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Can sustainability match quality citrus fruit growing production? An energy and economic balance of agricultural management models for 'PGI Clementine of Calabria'

G. Di Vita[1], T. Stillitano[2], G. Falcone[2,*], A.I. De Luca[2], M. D'Amico[1],
A. Strano[2] and G. Gulisano[2]

[1]University of Catania, Department of Agriculture, Food and Environment, Via S. Sofia 98, IT95123 Catania, Italy
[2]Mediterranean University of Reggio Calabria, Department of Agriculture, Via Graziella, Feo di Vito, IT89100 Reggio Calabria, Italy
[*]Correspondence: giacomo.falcone@unirc.it

Abstract. This paper analyses energy and economic balances for different growing methods (conventional, integrated and organic cultivation) for Protected Geographical Indications (PGI) Clementine of Calabria, a quality-oriented citrus species in South Italy. Through a double methodological approach, the economic and energy sustainability of each production system was assessed by accounting for the farm net value (FNV) of farms. The energy employment in terms of direct (D) and indirect (I) sources and in terms of renewable (R) and non-renewable (NR) energy sources was also analysed. Regarding FNV, the results show that in the presence of European subsidies, organic farming (with 6.06 k€ ha^{-1}) is more profitable than other systems (4.33 k€ ha^{-1} for integrated farming and 4.99 k€ ha^{-1} for conventional farming) due to the higher sales price of organic PGI clementines, which allow producers to obtain the highest remuneration for their capital (1.65 B/C organic, 1.48 B/C integrated, 1.61 B/C conventional). In addition, from an energy perspective, the organic farming systems showed better performances than conventional and integrated systems because they required the lowest average energy employment (49.5 GJ ha^{-1} $year^{-1}$) compared with the integrated (57.2 GJ ha^{-1} $year^{-1}$) and conventional scenarios (59.1 GJ ha^{-1} $year^{-1}$).

Key words: agricultural sustainability, citrus growing, economic analysis, energy balance, PGI.

INTRODUCTION

The sustainability of agricultural production is one of the most interesting fields of discussion among current research frontiers (Finco et al., 2007; Zanoli et al., 2012; De Luca et al., 2015a and 2015b; Mariani & Vastola 2015). There are many analytical and methodological approaches to establishing criteria to measure the impact of agricultural crops on the surrounding environment (Rigby & Càceres 2001). To that end, since the early 1990s, many scientists have tried to establish objective standards based on the use of specific indicators (Rigby et al., 2001), providing specific guidelines to measure the impacts of agricultural practices both per unit surface and per unit product (Van der Werf & Petit 2002). According to De Olde et al. (2016), even if new indicator-based tools for the assessment of agricultural sustainability are rapidly increasing, a lack of consensus on how to choose sustainability indicators remains.

The ever-growing dependence of modern agriculture on synthetic chemicals, such as fertilizers and pesticides, has certainly caused serious repercussions on public health and on the environment (Pimentel 2005a). Therefore, the need to ensure a more rational balance in the conservation of soil, water, energy, and biological resources has led to the growth of organic farming. Its benefits are well established in terms of conserving the organic matter of soil and using less fossil energy, with similar production yields as conventional systems. The increased organic efficiency in retaining soil wetness and water resources is also highlighted because this is particularly beneficial in drought conditions (Pimentel et al., 2005b). In addition, more sustainable practices should have positive effects for biodiversity and consumers. In fact, products obtained through organic agriculture are healthier and have a lower environmental impact because they contain a lower amount of pesticides than conventional systems (Finco et al., 2007; D'Amico et al., 2016).

Several analyses have deepened the main features of sustainable entrepreneurship linked to specific agricultural sectors, such as olive oil (Di Vita et al., 2015; Bernardi et al., 2016; Stillitano et al., 2016 and 2017; Bernardi et al., 2018; De Luca et al., 2018) and wine grape growing or the wine industry (Pellicanò & De Luca 2016; Schimmenti et al., 2016). Other studies have assessed the environmental impact of different cultivation practices (Falcone et al., 2015; Sgroi et al., 2015a; Falcone et al., 2016; Sgroi et al., 2015b; Nicolò et al., 2017; Strano et al., 2017). Furthermore, a large strand of literature has evaluated the impact of organic versus conventional cultivation of citrus. Among them, particular relevance has been found for energy and economic analyses (Banaeian et al., 2011; Pergola et al., 2013).

Concerning the economic analysis, several methodological approaches have been developed to evaluate economic sustainability in terms of the profitability of grain production (Hanson et al., 1997), current Mediterranean orchards (De Gennaro et al., 2012; De Luca et al., 2014; Liontakis & Tzouramani 2016) and other agro-food productions (Strano et al., 2015). In addition, energy analysis has taken on increased importance in the existing literature, being widely debated in several economic studies (Ozkan et al., 2004; Wood et al., 2006; Pergola et al., 2013) and focusing on energy use efficiency (Banaeian et al., 2011; Mohammadi et al., 2014).

However, certain aspects still deserve further attention, especially with regard to the specificity of cultivation environments related to the quality of orchards, e.g., geographical indications or others certified labels identifying specific characteristics of agricultural products. Another important aspect is measuring the sustainability levels of the organic cultivation method versus conventional farming. With an energy, environmental and production cost analysis, Pergola et al. (2013) evaluated the impact of every citrus fruit product on the environment, observing that the overall production cycles of lemons and oranges on organic farms can be considered more sustainable than those of conventional farms. In the context of citrus, a joint application of life cycle methodologies was performed by De Luca et al. (2014) to simultaneously assess the environmental and economic sustainability of clementine crops by confirming the advantages of organic orchards. Several studies comparing the energy consumption between organic and conventional farms can be found in the literature (Ozkan et al., 2004; Astier et al., 2014; Aguilera et al., 2015a and 2015b; Lee et al., 2015; Taxidis et al., 2015; Lin et al., 2016). Among these, Ozkan et al., 2004 found that the direct use of energy as well as the emissions of greenhouse gases are higher for organic farms compared to conventional farms. However, the contribution of indirect factors, which exercise greater pressure on the environment, appears to be negatively correlated with conventional farms, causing a substantially higher overall impact.

As already mentioned, because most of the relevant research has aimed to evaluate different environmental impacts of organic and conventional cultivation of citrus fruit (Chinnici et al., 2013; De Luca et al., 2014; Ribal et al., 2016) typical agro-food productions have received very little attention. Further studies are needed with respect to the specific features of growing cultivation areas, such as Protected Geographical Indications (PGI) and Protected Designation of Origin (PDO). In fact, yields and inputs can be strongly influenced by the production specifications of each producer association. In this direction, we believe it would be informative to compare the results of clementine producers derived from the three different growing methods (conventional, integrated and organic cultivation) in a homogenous citrus growing area, i.e., the PGI Clementines of Calabria, assessing energy and economic performances in terms of average total costs and average net values. Clementines are a typical citrus fruit with specific characteristics cultivated in a specific area of Calabria, a region of southern Italy. The authenticity of this fruit has been recently demonstrated by a multi-element fingerprint (Benabdelkamel et al., 2012), and it was also recently awarded with EU PGI designation.

