fertility management through minimal soil disturbance, permanent soil cover (green natural mulching or cover crops) and organic matter recycle or application (trimmed vegetal residues from green mulching mixed with pruning material, by-products from olive oil extraction process) represents the pivotal aspects to prevent soil erosion, increase organic matter availability and biodiversity. In long-term studies, the correct management in controlling growth of natural cover crop to avoid water competition is reported to efficiently reduce rainfall runoff and nutrients leaching when compared to conventional tillage. Soil fertility status also influences nutrients absorption and carbohydrates allocation in olive trees, so that in highly degraded soils great amounts of external inputs are required and productions are negligible. Unbalanced fertilization (mainly nitrogen) due to low soil fertility may lead the tree to vigorous vegetative growth and higher susceptibility to pest and diseases. An integrated approach is therefore required in organic olive farming to ensure good quantitative and qualitative productions, reduce environmental pollution and to increase agro-ecosystem sustainability.

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