Bulgarian Journal of Agricultural Science, 22 (No 4) 2016, 517–526
Agricultural Academy

ECONOMIC PROFITABILITY ASSESSMENT OF MEDITERRANEAN OLIVE GROWING SYSTEMS

T. STILLITANO*, A. I. DE LUCA, G. FALCONE, E. SPADA, G. GULISANO and A. STRANO
Mediterranea University of Reggio Calabria, Department of Agriculture (AGRARIA), Feo di Vito - 89122 Reggio Calabria (RC), Italy

Abstract

STILLITANO, T., A. I. DE LUCA, G. FALCONE, E. SPADA, G. GULISANO and A. STRANO, 2016. Economic profitability assessment of Mediterranean olive growing systems. *Bulg. J. Agric. Sci.*, 22: 517–526

In Italy, olive cultivation is mainly widespread in southern regions where it constitutes a key element of rural economy. Nevertheless, in such areas olive growing is affected by several critical factors related to farm management, by giving rise to economically unsustainable productions. In particular, olive growing is widely represented by small and medium-scale farms, as well as by traditional olive orchards with low productivity, low level of mechanization and, therefore, high production costs. Hence, more efficient management strategies and farming investments are needed to optimize and improve the olive farm's profitability, by increasing their productivity and competitiveness for moving towards a real economic sustainability. In this study, different olive production systems located in Southern Italy have been compared in order to assess their economic performance. The economic sustainability evaluation of investments has been carried out through a joint use of Life Cycle Costing (LCC) method and economic indicators. This integrated approach has allowed taking into account all cost and revenue factors of investments incurred throughout the life cycle of production processes. Results showed a suitable level of profitability of all scenarios, also thanks to contribution of public subsidies. Furthermore, our findings highlighted the importance of innovative management strategies, in terms of both olive orchard structure renewing and mechanical equipment adaptation in order to decrease agricultural practices costs and to increase the production yield.

Key words: economic analysis, Life Cycle Costing (LCC), olive farms, organic and conventional agriculture

List of abbreviations: CIS: Catanzaro Ionian Side; SLP: Saint'Eufemia-Lametia Plain; CP: conventional plain; CH: conventional hill; OP: organic plain; OH: organic hill

Introduction

Traditionally, Mediterranean basin symbolizes the geographic location in which, more than in other, the olive growing represents not only a crop, but above all a significant source of income and employment for rural populations both in Europeans countries, Spain, Italy, Greece and Portugal, and in non-European countries such as Algeria, Libya, Morocco, Syria, Tunisia and Turkey. According to the latest FAOSTAT data (2013), Mediterranean olive area amounts to 9.42 million of hectares (ha), representing more than 94% of the world olive surface. Mediterranean countries cover 95% of olive oil world production, approximately equal to 2.77 million of tons. As well as being the largest producers, such countries are also the largest consumers of olive oil with a share about 63% of world consumption (IOOC, 2013). Italy represents the second largest producer of olive oil, with 570 000 tons (about 20% of world production) and the first

**E-mail:* teodora.stillitano@unirc.it (*corresponding author); anna.deluca@unirc.it; giacomo.falcone@unirc.it; emanuele.spada@live.it; ggulisano@unirc.it; astrano@unirc.it

consumer, with 610 000 tons (19.8% of consumption worldwide) (FAOSTAT, 2013; IOOC, 2013). On the contrary, Italian olive oil industry records a loss in competitiveness in the world market, mainly because of stagnant demand by main producer/consumer countries and strong competition from the Spanish industry (Pomarici and Vecchio, 2013).

According to 6th Italian agriculture census (ISTAT, 2010), Italian olive area amounts to 1.12 million of ha (9% of the utilized agricultural area) and records a number of farms equal to 902 075 (56% of total Italian farms). Olive tree is mainly concentrated in the southern regions, Apulia, Calabria and Sicily, which together represent more than 60% of the national olive area. In Calabria, the second olive region in terms of utilized surface, about of 186 000 ha, the olive growing is the most important agro-food supply chain, which contributes to the economic development especially in rural areas (Galluzzo, 2011). However, the regional olive growing context is widely characterized by an obsolete productive structure that entails high production costs (Strano et al., 2014) and low unitary productivity (Famiani et al., 2014), especially because of low mechanization of agricultural practices as pruning and harvesting (Giametta and Bernardi, 2010; Bernardi et al., 2016). These weakness factors give rise to an economically unsustainable olive production; hence, such firms, in order to become competitive on the market and to increase their profitability, must to rationalize investment decisions, as well as optimize available resources use and manage effectively corporate assets. Therefore, the entrepreneur should be aware of anything that may affect its business activities and him should be able to carry out the necessary evaluations to improve the production process of its company; so, to this aim, it is essential to take into account all cost factors of investment projects incurred throughout each phase of firm process (Woodward, 1997). A life cycle perspective can be advantageous to enhance the vision of business strategy by analysing, systematically, the whole production process inclusive of all phases linked to "birth", "live" and "die" of a product/process (De Luca et al., 2015). In this sense, the methodological tool of Life Cycle Costing (LCC) allows to incorporate initial and operating costs incurred throughout the entire life cycle of product or system (Gluch and Baumann, 2004) from acquisition phase to final disposal (Dhillon, 1989) by rationalizing the long-term decision-making process when various investment alternatives are available. This approach properly used for costs assessment permit to conduct an optimal budget allocation during the system/product's lifetime, as well as a better business performance (Huppes et al., 2004). As Fuller and Petersen (1996:17) argued, a LCC analysis "provides a significantly better assessment of the long-term cost effectiveness of a project than alternative economic methods that focus only on first costs or on operating related costs in the short run".

