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A sustainable model for the management of olive orchards located in semi-arid marginal areas: Some remarks and indications for policy makers

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ABSTRACT

Traditional olive growing can survive only by improving olive farmer income and recognizing its multifunctional role. In this study, we propose a sustainable management model which entails the recycling of urban wastewater and its distribution by drip irrigation and the use of soil management techniques based on the recycling of polygenic carbon sources internal to the olive orchard (cover crops, pruning material). The model was applied for a 8-year period in an olive orchard located in a semi-arid marginal area of Southern Italy. An analysis is performed to evaluate the economical sustainability of the proposed model in comparison to the conventional management system (rainfed conditions, tillage, empirical fertilization, biennial pruning and pruned material burning). Furthermore, the study assesses the environmental benefits coming from the application of the examined orchard management systems focusing especially on CO_2 stocks in plants and soil, and anthropogenic and natural CO_2 emissions. The sustainable model appears productive and profitable, socially and environmentally sustainable. The significant income received every year by olive growers can persuade them to remain in the territory limiting the urgent phenomena of orchard abandonment, preserving typical landscape, and carrying out an ecological control role against land degradation processes.

1. Introduction

Olive (*Olea europaea* L.) finds the best climatic conditions for its growth in the Mediterranean Basin countries where it is the most widespread fruit tree crop (around 9.5 Mha in 2010) (FAOSTAT, 2012).

A wide variety of olive growing systems exist in such a large area depending on pedo-climatic conditions, social, economic and institutional driving forces. Referring to European countries (Beaufoy, 2002; Various Authors, 2006; Duarte et al., 2008; Gómez et al., 2008; Metzidakis et al., 2008; Xiloyannis et al., 2008), some of these cultivation systems are characterised by intensive agronomical techniques and

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Abbreviations: CAP, Common Agricultural Policy; CO_2, carbon dioxide; CO_2eq, carbon dioxide equivalent; CS, Conventional System; EC, Commission of the European Communities; EU, European Union; FC, Fixed Costs; GP, Gross Profit; NEP, Net Ecosystem Productivity; NPP, Net Primary Productivity; PC, Production Costs; SOC, soil organic carbon; SS, Sustainable System; TO, Total Output; VC, Variable Costs.

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they are proven to be effective with respect to land productivity and economic profitability, but they are restricted in flat and irrigated lands. Semi-intensive and extensive olive growing systems prevail instead in hilly and mountainous arid regions. Extensive systems, in particular, are characterised by low inputs of labour and materials. They show low productivity too, because of several limiting factors such as: difficult mechanization in sloping lands, old and big-size olive trees, low density plantation, unfertile soils, low rainfall and scarcity of water for irrigation. From a socio-economic point of view, these systems are mostly characterised by small size farming oriented to self-consumption or to the local market (Favia and Celano, 2005; Duarte et al., 2008). Furthermore, low productivity is coupled with high labour costs, mainly due to the difficulty in finding specialized workers required for manual operations (harvesting and pruning). Finally, the extensive olive groves are especially exposed to abandonment as consequence of several interacting causes: on one hand, the decoupling of farmer income aid after the Fischler reform of the Common Agricultural Policy (CAP) (Severini, 2006), and, on the other, the demographic decline and the farmers ageing, occurring in more marginal areas as in the case study presented here. Abandonment and its negative effects (erosion, fires, over-grazing, biodiversity losses) have been exasperated by the so-called Health check of the CAP (Commission of the European Communities, 2008) and, particularly in Italy, by the conversion of the historic support model into the regional model in the olive sector. These changes could determine the consequent shift of economic resources from this sector to others with seriously impacts on the revenues of olive-growing farms that often are uncertain (Roselli et al., 2008).

The abandonment of olive orchards is already causing significant effects on land degradation processes in olive specialized areas which should be reinforced because Mediterranean regions are particularly vulnerable to the impacts of climate changes and the severity of extreme weather events. Such changes are expected to put at risk crop yields, the location of production, in addition to the depletion of soil organic matter and to the worsening of the quality and availability of water resources, already traditionally scarce, for irrigation (EC, 2009).

In order to address such scenarios, during the last decade EU has implemented some measures into the CAP, such as cross-compliance and rural development, that are already helping to reduce greenhouse gas emissions from the agriculture. In particular, the CAP is aiming to modernize farms with energy-efficient equipments and buildings; to help farmers to better understand and meet the EU rules for environment by means of training and advisory services; to provide support for biogas and to offer compensation for the extra costs incurred by farmers who voluntarily favour the protection of the environment (agri-environmental schemes). Regarding the European water policy, it is continuously evolving towards a strategy facing water scarcity (Commission of the European Communities, 2007; Farmer, 2010) and drought up to integrating water issues in sectoral and regional policies and, in the first place, into the two CAP pillars (agriculture and rural development) (EC, 2012). At this regard, the last action plan, Blueprint to Safeguard Europe's Water, adopts a systemic approach combining a variety of instruments to regulate the water demand, saving and its efficient use. Even if water pricing remains the market key tool, increasing attention is being paid to economic incentives to the farmers providing ecosystem services, and to the reuse of wastewater for irrigation. Wastewater reusing provides wide economic and environmental benefits such as: lower energy costs compared to deep groundwater exploitation or desalination, abatement in nutrient removal costs to protect the surface waters through irrigation and in nutrient discharge to the environment, *etc.* (Durham et al., 2005).

More generally, the emergency and pervasiveness of environmental issues in the European growth strategy requires, *inter alia*, investments in knowledge and reduction of the gap between science and policy makers. This paper attempts to provide a partial contribution in this direction suggesting some guidelines to a more sustainable management of extensive olive groves than the traditional and conventional ones, commonly adopted in sloping and semi-arid areas of Mediterranean countries. The guidelines are the outcome of a 8-year (2001–2008) testing period of a model based on two cornerstones: the reuse of urban wastewater distributed by drip irrigation, and the recycling of polygenic carbon sources. The experiment was carried out in an olive orchard placed in a hilly and marginal zone of Southern Italy. An economic analysis was carried out in order to assess the profitability of the proposed model. In addition, the research evaluated the possible environmental benefits coming from the application of the examined orchard management systems focusing especially on carbon fate.

2. Materials and methods

2.1. *The experimental context*

The trial was performed in Ferrandina (Matera Province, Basilicata Region, Southern Italy, 40°29′N, 16°28′E) where olive tree represents the dominant crop. Olive plantations are generally set in hilly areas and grown under rainfed conditions. Except for very few cases, the olive farm size is around 1 ha. In particular, these last are small family farms managed by hobby farmers, while the few larger farms are often run by part-time entrepreneurs (Favia and Celano, 2005).

The experiment was carried in a 2-ha olive orchard of 'Maiatica' which is an autochthonous cultivar of Matera Province. It is a dual purpose cultivar with good productivity though it exhibits a strong alternate bearing behaviour. The drupe is medium to large with a high oil yield (around 22% of fresh weight) (Rotundo and Marone, 2005). 'Maiatica' oil is characterised by low content of total phenols, grassy and fruity aroma with a low intensity sensation of bitterness and sharpness. Fruits with specific merceological characteristics (big size, heavy weight, high pulp to stone ratio) are usually harvested at black maturity stage and then processed according to a typical local method in order to obtain oven-dried drupes, an excellent speciality of Ferrandina (Balatsouras et al., 1996; Brighigna, 1998). Both 'Maiatica' oil and table olives are appreciated by consumers and partly placed outside the local market, but table olives due to their tipicity