This study aims to evaluate the environmental and economic effects of different agricultural management models for quality citrus fruit production. The remainder of the paper consists of five different sections. The next section briefly describes the specificity of three different farming models: organic, conventional and integrated cultivation. The third section describes the methodological approach used in the study and the data sampling method. The fourth section presents the main economic and energy results, whereas the fifth part discusses the main outcomes and implications in terms of farms profitability and environmental and socio-economic sustainability. The last section provides some conclusions and directions of future work.

MATERIALS AND METHODS

The EU agricultural management models analysed

The three different farming systems identified in this study, conventional, integrated and organic practices, are characterized by specific regulations related to the use of fertilizers, pesticides, fungicides, herbicides and fito-regulators.

The conventional farming system represents the freest alternative, allowing the use of all chemical products authorized by European and national regulations. In particular, the use of fertilizers is constrained in Europe by Council Regulation (EC) no. 2003/2003 (EC 2003), whereas the use of phytoiatric compounds is constrained by Council Regulation (EC) no. 1107/2009 (EC 2009). Excluding other specific limitations related to specific areas susceptible to fertilizers and chemicals leaching, synthetic agricultural products can be used following the technical guidelines provided by fertilizer manufacturers.

In addition, organic farming systems are specifically regulated by Council Regulation (EC) no. 834/2007 (EC 2007) on organic production and the labelling of organic products, which limits the typology of products allowed and in some cases the quantity (e.g., for copper compounds, the norm limits the quantity to 6 kg ha^{-1} $year^{-1}$ of copper metal). National audit bodies, which monitor for fraud and allow companies to use the organic labels for verified products, guarantee compliance with the rules. Organic productions are characterized by the substitution of chemical fertilizers with organic compounds (e.g., manure, horn meal, poultry manure etc.) and chemical phytoiatric compounds with organic compounds, the biological control of pests and mechanical operations (e.g., mechanical weeding). Generally, organic systems have lower yields than conventional systems due to both the low use of inputs and the higher amount of rejected products due to damage.

Integrated production, compared to conventional production, attempts to move the goal from yield maximization to cost reduction and the quality of the product (Tamis & Van Den Brink, 1999) by implementing management strategies to limit as much as possible the use of synthetic compounds and the release of hazardous slag. In particular, this type of farming system is normed at the local level by specific procedural guidelines of regional authorities, which describe the most appropriate cultivation techniques for single species and fix the typology and the quantity of inputs allowed. All products in organic production are also allowed in the integrated production. In particular, for citrus cultivation, and especially for clementines in the Calabria region, the production rules fix the active ingredients allowed for each disease, the period of treatments, and the maximum amount allowed (Regione Calabria, 2016). For fertilizers, specific limits are fixed for nitrogen (120 kg ha^{-1}), for phosphorus pentoxide (60 kg ha^{-1}) and for potassium oxide (100 kg ha^{-1}). These limits are referred to as normal conditions, but incremental values are allowed in specific contexts (e.g., for a high yield and/or for low soil fertility). In particular, for nitrogen, the quantity can be increased up to 75 kg ha^{-1}. For phosphorus pentoxide, it can be increased up to 80 kg ha^{-1}. For potassium oxide, it can be increased up to 45 kg ha^{-1}. Specific recommendations are also made for tillage, with preference for soft operations, low energy consumption and conservative ploughings in terms of soil fertility and soil biodiversity.

Theory and modelling

This paper presents a double methodological approach to evaluate economic and energy sustainability. The first part of the analyses was addressed to evaluate the profitability among organic, integrated and conventional cultivations. According to previous research (Di Vita et al., 2013), this first analysis was mainly oriented towards evaluating the economic results of the sampled farms by comparing the farm net value (FNV) of each of the production systems. The farm net value was calculated as a mean for each homogeneous area by subtracting from total output (TO) the production costs (PC), which include total specific costs, farming overheads and depreciation. TO includes total crops saleable (production expressed in tons per average price). With the aim of reducing the biases arising from changes in the level of inputs, prices and seasonal productive trends (De Luca et al., 2014; Di Vita et al., 2014), the values of the TO and FNV were determined using their average values for at least four years (2012–2015).

Concerning the PC, the analysis identified three main classes of costs: materials, labour and services, and quotas and other duties (Gresta et al., 2014; Stillitano et al., 2016). The materials item includes the costs of all non-capital inputs (fertilizers, pesticides, herbicides, fuel, water and other crop specifics) and was calculated taking into consideration both the amount effectively used by the farm during the accounting years and the current market prices. The labour and services item identifies all expenditures for the remuneration of labour, considering all workers directly employed in the production process as well as the external farming services. Costs for farmworkers were evaluated in terms of opportunity cost and were equal to the employment of temporary workers for manual and mechanical operations, assuming current hourly wages. The expenditure for services and specialized labour provided by external agencies was considered as rental costs of mechanical means. Furthermore, in this typology of costs, all expenses for insurance, product sale mediation and transport were accounted for. The quotas and other duties item include depreciation costs for machinery, equipment, land and buildings, circulating and current capital, taxes and fees. Direct subsidies were also included in the analysis by calculating the support of the Common Agricultural Policy (CAP) for the citrus fruit sector provided per hectare, according to Council Regulation (EC) no. 1307/2013 (EC 2013).

The second methodology applied in this paper focuses on an energy analysis approach. In particular, an input-output energy analysis was applied to deepen all energy requirements connected to agricultural production, including the indirect contribution made by the manufacturing of agricultural inputs. With the aim to assess the energy demand of different citrus farming techniques, an approach 'from gate to gate' was chosen (Fig. 1).

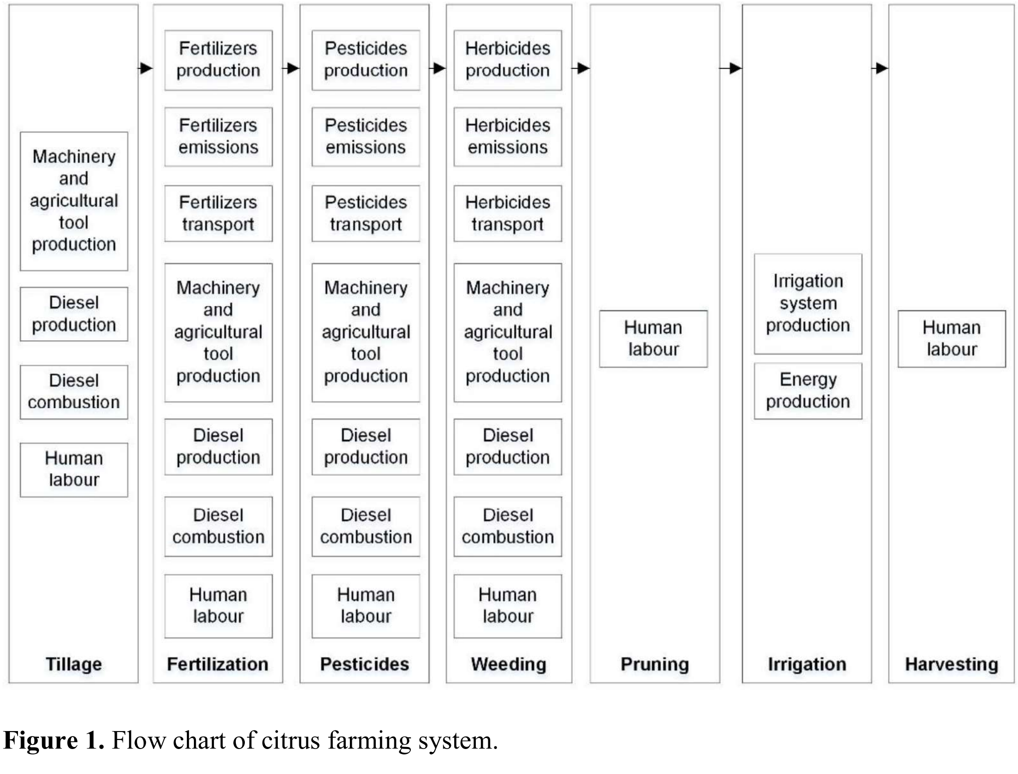

Figure 1. Flow chart of citrus farming system.