In particular, conventional LCC analysis, a method internationally recognized, follows the ISO norm (ISO, 2008), which gives guidelines on the procedures to calculate and compare costs and use the discounting technique through which all future costs and benefits are reduced to their present value (Woodward, 1997). Existing scientific literature shows that, frequently, cash flows models inspired most of LCC approaches (Emblemsvåg, 2003). Several applications of LCC method in engineering-industrial fields are frequently in literature, but this not occurs for the agro-food sector. However, in recent years the interest in LCC to evaluate the economic sustainability of farming investments (Baquero et al., 2011; Iotti and Bonazzi, 2014a, 2014b; Strano et al., 2015), also jointly with environmental assessment carried out through Life Cycle Assessment has become increasingly (Notarnicola et al., 2003, 2004; De Gennaro et al., 2012; Pergola et al., 2013; Strano et al., 2013; De Luca et al., 2014; Mohamad et al., 2014; Falcone et al., 2015).

This paper aims to achieve an economic feasibility assessment of different olive farming investments through a joint use of Conventional LCC and economic indicators, in order to identify, along the agricultural processes, the key elements to optimize their economic performance, for improved farm management. Despite, as already mentioned, in Calabria region the most widespread olive growing systems are traditional, the present case study concerns the evaluation of innovative systems, managed through an optimization both the agricultural practices and production factors, that are emerging increasingly in recent years.

Materials and Methods

Case study area

The study area is located in the province of Catanzaro in Calabria Region (Southern Italy), characterised by both a high potentiality toward a competitive olive growing and a great quality of extra-virgin olive oil production. Starting from empirical surveys and statistical analysis carried out on the regional olive sector, the area under investigation was divided into two subareas: "Catanzaro Ionian Side" and "Sant'Eufemia-Lamezia Plain", located, respectively, in the eastern and western central part of Calabria (Figure 1). These territories, characterised by homogeneous pedo-climatic and varietal features, were identified based on the significance of their olive productions both in terms of dedicated surface and of the existence of quality-branded products certified by specific Protected Designations of Origin (PDO), e.g. PDO

Table 1
Main features of two olive subareas

Elements	Catanzaro Ionian Side	Sant'Eufemia-Lamezia Plain
Slope	Mainly hilly	Mainly plain
Soil fertility	Medium	Good
Annual rainfall	Low (650 mm)	Good (750 mm)
Olive area	15 050.61 ha	13 956.91 ha
Olive farms	5807	7616
Percent of olive area on the Utilised Agricultural Area (UAA)	45%	59.8%
Percent of holdings with an average farm size less than 2 ha	50%	70%
Level of farm mechanization	Medium-high	Medium-high
Management systems	Organic and conventional	Organic and conventional
Olive tree	*Olea europaea* L., cv. Carolea	*Olea europaea* L., cv. Carolea
Dedicated plant nursery	Absent	Present
Diseases	High	High
Percent of extra-virgin olive oil on the total production	60%	70%
Quality-branded products	Absent	Protected Designation of Origin (PDO): "Extra-virgin olive oil PDO "Lametia"
Infrastructure connecting to points of sale	Absent	Present

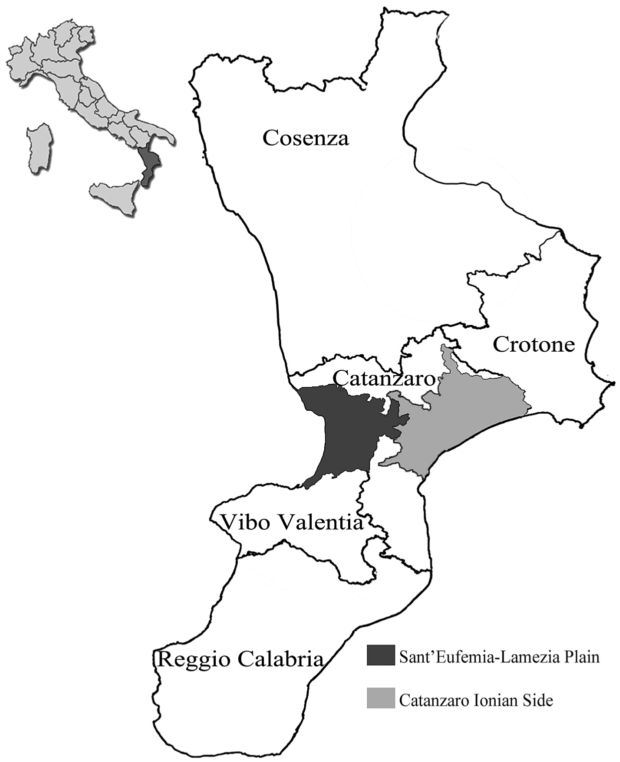

Fig. 1. Study area in Calabria region (Southern Italy)

"Lamezia" (EC, 1999). Table 1 shows the differences between the two subareas of production analysed focusing on their specific characteristics.

Olive growing scenarios description and data collection

Based on information acquired by means of statistical surveys and face-to-face interviews with privileged stakeholders (olive growers, wholesalers and trade associations), eight specific olive growing scenarios, four for each subarea, were identified. Each scenario is obtained by the combination of altitude levels (plain and hill) and management systems (conventional and organic), as described in Table 2. For each scenario a useful life of 60 years, corresponding to the "Carolea" cultivar life cycle, was assumed. Moreover, for analysis requirements, the whole life cycle was divided into six phases, as better explained in the next section: *i.* planting phase, *ii.* unproductive phase, *iii.* increasing production phase, *iv*. constant production phase, *v.* decreasing production phase, *vi.* end of life phase). To compare the different scenarios, 1 hectare (ha) of olive orchard was used as Functional Unit (FU) and a cradle-to-gate analysis, as system boundaries, was carried out.

To implement the economic analysis an accurate data collection process was required. Economic and technical data of eight scenarios were collected for each study area, separately. For this purpose, a custom-fitted questionnaire

Table 2
Case study olive growing scenarios

Altitude	Management system	Scenario
	Catanzaro Ionian Side (CIS)	
Plain	Conventional	CP-CIS
	Organic	OP-CIS
Hill	Conventional	CH-CIS
	Organic	OH-CIS
	Sant'Eufemia-Lametia Plain (SLP)	
Plain	Conventional	CP-SLP
	Organic	OP-SLP
Hill	Conventional	CH-SLP
	Organic	OH-SLP

was handed out to a sample of 30 olive farms, equally distributed between both the two subareas analysed and the scenarios considered. This sample was selected through a non-probability sampling procedure with stratified allocation (De Luca et al., 2014; Strano et al., 2015), that allowed to define a sample distributed, proportionally, within the total population of farms in the area analysed. Farms are characterised by an average size from 20 ha to 30 ha, with a medium-high level of farm innovations (i.e., mechanized operations and rationalization of input use). It is noteworthy that the choice of this typology of olive farms was consequent from the purpose to make the analysis more significant from an economic point of view, although the local area is characterised by a high fragmentation of agricultural holdings frequently corresponding to absence or low levels of innovation systems. Furthermore, by choosing this average farm size it was possible to reconstruct the entire useful life of each scenario due to the high presence of uneven-aged plants inside of farms analysed.

In particular, annual data were collected, relating to the 2009-2012 period, concerning the main characteristics of olive orchard (e.g. cultivar, planting distance and density, tree's age) and information related to: agricultural operations (fertilization, disease control, tillage, pruning and harvesting); use of materials, human labour and mechanical means; olive production. Finally, for each scenario, average data were processed. Agricultural practices per scenario are shown in Table 3, in particular focusing on the specific differences occurring between organic and conventional systems in the constant production phase (as example due to the significance of annual supply of inputs).

Conventional LCC and economic analysis

Conventional LCC (ISO, 2008) has allowed identifying all future costs incurred throughout the useful life of each olive growing scenario. In Figure 2, all olive orchard costs associated to each life-cycle phase are shown. Specifically, at the beginning of the life cycle analysed, plantation costs concerned the design expenses and initial investments (i.e. agricultural building and purchasing of seedlings and poles), as well as costs related to labour, materials and services, were considered. To evaluate operating costs (related years from first to 60th), all cost items linked to agricultural operations performed in olive growing (Table 3) were analysed, taking into account for each agricultural practice, expenses related to use of labour, materials and services. Moreover, expenses arising from the olive orchard disposal (60th year) were considered.

Table 3
Agricultural practices in the constant production phase (*performed every year*)

Agricultural practice		CP	OP	CH	OH
Tillage	Harrowing	CIS and SLP: 1 operation			
	Milling	CIS and SLP: 2 operations		CIS: 1 operation SLP: 2 operations	CIS: 1 operation SLP: 2 operations
Fertilization		Mechanical distribution. N.P.K. fertilizer	Mechanical distribution. Manure fertilizer	Mechanical and manual distribution. N.P.K. and manure fertilizer	Mechanical and manual distribution. Manure fertilizer
Disease control		2 fungicide and 4 insecticide treatments (Chemicals)	2 fungicide and 8 insecticide treatments (Organic products)	2 fungicide and 3 insecticide treatments (Chemicals)	2 fungicide and 7 insecticide treatments (Organic products)
Pruning		Biennial by pneumatics aids			
Harvesting		Mechanically by trunk shaker and nets		Semi-mechanized bytrunk shaker, pneumatics aids and nets	
Average production		CIS 11 587 kg ha^{-1} SLP 12 127 kg ha^{-1}	CIS 9390 kg ha^{-1} SLP 10 050 kg ha^{-1}	CIS 8122 kg ha^{-1} SLP 8344 kg ha^{-1}	CIS 7211 kg ha^{-1} SLP 7344 kg ha^{-1}