According to Ribal et al. (2016), the energy balance assessment was carried out taking into account the full production phase of orchards, which represents the most representative phase in terms of practices, material inputs and environmental impacts.

A reference unit equal to 1 ha $year^{-1}$ was adopted. In terms of comparing different land utilizations, it appears to be more appropriate than a mass unit (e.g., kg of product), especially for practical implications pertinent to managerial strategies for farmers and policy makers (Cerutti et al., 2015). Data on the input quantities were directly measured from primary sources, whereas the energy equivalent requirement for each input (Table 1) was estimated according to Namdari et al. (2011). To note the different typologies of employed energy, inputs connected to clementine production were classified in direct (D) and indirect (I) sources and in renewable (R) and non-renewable (NR) energies (Yilmaz et al., 2005).

Table 1. Energy equivalent requirement for each input and output considered

Input	Sources typology	Energy typology	Measurement unit	Characterization factors (MJ $unit^{-1}$)	Reference
Diesel Fuel	(D)	(NR)	L ha^{-1}	56.31	Mohammadi et al., 2008
Human Labor	(D)	(R)	h ha^{-1}	1.96	Ozkan et al., 2004
Water	(D)	(R)	m^3 ha^{-1}	1.02	Mohammadi et al., 2008
Electicity	(D)	(NR)	kWh ha^{-1}	11.93	Ozkan et al., 2004
Machinery	(I)	(NR)	h ha^{-1}	62.70	Ozkan et al., 2004
Manure	(I)	(R)	kg ha^{-1}	0.30	Canakci et al., 2005
N	(I)	(NR)	kg ha^{-1}	66.14	Mohammadi et al., 2008
P_2O_5	(I)	(NR)	kg ha^{-1}	12.44	Mohammadi et al., 2008
K_2O	(I)	(NR)	kg ha^{-1}	11.15	Mohammadi et al., 2008
Pesticides	(I)	(NR)	kg ha^{-1}	199.00	Ozkan et al., 2004
Fungicides	(I)	(NR)	kg ha^{-1}	92.00	Ozkan et al., 2004
Herbicides	(I)	(NR)	kg ha^{-1}	238.00	Ozkan et al., 2004

The investigation covered the areas of clementine of Calabria PGI production. Representative farms were identified in each of three most representative areas, Cosenza, Reggio Calabria and Catanzaro, taking into account the characteristics of the territories and the ordinariness of the production units. Because of the diversity of citrus cultivation and to ensure that the sample adequately reflected this heterogeneity, we stratified the universe of farms using the following criteria: average production, specialized farms, age of cultivation (constant production stage) and plant density. As a consequence, 27 representative farms, equally distributed in three different areas, were totally identified. Data were collected during face-to-face interviews with each producer using a custom-fitted survey questionnaire. The final organization of the questionnaire was derived using outcomes, items and information obtained in a previous focus group. The questionnaire consisted of two main parts; the first one took into account the structural and entrepreneurial characteristics of farms, and the second section was aimed at gathering data on economic aspects and energy use.

Synthetically, the data gathering concerned farm production (yield), farm inputs (types and quantities of agricultural inputs), machinery use for farm management (e.g., fertilizer application, tillage, pruning, weed mowing, etc.), outsourced cost items (e.g., expert consultancies, transport and outsourced cultivation operations), wages, and all cost items not directly attributable to specific growing operations, represented by quotas (depreciation, maintenance and insurance), levies, and interests (remuneration of working capital) and rent (remuneration of land). Table 2 reports the main features characterizing the sample of analysed farms.

Table 2. Main features of sampled farms (means)

Production systems	Cultivated ha area	Diesel Fuel (L ha^{-1})	Human Labor	Machinery (h ha^{-1})	Water (m^3 ha^{-1})	Manure (kg ha^{-1})	N (kg ha^{-1})	P_2O_5 (kg ha^{-1})	K_2O (kg ha^{-1})	Pesticides (kg ha^{-1})	Herbicides (kg ha^{-1})	Fungicides (kg ha^{-1})	Energy (kW ha^{-1})	Yield (ton ha^{-1})
Organic	5.6	302.7	432.1	66.2	6,552.0	1,698.9	0.0	0.0	0.0	65.9	0.0	30.0	931.1	29.0
Conventional	6.1	231.9	473.7	50.4	6,685.0	0.0	217.8	142.7	168.8	19.1	5.4	16.1	966.7	36.05
Integrated	6.4	232.6	461.6	53.6	6,776.0	0.0	165.6	120.0	124.4	18.0	5.2	14.9	966.7	34.16

RESULTS AND DISCUSSION

The results are organized in two different subsections. The first analysed the economic results in terms of FNV obtained both including and excluding CAP aids, whereas the second part reported the energy analysis carried out according to the current existing literature (Gündoğmuş 2006; Namdari et al., 2011; Pergola et al., 2013).

Economic results (comparison between organic and conventional growing)

Observing data reported in Tables 3, 4 and 5, the more profitable results were found for organic cultivation in terms of both total output (TO) and farm net value (FNV) in the absence of CAP aids. Obviously regarding FNV in the presence of incentives (which include those for Mediterranean cultivation plus those for organic cultivation), the outcome is even more favourable for organic farming. In fact, despite the total costs of production being the highest in organic farms, the higher sale price of organic PGI clementines allowed producers to obtain the highest remuneration of their capital. Organic cultivation allows producers to obtain specific aid provided for the organic method in addition to the agricultural incentives provided by the EU for each Italian citrus fruit farm.

Differences were also observed for the three different samples with respect to materials and quotas and other duties, whereas statistically relevant differences were observed for the costs linked to labour and services. In organic cultivation, the expenditures for materials, especially for fertilizers and pesticides, are lower than those in conventional and integrated systems. Our results confirm those reported in other studies (Padel & Lampkin, 1994). As expected in the organic cultivation, the expenditure for quotas and other duties is the highest. This result is due to the fees for control required by the inspection body for the certification of organic process.

Concerning the second management model based on integrated agricultural practices, it registers the lowest economic performance compared to the others methods. The lower profitability of the integrated management model is due mainly to the presence of higher average costs, despite the total output of production being on average slightly higher than conventional systems, causing a more favourable price in the final markets. This result is strictly coherent with other studies carried out on organic farming of perennial crops of the Mediterranean Basin (Sgroi et al., 2015a).