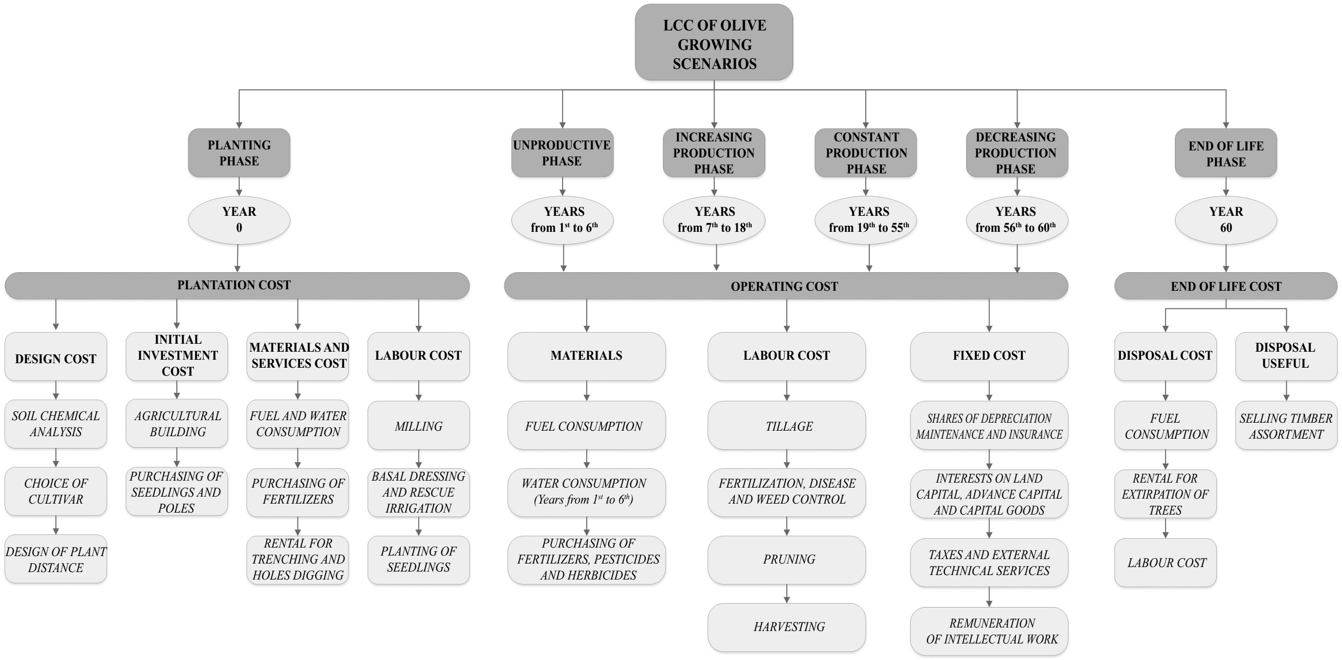

Fig. 2. Case study LCC framework

In order to calculate each cost item the following assumptions were adopted:

■ work remuneration was evaluated in terms of opportunity cost and was equalized to the employment of temporary workers for manual and mechanical operations, by assuming current hourly wage. In particular, for pruning operations qualified workers were employed;

■ for specific operations such as trenching, holes diggings and extirpation of trees were considered as provided by third parties and, therefore as rental costs of mechanical means. In this case, to evaluate mechanical labour costs current tariffs charged by firms hire were adopted;

■ material costs such as fertilizers, herbicides, pesticides and fuel were calculated taking into consideration both the quantity effectively used by farm and the current market prices.

To assess the annual total operating cost, the following fixed costs were also added:

■ shares of depreciation, maintenance and insurance associated with capital goods (machinery and equipment) and land capital (agricultural building);

■ interests on advance capital and capital goods, evaluated by applying an interest rate equal to 4.5% and 2%, respectively;

■ interests on land capital, calculated by multiplying the land value by an interest rate equal to 1.8%;

■ remuneration of intellectual work, calculated as a percentage equal to 5% of the Gross Production Value (GPV);

■ taxes and costs related to the external technical services.

In order to evaluate the economic profitability of olive growing investments, it was also necessary to calculate the annual total revenues, corresponding to the GPV, obtained by multiplying the average olive production by its market price referred to the last harvesting campaign (2011–2012). Furthermore, the following extra revenues were added:

■ CAP direct payments and subsidies to organic farming, according to Common Agricultural Policy (CAP) regulations, equal to 600.00 € ha^{-1} and 700.00 € ha^{-1}, respectively;

■ revenues obtained from selling of residual woody material obtained from pruning, starting from 21^{st} year of the plant;

■ revenues obtained from selling of timber assortment which resulting from extirpation of olive trees throughout the “end of life” phase.

Once the cash flows of the investments were identified, it is possible to actualize them by using a discount rate equal to 1.8% (Pergola et al., 2013; Mohamad et al., 2014), chosen by considering the low risk and long-term feature of agricultural investments. Based on discounted values, the following economic indices of profitability were determined, as used by several scholars (Gunluk et al., 2014; Hoogmartens et al., 2014; Sgroi et al., 2015; Strano et al., 2015; Utne, 2009):

the Net Present Value (NPV), the ratio between Benefits and Costs (B_0/C_0) and the Internal Rate of Return (IRR).

Results and Discussion

In line with the proposed methodology, all costs and revenues for each life-cycle phase of the olive growing scenarios were quantified. In Table 4, the plantation costs incurred in planting phase are reported. Results show that this phase is the heaviest of the overall life cycle cost for all scenarios due to the substantial start-up investment, including the realization of agricultural building, the purchasing of seedlings and poles and the labour cost for preparatory plant operations. In each scenario studied, the average plantation cost varies from 6900.00 € ha^{-1} $year^{-1}$ to 7900.00 € ha^{-1} $year^{-1}$. However, although costs shares tend to be approximately equal, the lower cost for planting are recorded in the scenarios located in Sant'Eufemia-Lamezia Plain (SLP).

The expenses incurred to carry out the agricultural operations during the constant production phase are shown in Figure 3. Findings highlight that, despite the medium-high level of farm mechanization, among the agricultural practices, the harvesting and pruning operations are the main cost items. Indeed, such costs absorb the most employing of human labour (Mohamad et al., 2013) and, therefore, by affecting the economic performance of olive systems according to Testa et al. (2014), Mohamad et al. (2014) and De Gennaro et al. (2012). The introduction of technological investments during the cultivation phase, as well as the renewing of olive orchard structures, may ensure an increase of production efficiency and a decrease of cultivation costs (Vieri and Sarri, 2010; Polidori et al., 2011).

Table 4
Investment costs (€ ha^{-1} $year^{-1}$) in planting phase

SCENARIO	Design cost	Initial investment cost		Materials and Services cost	Labour cost	TOTAL
		Agricultural building	Purchasing of seedlings and poles			
CP-CIS	350.00	1982.00	1760.00	2299.40	1293.21	7684.61
OP-CIS	350.00	1982.00	1760.00	2242.60	1271.36	7605.96
CH-CIS	355.00	1991.00	1305.00	2779.26	1497.21	7927.47
OH-CIS	355.00	1991.00	1305.00	2232.79	1475.37	7359.16
CP-SLP	335.00	1975.00	1755.00	2282.73	1251.14	7598.87
OP-SLP	335.00	1975.00	1.75500	1872.61	1262.26	7199.87
CH-SLP	340.00	1979.00	1294.00	2290.22	1487.21	7390.43
OH-SLP	340.00	1979.00	1294.00	1882.70	1470.35	6966.05

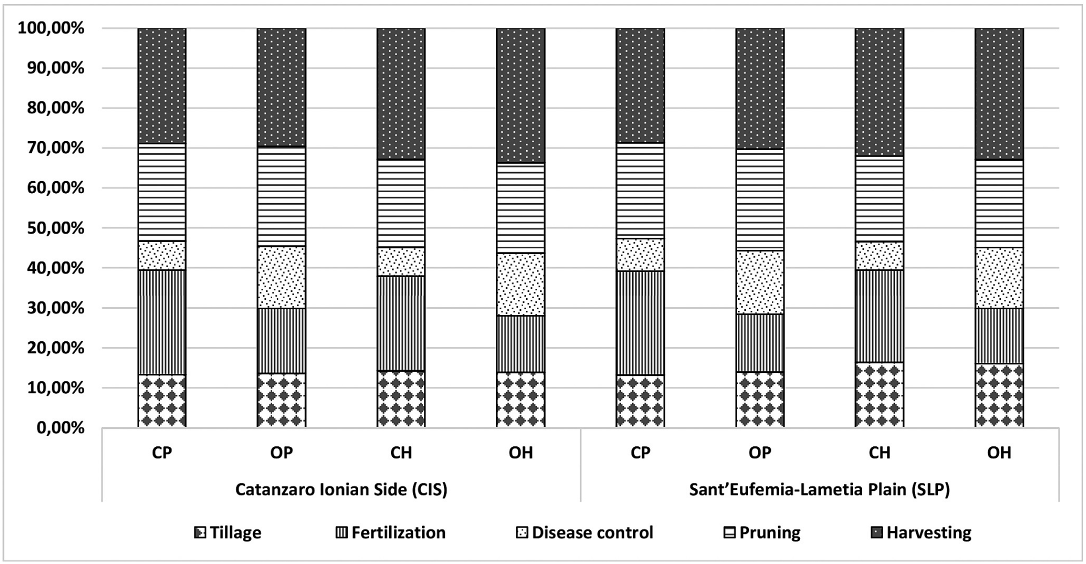

Fig. 3. Cost distribution of the agricultural practices in the constant production phase

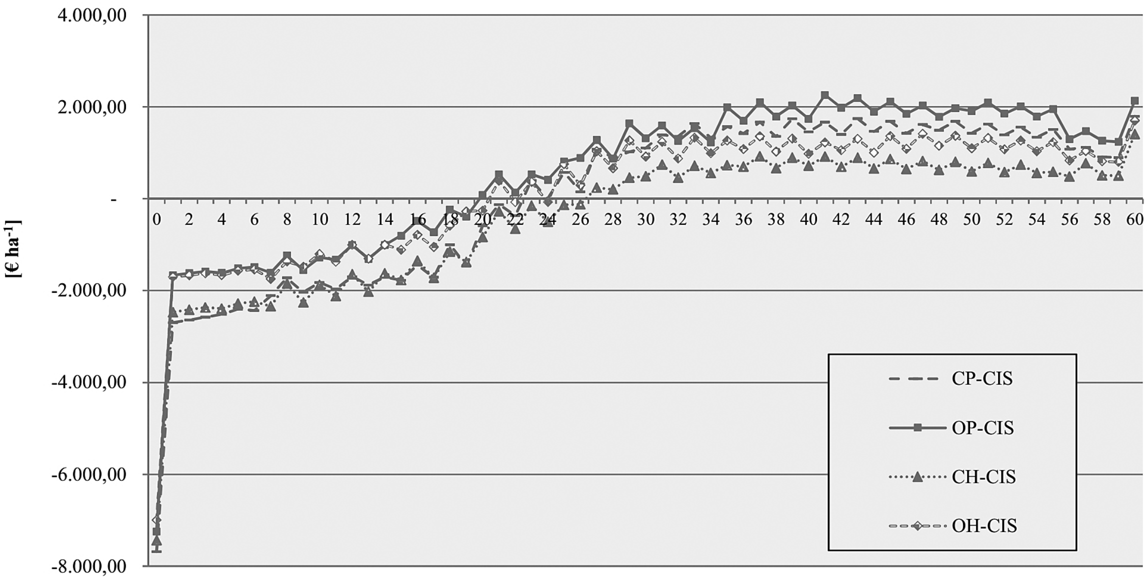

Fig. 4. Net cash flows of the whole olive life cycle for each scenario located in Catanzaro Ionian Side (CIS)