Table 3. Economic results of the organic farming systems (expressed in k€ ha^{-1})

Farm no.	Materials	Labour and services	Quotas and other duties	Production Cost (PC)	Total Output (TO)	Farm Net Value (FNV)	Farm Net Value (FNV) + CAP aids	B/C	(B+CAP aids) /C
Org 1	1.07	3.27	3.89	8.23	12.80	4.57	6.38	1.56	1.77
Org 2	0.99	3.87	3.86	8.71	12.18	3.47	5.27	1.40	1.61
Org 3	0.98	3.72	3.84	8.54	11.20	2.66	4.46	1.31	1.52
Org 4	1.53	4.59	3.37	9.49	14.00	4.51	6.32	1.48	1.66
Org 5	1.46	4.56	3.37	9.40	15.00	5.60	7.41	1.60	1.79
Org 6	1.44	4.61	3.80	9.85	13.75	3.90	5.71	1.40	1.58
Org 7	1.52	3.70	4.22	9.45	14.46	5.00	6.81	1.53	1.72
Org 8	1.43	3.97	4.66	10.06	14.80	4.74	6.54	1.47	1.65
Org 9	1.55	4.51	4.30	10.36	14.21	3.85	5.65	1.37	1.55
Min	0.98	3.27	3.37	8.23	11.20	2.66	4.46	1.31	1.52
Max	1.55	4.61	4.66	10.36	15.00	5.60	7.41	1.60	1.79
Mean	**1.33**	**4.09**	**3.92**	**9.34**	**13.60**	**4.26**	**6.06**	**1.46**	**1.65**
Sd	0.24	0.49	0.42	0.72	1.28	0.88	0.88	0.09	0.10

Table 4. Economic results of the integrated farming systems (expressed in k€ ha^{-1})

Farm no.	Materials	Labour and services	Quotas and other duties	Production Cost (PC)	Total Output (TO)	Farm Net Value (FNV)	Farm Net Value (FNV) + CAP aids	B/C	(B+CAP aids)/C
Int 1	1.63	4.66	2.95	9.27	11.55	2.28	3.48	1.25	1.38
Int 2	1.64	3.95	2.80	8.39	11.88	3.49	4.69	1.42	1.56
Int 3	1.50	4.09	2.77	8.35	10.85	2.50	3.70	1.30	1.44
Int 4	1.55	3.59	3.70	8.84	12.96	4.12	5.32	1.47	1.60
Int 5	1.70	4.26	3.49	9.45	12.25	2.80	4.01	1.30	1.42
Int 6	1.66	3.36	3.83	8.86	13.30	4.44	5.65	1.50	1.64
Int 7	1.53	4.04	3.48	9.04	12.16	3.12	4.32	1.35	1.48
Int 8	1.37	4.40	3.39	9.16	11.78	2.62	3.83	1.29	1.42
Int 9	1.65	4.63	3.27	9.55	12.35	2.80	4.01	1.29	1.42
Min	1.37	3.36	2.77	8.35	10.85	2.28	3.48	1.25	1.38
Max	1.70	4.66	3.83	9.55	13.30	4.44	5.65	1.50	1.64
Mean	**1.58**	**4.11**	**3.30**	**8.99**	**12.12**	**3.13**	**4.34**	**1.35**	**1.48**
Sd	0.10	0.44	0.38	0.42	0.73	0.74	0.74	0.09	0.09

The conventional farming system shows the lowest cost of all three samples. It is less rentable than organic agricultural method, but it registers a higher profitability than the integrated system. The average total costs of conventional farms amount to 8.13 k€ ha^{-1}, with a minimum of 6.99 and a maximum of 8.95 k€ ha^{-1}. Quotas and other duties constitute the most significant proportion of total costs, which differs from that detected for the other two systems, whereas Labour and services constitute the major cost. These last results were consistent with earlier findings reported by other authors arguing that organic management systems are more economically sustainable than conventional systems (Pergola et al., 2013; Sgroi et al., 2015a).

Table 5. Economic results of the conventional farming systems (expressed in k€ ha^{-1})

Farm no.	Materials	Labour and services	Quotas and other duties	Production Cost (PC)	Total Output (TO)	Farm Net Value (FNV)	Farm Net Value (FNV) + CAP aids	B/C	(B+CAP aids)/C
Conv 1	1.53	2.06	3.71	7.30	9.50	2.20	3.41	1.30	1.47
Conv 2	1.41	1.95	3.63	7.00	9.24	2.24	3.45	1.32	1.49
Conv 3	1.43	2.18	3.85	7.46	10.50	3.04	4.25	1.41	1.57
Conv 4	1.64	2.93	3.80	8.37	11.44	3.07	4.28	1.37	1.51
Conv 5	1.58	2.86	3.71	8.15	11.75	3.60	4.81	1.44	1.59
Conv 6	1.56	2.98	3.89	8.44	12.16	3.73	4.93	1.44	1.58
Conv 7	1.54	4.44	2.91	8.89	14.00	5.11	6.32	1.57	1.71
Conv 8	1.68	4.28	3.00	8.95	15.00	6.05	7.25	1.68	1.81
Conv 9	1.76	4.02	2.92	8.70	13.75	5.05	6.25	1.58	1.72
Min	1.41	1.95	2.91	7.00	9.24	2.20	3.41	1.30	1.47
Max	1.76	4.44	3.89	8.95	15.00	6.05	7.25	1.68	1.81
Mean	**1.57**	**3.08**	**3.49**	**8.14**	**11.93**	**3.79**	**4.99**	**1.46**	**1.61**
Sd	0.11	0.96	0.42	0.72	2.02	1.34	1.34	0.13	0.12

Energy analysis: comparison among organic, integrated and conventional farming

As previously observed in the economic analysis, from an energetic point of view, the organic farming system (Table 6) shows better performances than the conventional and integrated systems (Tables 7 and 8). Organic clementines require the lowest average energy employment (49.55 GJ ha^{-1} year^{-1}) compared with the integrated (57.21 GJ ha^{-1} year^{-1}) and conventional scenarios (59.09 GJ ha^{-1} year^{-1}). The larger amount of energy consumption in the organic farming systems is related to the depletion of fossil fuels due to machinery use (on average 34.5% of total), followed by the use of electricity and irrigation (22.3%). Fertilization represents only 1.03% whereas the use of plant protection products accounts for 18.6%. Analysing the standard deviation, a higher value was reached for the 'Diesel Fuel' category (2.6%) followed by the 'Pesticides' (2.1%) and 'Electricity' (1.8%) categories. The other categories show, on average, values approximately 0.5%, indicating low dispersion of the distribution of results.

As mentioned above, the integrated farming system represents the second less impactful scenario in terms of energy consumption, with a higher energy requirement in terms of 'fossil energy'. The ratio of this energy category consumption to the total requirement is less than that for the organic scenario and is, on average, 24%. Fertilization represents the most impactful operation overall, particularly nitrogen fertilizer (20.1%), together with phosphorus pentoxide and potassium oxide, which brings the share of total energy required for fertilizers to 25.3%.