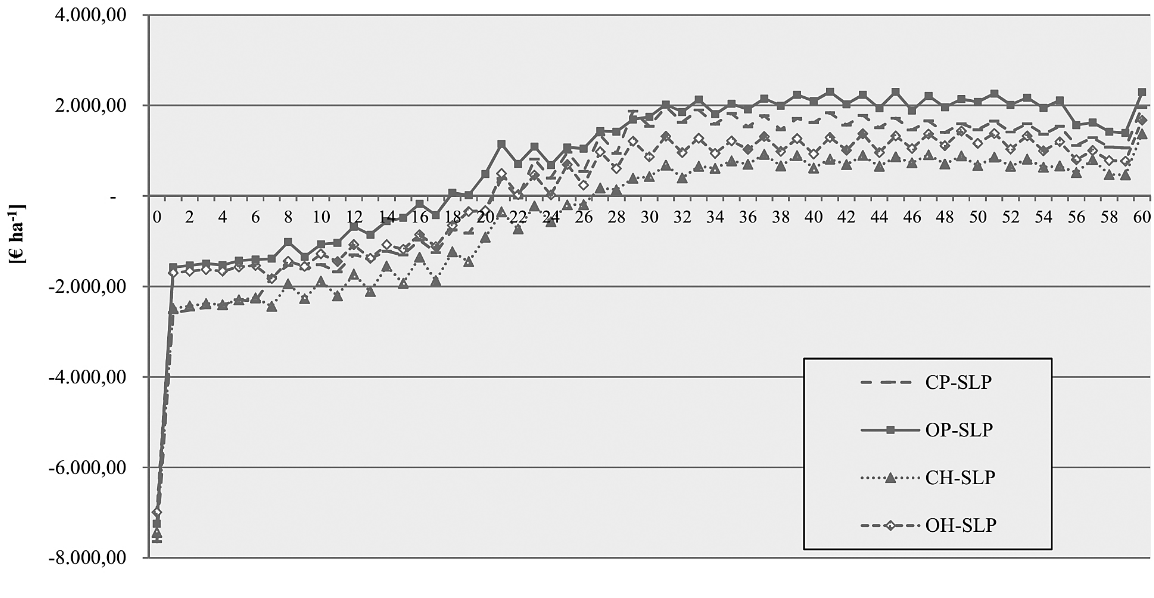

Fig. 5. Net cash flows of the whole olive life cycle for each scenario located in Sant'Eufemia-Lamezia Plain (SLP)

In particular, harvesting operation recorded the worse performance in the hill scenarios than plain ones, with a value about equal to 33% of the total operating cost in both olive subareas considered. This is justified because the inaccessible layout of the terrain where it is not possible to use trunk shaker and, therefore, a greater labour for additional harvesting with pneumatic aids and nets handling occurs.

Among the agricultural practices, fertilization gets the worst performance in "Catanzaro Ionian Side" (CIS) subarea, because of its lack of soil nutrients, often washed away by rainwater. Furthermore, fertilization costs are lower for organic scenarios (with a percentage value between 13% and 16%) than conventional one (between 23% and 26%), due to the exclusive use of manure fertilizer. Concerning the disease control activity, plain scenarios located in Sant'Eufemia-Lamezia plain record the larger number of pesticide applica-

Table 5
Results of the economic analysis

Scenarios	Including subsidies			Excluding subsidies		
	NPV (€ ha^{-1})	B_0/C_0	IRR (%)	NPV (€ ha^{-1})	B_0/C_0	IRR (%)
CP-CIS	2 592.90	1.02	1.96	-19 311.34	0.88	0.65
OP-CIS	32 833.60	1.21	3.92	-14 625.57	0.91	0.92
CH-CIS	-24 428.35	0.84	-0.20	-46 332.58	0.70	-2.16
OH-CIS	8 875.80	1.06	2.51	-38 583.37	0.75	-1.28
CP-SLP	16 037.88	1.09	2.79	-13 167.77	0.92	1.00
OP-SLP	47 456.58	1.29	4.88	-7 304.00	0.95	1.37
CH-SLP	-25 752.49	0.84	-0.25	-47 656.72	0.70	-2.16
OH-SLP	7 519.54	1.05	2.40	-39 939.63	0.75	-1.39

tions if compared with all others scenarios, which involve higher costs. This is mainly due to greater presence of pests caused by climatic conditions more humid and rainy, which entail an environment conducive to the buildup and infestation of pests. In all organic systems, the weight of disease control costs is almost doubled (equal to 16%, than to 8% recorded in the conventional scenarios) since, in addition to the higher unit cost of pesticides, multiple applications result necessary.

Figures 4 and 5 show the net cash flows resulting from the eight scenarios located in Catanzaro Ionian Side and Sant'Eufemia-Lamezia Plain, respectively. CH-CIS and CH-SLP scenarios get the worst performance, as the profits remain negative i.e., the revenues are not able to cover the costs, until 26th year. This result can be explained by the presence of less favourable conditions in the hilly areas than in the plain one, especially due to both the lower availability of soil nutrients and the orographic characteristics. The first factor causes a low productivity of olive trees followed by a higher use of fertilizers, whereas, the second one induce a low planting density and a low-medium degree of mechanization and therefore, a lesser productivity. All these conditions involve higher costs due to an increased use of human labour and working days for performing agricultural practices, as well as, to the high amount of fertilizers applied.

Focusing on the OH-CIS and OH-SLP scenarios (Figures 4 and 5), results reveal that the profits are positive starting from 24th and 21th year, respectively. The better performance of organic hill systems than conventional ones is due to the greater olives market price and to the further subsidy to organic farms in addition to the direct aids. Therefore, the profits are high despite a lower level of productivity and higher disease control costs.

Among all olive systems analysed, the organic plain scenarios achieve the best performance. The OP-SLP scenario gets positive profits starting from 18th year due to the above factors related to organic farms and to the better climatic and soil conditions that characterize plain areas and, in particular, the Sant'Eufemia-Lamezia Plain.

Therefore, according to our findings, olive production systems located in "Sant'Eufemia-Lamezia Plain" show a better productive performance due to the favourable pedo-climatic conditions and their recent origins, which make it a territory particularly suitable for the introduction of innovative olive growing. The "Catanzaro Ionian Side" subarea, although characterized by favourable pedo-climatic conditions and the presence of innovative systems, records slower growth in productivity. In both areas, organic systems are more competitive than conventional ones as argued by other results existing in literature and for other crops (De Luca et al., 2014; Sgroi et al., 2015; Falcone et al., 2015) because of the higher market prices and the European subsidies.

In order to assess the profitability of investment for each scenario analysed, the economic indices, both by including public subsidies and by excluding them, were evaluated (Table 5).

In the first case, results show a positive economic feasibility for all scenarios, except for conventional hill scenarios. OP-SLP scenario reveals the higher profitability of the investment by recording a positive NPV amounting to 47 456.58 € ha^{-1}, an IRR higher than the discount rate, considered equal to 4.88%, and a B_0/C_0 ratio equal to 1.29. On the contrary, by excluding subsidies and considering only the sale of olives, findings prove that the olive orchards management is not sustainable and economically viable, in line with similar results obtained from Oxouzi et al. (2012). However, the investment would be more convenient if the assessment was carried out in terms of net income (i.e. the return to farm operators for their labour, management and capital, after all production expenses have been paid), by considering that the olive farms analysed are characterized by family-run business.

Conclusions

In southern Italy, and especially in Calabrian rural areas, the olive growing represents one of the most important agricultural activities essential to the economic development, both in terms of employment and income. Nevertheless, the olive production is, often, obsolete with high production costs and low productivity, so much so a large quote of olive farms fail to become competitive on the market, by risking to be economically unsustainable. At once, in some sub-regional territories it has witnessed to the spread of olive innovative systems that are potentially able to make more effective the corporate assets. The analysis of the economic feasibility of different farming systems (conventional and organic) in several areas (hill and plain), conducted through a joint use of Conventional LCC and economic indicators, has identified, along each phase of the production process, the economic hot spots in order to suggest management strategies to reduce production costs and to increase production efficiency.

Acknowledgements

This work is a part of the research project "Advanced technological systems and integrated methods in the olive growing and processing chain for the increase in value of products and exploitation of by-products, the development of new sectors and the creation of eco-friendly productive systems" (OLIO PIU') carried out by the Department of AGRARIA (Mediterranean University of Reggio Calabria) and supported by the Italian Ministry of Education, University and Research (MIUR).

References

Baquero, G., B. Esteban, J. R. Jordi-Roger Riba, A. Riu and R. Puig, 2011. An evaluation of the life cycle cost of rapeseed oil as a straight vegetable oil fuel to replace petroleum diesel in agriculture. *Biomass and Bioenergy*, **35**: 3687–3697.

Bernardi, B., S. Benalia, A. Fazari, G. Zimbalatti, T. Stillitano and A. I. De Luca, 2016. Mechanical harvesting in traditional olive orchards: Oil-picker case study. *Agronomy Research*, **14** (3): 683–688.

De Gennaro, B., B. Notarnicola, L. Roselli and G. Tassielli, 2012. Innovative olive-growing models: an environmental and economic assessment. *Journal of Cleaner Production*, **28**: 70–80.

De Luca, A. I., G. Falcone, N. Iofrida, T. Stillitano, A. Strano and G. Gulisano, 2015. Life Cycle methodologies to improve agri-food systems sustainability. *Rivista di Studi sulla Sostenibilità*, **1**: 135–150.

De Luca, A. I., G. Falcone, T. Stillitano, A. Strano and G. Gulisano, 2014. Sustainability assessment of quality-oriented citrus growing systems in Mediterranean area. *Quality – Access to Success*, **15** (141): 103–108.

Dhillon, B. S., 1989. Life Cycle Costing: Techniques, Models, and Applications. *Gordon and Breach Science Publishers,* New York.

EC., 1999. Commission Regulation (EC) No 2107/1999 of 4 October 1999 supplementing the Annex to Regulation (EC) No 2400/96 on the entry of certain names in the 'Register of protected designations of origin and protected geographical indications' provided for in Council Regulation (EEC) No 2081/92 on the protection of geographical indications and designations of origin for agricultural products and foodstuffs. *Official Journal of the European Communities*, L258, 05/10/1999.

Emblemsvåg, J., 2003. Life-cycle costing. Using Activity-Based Costing and Monte Carlo Methods to Manage Future Costs and Risks. *John Wiley & Sons, Inc. Hoboken*. New Jersey.

Falcone, G., A. Strano, T. Stillitano, A. I. De Luca, N. Iofrida and G. Gulisano, 2015. Integrated sustainability appraisal of wine-growing management systems through LCA and LCC methodologies. *Chemical Engineering Transactions*, **44***:* 223–228.

Famiani, F., D. Farinelli, S. Rollo, S. Camposeo, C. Di Vaio and P. Inglese, 2014. Evaluation of different mechanical fruit harvesting systems and oil quality in very large size olive trees. *Spanish Journal of Agricultural Research*, **12** (4): 960–972.

FAOSTAT, 2013. Crops Production.
http://faostat3.fao.org/download/Q/QC/E (accessed May 2015).

Fuller, S. K. and S. R. Petersen, 1996. Life Cycle Costing manual for the Energy Federal Management Program. *U.S Government Printing Office*, Washington.

Galluzzo, N., 2011. Quality olive cultivation of specific cultivars and rural protection and development in a DOP area. *Acta Italus Hortus*, **1**: 238–242.