Table 6. Energy results of the organic farming systems

Farm no.	Diesel Fuel (%)	Human Labor (%)	Water (%)	Electricity (%)	Machinery (%)	Manure (%)	Pesticides (%)	Fungicides (%)	TOTAL (GJ ha^{-1} year^{-1})
Org 1	36.25	1.98	12.72	20.70	8.80	1.00	12.00	6.55	44.95
Org 2	37.57	1.97	12.23	19.62	9.09	1.04	12.21	6.27	42.57
Org 3	37.92	1.88	12.78	20.36	9.21	0.94	10.64	6.28	43.95
Org 4	30.41	1.57	14.60	23.88	7.35	1.03	15.55	5.61	52.45
Org 5	31.97	1.64	13.98	24.96	7.77	1.03	13.76	4.90	52.59
Org 6	32.54	1.64	13.98	21.61	7.90	0.94	16.02	5.37	49.68
Org 7	33.08	1.56	13.28	23.71	8.08	1.08	14.38	4.82	55.35
Org 8	35.43	1.61	13.83	23.90	8.73	1.14	9.92	5.44	52.42
Org 9	35.80	1.65	13.54	21.79	8.74	1.04	12.14	5.31	52.02
Min	30.41	1.56	12.23	19.62	7.35	0.94	9.92	4.82	42.57
Max	37.92	1.98	14.60	24.96	9.21	1.14	16.02	6.55	55.35
Mean	**34.55**	**1.72**	**13.44**	**22.28**	**8.41**	**1.03**	**12.96**	**5.62**	**49.55**
Sd	2.64	0.17	0.75	1.88	0.65	0.07	2.11	0.62	4.57

Irrigation was the third most energy expensive operation, accounting for 21% of the total energy requirement. The standard deviation was higher for electricity (2.9%) and nitrogen fertilizer (2.5%), whereas for the other inputs, it was, on average, 0.5%.

Table 7. Energy results of the integrated farming systems

Farm no.	Diesel Fuel (%)	Human Labor (%)	Water (%)	Electricity (%)	Machinery (%)	N (%)	P_2O_5 (%)	K_2O (%)	Pesticides (%)	Fungicides (%)	Herbicides (%)	TOTAL (GJ ha^{-1} year^{-1})
Int 1	24.44	1.72	10.93	17.93	6.06	24.23	2.80	2.62	4.16	2.42	2.68	53.22
Int 2	26.11	1.80	10.76	17.14	6.62	22.81	2.74	2.46	4.46	2.82	2.28	52.19
Int 3	25.25	1.85	10.98	16.95	6.30	21.48	3.28	2.83	5.87	2.80	2.41	49.28
Int 4	24.04	1.71	14.07	23.02	5.96	17.02	2.63	2.36	4.25	2.54	2.41	54.41
Int 5	22.16	1.62	13.71	25.30	5.98	18.70	2.31	2.07	3.76	2.28	2.10	56.58
Int 6	23.53	1.67	13.28	22.64	6.26	17.93	2.47	2.22	5.08	2.33	2.58	55.32
Int 7	22.46	1.47	13.14	22.22	5.53	21.28	2.74	2.74	4.09	2.34	2.02	59.05
Int 8	23.83	1.52	13.14	22.09	6.36	18.66	2.74	2.75	4.42	2.60	1.89	56.70
Int 9	23.98	1.58	13.24	21.35	6.26	18.34	2.89	2.79	5.18	2.47	1.92	55.89
Min	22.16	1.47	10.76	16.95	5.53	17.02	2.31	2.07	3.76	2.28	1.89	49.28
Max	26.11	1.85	14.07	25.30	6.62	24.23	3.28	2.83	5.87	2.82	2.68	59.05
Mean	**23.98**	**1.66**	**12.58**	**20.96**	**6.15**	**20.05**	**2.73**	**2.54**	**4.59**	**2.51**	**2.25**	**54.74**
Sd	1.24	0.12	1.31	2.93	0.31	2.47	0.27	0.27	0.66	0.20	0.29	2.88

The conventional farming system has the worst results; however, the mean value is close to that of the integrated farming system. In terms of the incidence of a single input to total energy requirements, fertilization represents the most wasteful operation. In particular, the use of nitrogen share is on average 24.45% of the total, representing overall the most impactful input. Considering phosphorus pentoxide and potassium oxide, the use of fertilizers constitutes approximately 30.5% of the energy required. As seen above for the integrated farming system, diesel fuel (22.1%) and electricity (19.44%) represent the second and the third most influential inputs, respectively. The standard deviations have higher values in the nitrogen category (3.1%) and in the electricity category (2.55%) but generally have values comparable with the other farming systems.

Table 8. Energy results of the conventional farming systems

Farm no.	Diesel Fuel (%)	Human Labor (%)	Water (%)	Electricity (%)	Machinery (%)	N (%)	P_2O_5 (%)	K_2O (%)	Pesticides (%)	Fungicides (%)	Herbicides (%)	TOTAL (GJ ha^{-1} $year^{-1}$)
Conv 1	21.56	1.78	10.56	16.83	5.23	27.87	2.81	2.52	5.50	3.12	2.24	53.16
Conv 2	24.80	1.54	9.51	15.45	6.03	27.41	2.58	2.31	5.37	2.54	2.47	57.92
Conv 3	24.31	1.57	9.84	16.29	5.89	27.09	2.55	2.28	5.31	2.83	2.03	58.59
Conv 4	20.79	1.50	12.39	22.22	4.96	25.71	2.42	2.17	3.67	2.24	1.93	61.73
Conv 5	21.86	1.47	12.21	20.40	5.23	24.43	2.45	2.19	4.95	2.36	2.44	58.47
Conv 6	19.73	1.57	12.64	21.68	4.77	25.79	2.57	2.30	4.45	2.13	2.36	60.52
Conv 7	21.71	1.58	12.08	20.17	5.31	21.47	4.04	5.13	4.17	2.33	2.01	59.15
Conv 8	21.92	1.61	12.07	20.58	5.33	20.86	3.92	4.98	4.45	2.12	2.15	60.87
Conv 9	22.37	1.54	12.29	21.36	5.40	19.38	3.65	4.63	4.25	3.00	2.13	61.43
Min	19.73	1.47	9.51	15.45	4.77	19.38	2.42	2.17	3.67	2.12	1.93	53.16
Max	24.80	1.78	12.64	22.22	6.03	27.87	4.04	5.13	5.50	3.12	2.47	61.73
Mean	**22.12**	**1.57**	**11.51**	**19.44**	**5.35**	**24.45**	**3.00**	**3.17**	**4.68**	**2.52**	**2.20**	**59.09**
Sd	1.59	0.09	1.20	2.55	0.40	3.13	0.67	1.32	0.63	0.38	0.19	2.62

In terms of the type of energy used in the different farming systems, the share of non-renewable energy is higher than that of renewable. For the conventional and integrated scenarios, renewable energy represents only 13%, whereas for the organic scenario, the share increases up to 16% (Fig. 2).

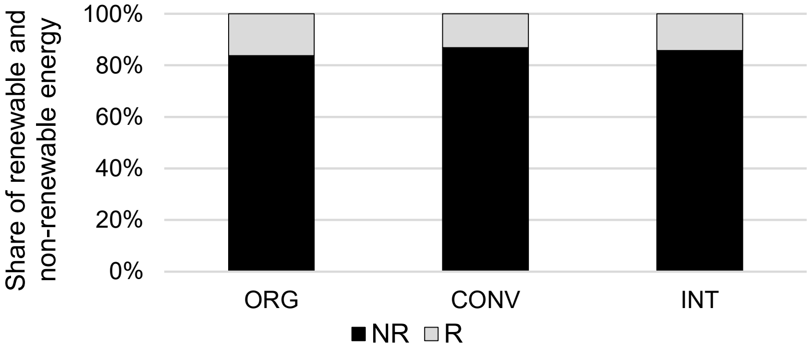

Figure 2. Average share of renewable and non-renewable energy for different farming systems.

In terms of direct and indirect energy, the conventional and integrated systems show a similar trend, using 55% and 60% of direct energy and 45% and 40% of indirect energy, respectively. Conversely, the organic farming systems use 72% of direct energy and only 28% of indirect energy (Table 9).

Table 9. Average share of direct and indirect energy for different farming systems

	(D)				(I)							
	Diesel Fuel	Human Labor	Water	Electicity	Machinery	Manure	N	P	K	Pesticides	Fungicides	Herbicides
ORG	34.39%	1.71%	13.49%	22.42%	8.37%	1.03%	0.00%	0.00%	0.00%	13.02%	5.57%	0.00%
CONV	22.10%	1.57%	11.54%	19.52%	5.35%	0.00%	24.37%	3.00%	3.18%	4.66%	2.51%	2.19%
INT	23.93%	1.65%	12.63%	21.07%	6.14%	0.00%	20.00%	2.73%	2.53%	4.57%	2.50%	2.25%

Discussion

The results confirm the differences in the energy and economic performances among three different farming systems, and the outcomes seem to be in line with previous research concerning these issues. The analyses showed the best economic performance for organic farming, unlike the findings obtained in an analogous study conducted on orange farming that showed the highest profitability for the conventional method (Chinnici et al., 2013). These initial results, confirmed by most of the subsequent studies (Pergola et al., 2013; Patil et al., 2014; Sgroi et al., 2015a), are due to current availability of European Union farm support to help organic growers gain additional value from citrus fruit production. At the same time, this result is justified by the progressive increase in the consumer prices of clementine that benefit from a favourable price due to it being organic and having PGI certification, confirming current trends of modern consumers that show an increasing appreciation for organic products and the origin of fresh fruit production (Lombardi et al., 2013). From a consumer behaviour perspective, further analysis can be directed to evaluating a hedonic price function of the effects of each certification on the final price of clementines. In addition, the analysis noted that organic farming is more labour intensive than the other scenarios. As a consequence, from a macroeconomics approach, it would seem that organic and even integrated farming requires a larger amount of work in relation to the final output. In this sense, our results seem to have interesting implications for rural and local development because the outcomes show that putting more effort into the development of sustainable practices in the agriculture of PDO and PGI areas would require greater use of manpower. As a result, this increasing demand in terms of extra labour could be redirected towards structural employment policies for both skilled and generic agricultural jobs.

Therefore, we can reasonably affirm that organic agriculture produces positive economic effects not only due to the higher prices or to EU additional payments for organic growing, which lead to an increase in farm profitability but also because it generates favourable social effects and benefits on the local system thanks to the major participation of local organic stakeholders. This result appears to be in line with a study arguing the role of organic farming in preventing the abandonment of rural areas (Testa et al., 2015). Therefore, the increasing demand of employment and more profitable incomes of organic farming can ensure a more favourable impact overall on the territory, with positive economic and social effects within the rural areas (Timpanaro et al., 2013; Spampinato et al., 2013; Zarbà et al., 2013; De Luca et al., 2015a; Frischknecht et al., 2015). Concerning environmental sustainability, by observing the results obtained in the energy analysis, it was found that the organic farming system requires less energy input than the conventional system. This result appears to be consistent with earlier studies that compared these different farming systems using energy input-output analyses (Gündoğmuş et al., 2006; Pergola et al., 2013). Similar results have been obtained in different life cycle assessment (LCA) studies in which the depletion of non-renewable resources was considered (Falcone et al., 2015; Ribal et al., 2016); however, these energy source generally considers only fossil fuel consumption (Frischknecht et al., 2015). Furthermore, the results are comparable with some studies that assessed the energy consumption of citrus orchards (Namdari et al., 2011; Pergola et al., 2013).

In particular, taking into account the study of Ozkan et al. (2004), their results determined an energy requirement for mandarins that is lower than our findings (48.84 GJ ha^{-1}), but they used different cultivation techniques and characterization factors. For the energy requirements of mandarins, the results of Namdari et al. (2011) are very similar to ours (77.50 GJ ha^{-1}), and in this case, the cultivation techniques are different and strongly connected to the area of the survey. Considering only one year of production, the results of Pergola et al. (2013) show a higher energy demand compared to our findings, but their results are relative to the full production phase and a different citrus species. In contrast, our results appear consistent, especially considering that the area analysed by Pergola et al. (2013) is relatively close to that considered for this study.

In terms of energy demand by farming operations, as mentioned above, the fertilization and pesticide distributions constitute approximately 40% of the total energy requirement for the conventional and integrated scenarios, according to Ozkan et al. (2004) and Namdari et al. (2011), whereas for the organic system, it covers approximately 20%. Also in Beccali et al. (2010) fertilization is the most impactful operation, but it is not possible to attribute the share of the cumulative energy demand linked to this operation for the different reference unit used (1 kg of transformed product) and in the absence of an in-depth analysis of the agricultural phase. Tillage and irrigation generally represent the second and the third most energy-expensive operations, due to the use of fossil fuels and electricity, according to Ozkan et al. (2004) and Namdari et al. (2011). On the contrary, Pergola et al. (2013) observed that the most impactful operation is harvesting in lemon cultivation for both the organic and conventional systems. This result is due to the higher planting density of lemon orchards and to the distribution throughout the year of the harvesting of lemon fruits.

Considering one ha of cultivated surface, the organic farming systems exhibited better performances respect than the conventional and integrated systems, but these could be subject to relevant changes considering, as a reference unit, one kilo of product. For example, considering the mean values of energy consumption and the average yield (organic 29,000 kg ha^{-1}; integrated 34,167 kg ha^{-1}; conventional 36,056 kg ha^{-1}), the results of the present study change 1.71 MJ kg^{-1} for organic, 1.64 MJ kg^{-1} for conventional and 1.60 MJ kg^{-1} for integrated farming systems. The alternative results in terms of the kg of products show that the integrated system performed better compared to the conventional and/or organic systems, apparently, contrasting the results outlined above; however, it is only a perspective question. In fact, the results expressed in terms of mass are strictly connected to the difference in the yield between cultivation techniques (which is lower in the organic system). The use of a mass FU favours the integrated and conventional scenarios, according to Mattsson (1999), Nicoletti et al. (2001) and Cerutti et al. (2015). Therefore, in terms of energy consumption, it might be plausible to assert that organic practices are not always sustainable. A thorough environmental assessment should consider other indicators, for example, the effects on biodiversity at a local scale and the impact on soil quality. Only considering the energy footprint, it would be hazardous to affirm that integrated or conventional agriculture is in anyway better than organic agriculture (Cerutti et al., 2015).