Giametta, G. and B. Bernardi, 2010. Olive grove equipment technology. Straddling trees: mechanized olive harvests. *Advances in Horticultural Science*, **24** (1): 64–70.

Gluch, P. and H. Baumann, 2004. The life cycle costing (LCC) approach: a conceptual discussion of its usefulness for environmental decision-making. *Building and Environment,* **39**: 571–580.

Gunluk, M., G. Ozer and E. Yilmaz, 2014. Cost analysis of three phased olive mills in Turkey with Life Cycle Costing approach: the case of Milas region. *Agriculture & Forestry*, **60** (4): 155–164.

Hoogmartens, R., S. Van Passel, K. Van Acker and M. Dubois, 2014. Bridging the gap between LCA, LCC and CBA as sustainability assessment tools. *Environmental Impact Assessment Review*, **48**: 27–33.

Huppes, G., M. van Rooijen, R. Kleijn, R. Heijungs, A. de Konin and L. van Oers, 2004. Life Cycle Costing and the Environment. Report of a project commissioned by the Ministry of VROM-DGM for the RIVM Expertise Centre LCA.

IOOC, 2013. Economic Activity.
http://www.internationaloliveoil.org/world-olive-oil-figures (accessed June 2015)

Iotti, M. and G. Bonazzi, 2014a. The application of life cycle cost (LCC) approach to quality food production: a comparative analysis in the Parma PDO ham sector. *American Journal of Applied Sciences*, **11** (9): 1492–1506.

Iotti, M. and G. Bonazzi, 2014b: Life cycle flow analysis: Methodological improvement and application to the Parma PDO Ham Sector. *Quality - Access to Success*, **15** (143): 98-103.

ISO, 2008. ISO 15686-5:2008 Buildings and Constructed Assets-Service Life Planning-Life Cycle Costing. *International Organization for Standardization* (ISO), Geneva.

ISTAT, 2010. 6th Italian agriculture census.
http://dati-censimentoagricoltura.istat.it/ (accessed April 2015)

Mohamad, R. S., V. Verrastro, G. Cardone, M. R. Bteich, M. Favia, M. Moretti and R. Roma, 2014. Optimization of organic and conventional olive agricultural practices from a life cycle assessment and life cycle costing perspectives. *Journal of Cleaner Production*, **70**:78–89.

Notarnicola, B., G. Tassielli and G. M. Nicoletti, 2003. LCC and LCA of extra-virgin olive oil: organic vs conventional. 4th International Conference on Life Cycle Assessment in the Agri-food Sector, Bygholm, Denmark (October).

Notarnicola, B., G. Tassielli and G. M. Nicoletti, 2004. Environmental and economic analysis of the organic and conventional extra-virgin olive oil. *New Medit*, **3**: 28–34.

Oxouzi, E., K. Melfou, M. Galea and E. Papanagiotou, 2012. Economic performance and crop farm efficiency in mountainous and other less favoured areas in Greece. *Bulgarian Journal of Agricultural Science*, **18** (6): 846–853.

Pergola, M., M. D'Amico, G. Celano, A. M. Palese, A. Scuderi, G. Di Vita, G. Pappalardo and P. Inglese, 2013. Sustainability evaluation of Sicily's lemon and orange production: An energy, economic and environmental analysis. *Journal of Environmental Management*, **128**: 674–682.

Pomarici, E. and R. Vecchio, 2013. The Italian olive oil industry in the global competitive scenario. *Agricultural Economics - Czech*, **59** (8): 361–372.

Polidori, R., L. O. Zorini, M. Vieri and R. Gucci, 2011. Technical-economic analysis for decision making in olive-growing management in Tuscany. *Acta Italus Hortus*, **1**: 219–223.

Sgroi, F., M. Foderà, A. M. Di Trapani, S. Tudisca and R. Testa, 2015. Cost-benefit analysis: A comparison between conventional and organic olive growing in the Mediterranean Area. *Ecological Engineering*, **82**: 542–546.

Strano, A., A. I. De Luca, G. Falcone, N. Iofrida, T. Stillitano and G. Gulisano, 2013. Economic and environmental sustainability assessment of wine grape production scenarios in Southern Italy. *Agricultural Sciences*, **4** (5B): 12–20.

Strano, A., A. I. De Luca, C. Marcianò and G. Gulisano, 2014. The agronomic utilisation of Olive Mill Wastewater (OMW): Technical and economic trade-offs in olive growing in Calabria (South Italy). *Quality – Access to Success*, **15** (143): 83–91.

Strano, A., T. Stillitano, A. I. De Luca, G. Falcone and G. Gulisano, 2015. Profitability Analysis of Small-scale Beekeeping Firms by Using Life Cycle Costing (LCC) Methodology. *American Journal of Agricultural and Biological Sciences,* **10** (3): 116–127.

Testa, R., A. M. Di Trapani, F. Sgroi and S. Tudisca, 2014. Economic analysis of process innovations in the management of olive farms. *American Journal of Applied Sciences*, **11** (9): 1486–1491.

Utne, I. B., 2009. Life cycle cost (LCC) as a tool for improving sustainability in the Norwegian fishing fleet. *Journal of Cleaner Production,* **17**: 335–344.

Vieri, M. and D. Sarri, 2010. Criteria for introducing mechanical harvesting of oil olives: results of a five-year project in Central Italy. *Advances in Horticultural Science*, **24** (1): 78–90.

Woodward, D. G., 1997. Life Cycle Costing-theory, information acquisition and application. *International Journal of Project Management*, **15** (6): 335–344.

Received December, 2, 2015; accepted for printing June, 17, 2016