CONCLUSIONS

This study provides empirical research on the economic and energy sustainability of different citrus cultivation practices in Southern Italy to ascertain whether differences exist among different agricultural management models in terms of profitability and energy use in PGI areas. The results allowed us to compare the economic and energy performances of each farming typology, describing the outcomes for three different scenarios: organic, integrated and conventional farming.

Economic analysis found the highest economic and social sustainability performances for organic farming. In terms of product quality, this production method ensures the highest profitability and seems to be more beneficial in terms of rural development and environmental protection. Furthermore, concerning energy analysis, the organic farming system yields better results. The results referring to the cultivated area could be useful for defining energy-oriented development strategies. From a consumer perspective, referring to the assessment of the product, the results revealed that the increase of the yield plays a key role, allowing a greater distribution of energy consumption. Increasing the yield of the organic farming system should be the path to obtaining more sustainable products.

Therefore, the present paper confirms the main outcomes of a large strand of existing literature on organic farming and introduces for the first time new insights linked to the energy balance for crops cultivated in protected geographical indication areas.

Further analysis of sustainability in other PDO and PGI areas is needed to corroborate our results. More in-depth studies could be useful for understanding the different levels of sustainability by investigating additional environmental and economic indicators through life cycle methodologies and financial analysis.

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REFERENCES

Aguilera, E., Guzmán, G. & Alonso, A. 2015a. Greenhouse gas emissions from conventional and organic cropping systems in Spain. I. Herbaceous crops. *Agronomy for Sustainable Development* **35**(2), 713–724.

Aguilera, E., Guzmán, G. & Alonso, A. 2015b. Greenhouse gas emissions from conventional and organic cropping systems in Spain. II. Fruit tree orchards. *Agronomy for Sustainable Development* **35**(2), 725–737.

Astier, M., Merlín-Uribe, Y., Villamil-Echeverri, L., Garciarreal, A., Gavito, M.E. & Masera, O.R. 2014. Energy balance and greenhouse gas emissions in organic and conventional avocado orchards in Mexico. *Ecological Indicators* **43**, 281–287.

Banaeian, N., Omid, M. & Ahmadi, H. 2011. Energy and economic analysis of greenhouse strawberry production in Tehran province of Iran. *Energy Conversion and Management* **52**(2), 1020–1025.

Beccali, M., Cellura, M., Iudicello, M. & Mistretta, M. 2010. Life cycle assessment of Italian citrus-based products. Sensitivity analysis and improvement scenarios. *Journal of Environmental Management* **91**, 1415–1428.

Benabdelkamel, H., Di Donna, L., Mazzotti, F., Naccarato, A., Sindona, G., Tagarelli, A. & Taverna, D. 2012. Authenticity of PGI 'Clementine of Calabria' by multielement fingerprint. *Journal of agricultural and food chemistry* **60**(14), 3717–3726.

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

Bernardi, B., Falcone, G., Stillitano, T., Benalia, S., Strano, A., Bacenetti, J. & De Luca, A.I. 2018. Harvesting system sustainability in Mediterranean olive cultivation. *Science of the Total Environment* **625**, 1446–1458.

Canakci, M., Topakci, M., Akinci, I. & Ozmerzi, A. 2005. Energy use pattern of some field crops and vegetable production: Case study for Antalya Region. *Turkey Energy Conversion and Management* **46**, 655–666.

Cerutti, A.K., Beccaro, G.L., Bosco, S., De Luca, A.I., Falcone, G., Fiore, A., Iofrida, N., Lo Giudice, A. & Strano, A. 2015. Life Cycle Assessment in the Fruit Sector. In Notarnicola, B., Salomone, R., Petti, L., Renzulli, P.A., Roma, R. & Cerutti, A.K. (eds): *Life Cycle Assessment in the Agri-food Sector Case Studies, Methodological Issues and Best Practices*. Springer International Publishing, Switzerland, CH, pp. 333–388.

Chinnici, G., Pecorino, B. & Scuderi, A. 2013. Environmental and economic performance of organic citrus growing. *Quality-Access to Success* **14**(1), 106–112.

Council Regulation (EC) No 2003/2003 of the European Parliament and of the Council of 13 October 2003 relating to fertilisers (Text with EEA relevance). 2003. *Official Journal of the European Union* **L304**, 1–194.

Council Regulation (EC) No 834/2007 of 28 June 2007 on organic production and labelling of organic products and repealing Regulation (EEC) No 2092/91. 2007. *Official Journal of the European Union* **L189**, 1–23.

Council Regulation (EC) No 1107/2009 of the European Parliament and of the Council of 21 October 2009 concerning the placing of plant protection products on the market and repealing Council Directives 79/117/EEC and 91/414/EEC. 2009. *Official Journal of the European Union* **L309**, 1–50.

Council Regulation (EC) No 1307/2013 of the European Parliament and of the Council of 17 December 2013 establishing rules for direct payments to farmers under support schemes within the framework of the common agricultural policy and repealing Council Regulation (EC) No 637/2008 and Council Regulation (EC) No 73/2009. 2013. *Official Journal of the European Union* **L347**, 608–670.

D'Amico, M., Di Vita, G. & Monaco, L. 2016. Exploring environmental consciousness and consumer preferences for organic wines without sulfites. *Journal of Cleaner Production* **120**, 64–71.

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

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

De Luca, A.I., Iofrida, N., Strano, A., Falcone, G. & Gulisano, G. 2015a. Social life cycle assessment and participatory approaches: A methodological proposal applied to citrus farming in Southern Italy. *Integrated environmental assessment and management* **11**(3), 383–396.

De Luca, A.I., Molari, G., Seddaiu, G., Toscano, A., Bombino, G., Ledda, L., Milani, M. & Vittuari, M. 2015b. Multidisciplinary and innovative methodologies for sustainable management in agricultural systems. *Environmental Engineering and Management Journal* **14**(7), 1571–1581.

De Luca, A.I., Falcone, G., Stillitano, T., Iofrida, N., Strano, A. & Gulisano, G. 2018. Evaluation of sustainable innovations in olive growing systems: A Life Cycle Sustainability Assessment case study in southern Italy. *Journal of Cleaner Production* **171**, 1187–1202.

De Olde, E.M., Moller, H., Marchand, F., McDowell, R.W., MacLeod, C.J., Sautier, M., Halloy, S., Barber, A., Benge, J., Bockstaller, C., Bokkers, E.A.M., de Boer, I.J.M., Legun, K.A., Le Quellec, I., Merfield, C., Oudshoorn, F.W., Reid, J., Schader, C., Szymanski, E., Sørensen, C.A.G., Whitehead, J. & Manhire, J. 2016. When experts disagree: the need to rethink indicator selection for assessing sustainability of agriculture. *Environment, Development and Sustainability* **19**(4), 1–16.

Di Vita, G., D'Amico, M. & Bracco, S. 2013. Economic performance of smallholders PDO wine grapes in Eastern Sicily. *Quality Access-to Success* **14**(S1), 99–105.

Di Vita, G., Chinnici, G., Pappalardo, G., D'Amico, M. & Bracco, S. 2014. Standard output versus standard gross margin, a new paradigm in the EU farm economic typology: what are the implications for wine-grape growers?. *Journal of Wine Research* **25**(4), 229–242.

Di Vita, G., Chinnici, G. & D'Amico, M. 2015. Sustainability of olive oil production in Sicilian marginal agricultural areas. *Quality Access to Success* **16**(S1), 118–125.

Falcone, G., Strano, A., Stillitano, T., De Luca, A.I., Iofrida, N. & Gulisano, G. 2015. Integrated Sustainability Appraisal of Wine-growing Management Systems through LCA and LCC Methodologies. *Chemical Engineering Transactions* **44**, 223–228.

Falcone, G., De Luca, A.I., Stillitano, T., Strano, A., Romeo, G. & Gulisano, G. 2016. Assessment of environmental and economic impacts of vine-growing combining life cycle assessment, life cycle costing and multicriterial analysis. Sustainability **8**(8), n. 793.

Finco, A., Pollonara, M. & Di Pronio, G. 2007. Sustainable management of agriculture and biodiversity conservation. *Fitosociologia* **44**, 307–312.

Frischknecht, R., Wyss, F., Büsser Knöpfel, S., Lützkendorf, T. & Balouktsi, M. 2015. Cumulative energy demand in LCA: the energy harvested approach. *International Journal of Life Cycle Assessment* **20**, 957–969.

Gresta, F., De Luca, A.I., Strano, A., Falcone, G., Santonoceto, C., Anastasi, U. & Gulisano, G. 2014. Economic and environmental sustainability analysis of guar (Cyamopsis tetragonoloba L.) farming process in a Mediterranean area: two case studies. *Italian Journal of Agronomy* **9**, 20–24.

Gündoğmuş, E. 2006. Energy use on organic farming: A comparative analysis on organic versus conventional apricot production on small holdings in Turkey. *Energy Conversion and Management* **47**, 3351–3359.

Hanson, J.C., Lichtenberg, E. & Peters, S.E. 1997. Organic versus conventional grain production in the mid-Atlantic: An economic and farming system overview. *American Journal of Alternative Agriculture* **12**(01), 2–9.

Lee, K.S., Choe, Y.C. & Park, S.H. 2015. Measuring the environmental effects of organic farming: A meta-analysis of structural variables in empirical research. *Journal of Environmental Management* **162**, 263–274.

Lin, H-C., Huber, J.A., Gerl, G. & Hülsbergen, K.J. 2016. Effects of changing farm management and farm structure on energy balance and energy-use efficiency-A case study of organic and conventional farming systems in southern Germany. *European Journal of Agronomy* **82**, 203–356.

Liontakis, A. & Tzouramani, I. 2016. Economic Sustainability of Organic Aloe Vera Farming in Greece under Risk and Uncertainty. *Sustainability* **8**(4), 338.

Lombardi, P., Caracciolo, F., Cembalo, L., Colantuoni, F., D'Amico, M., Del Giudice, T., Maraglino, T., Menna, C., Panico, T., Sannino, G., Tosco, D. & Cicia, G. 2013. Country-of-origin labelling for the Italian early potato supply chain. *New Medit* **12**(1), 37–48.

Mariani, A. & Vastola, A. 2015. Sustainable winegrowing: Current perspectives. *International Journal of Wine Research* **7**(1), 37–48.

Mattsson, B. 1999. Environmental Life Cycle Assessment (LCA) of Agricultural Food Product. *Swedish Institute for Food and Biotechnology*, SIK, Gothenburg, 55 pp.

Mohammadi, A., Rafiee, S., Jafari, A., Keyhani, A., Mousavi-Avval, S.H. & Nonhebel, S. 2014. Energy use efficiency and greenhouse gas emissions of farming systems in north Iran. *Renewable and Sustainable Energy Reviews* **30**, 724–733.

Mohammadi, A., Tabatabaeefar, A., Shahin, S., Rafiee, S. & Keyhani, A. 2008. Energy use and economical analysis of potato production in Iran a case study: Ardabil province. *Energy Conversion and Management* **49**, 3566–3570.

Namdari, M., Kangarshahi, A.A. & Amiri, N.A. 2011. Input-output energy analysis of citrus production in Mazandaran province of Iran. *African Journal of Agricultural Research* **6**, 2558–2564.

Nicoletti, G.M., Notarnicola, B. & Tassielli, G. 2001. Comparison of conventional and organic wine. In: *Proceedings of the International Conference LCA in: Foods*, Goteborg, Sweden, pp. 131–135.

Nicolò, B.F., De Luca, A.I., Stillitano, T., Iofrida, N., Falcone, G. & Gulisano, G. 2017. Environmental and economic sustainability assessment of navel oranges from the cultivation to the packinghouse according to environmental product declarations system. *Quality – Access to Success* **18**(158), 108–112.

Ozkan, B., Akcaoz, H. & Karadeniz, F. 2004. Energy requirement and economic analysis of citrus production in Turkey. *Energy Conversion and Management* **45**(11), 1821–1830.

Padel, S. & Lampkin, N. 1994. The economics of organic farming: An international perspective. *CAB International,* Wallingford, Oxon, UK, 468 pp.

Patil, S., Reidsma, P., Shah, P., Purushothaman, S. & Wolf, J. 2014. Comparing conventional and organic agriculture in Karnataka, India: Where and when can organic farming be sustainable? *Land Use Policy* **37**, 40–51.

Pellicanò, A. & De Luca, A.I. 2016. Dynamics, motivations and barriers in internationalisation of Italian wineries: a qualitative survey in South Italy. *Journal of Wine Research* **27**(4), 257–283.

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

Pimentel, D., Hepperly, P., Hanson, J., Douds, D. & Seidel, R. 2005a. Environmental, energetic, and economic comparisons of organic and conventional farming systems. *BioScience* **55**(7), 573–582.

Pimentel, D. 2005b. Environmental and economic costs of the application of pesticides primarily in the United States. *Environment, development and sustainability* **7**(2), 229–252.

Regione Calabria. 2016. Disciplinari di produzione integrate - Difesa fitosanitaria e controllo delle infestanti 2016; Available from: http://www.agroservizi.regione.calabria.it/documents/12605/13415/DISCPLINARI++2016++PARTE+DIFESA+E+DISERBO+-+REGIONE+CALABRIA+PUBBLICATO+OK+%281%29.pdf/723146fa-247f-4c9b-b343-e5bede611056 [accessed 19.07.16].

Ribal, J., Ramírez-Sanz, C., Estruch, V., Clemente, G. & Sanjuán, N. 2016. Organic versus conventional citrus. Impact assessment and variability analysis in the Comunitat Valenciana (Spain). *The International Journal of Life Cycle Assessment* **22**(4), 571–586.

Rigby, D. & Cáceres, D. 2001. Organic farming and the sustainability of agricultural systems. *Agricultural systems* **68**(1), 21–40.

Rigby, D., Woodhouse, P., Young, T. & Burton, M. 2001. Constructing a farm level indicator of sustainable agricultural practice. *Ecological economics* **39**(3), 463–478.

Schimmenti, E., Migliore, G., Di Franco, P.C. & Borsellino, V. 2016. Is there sustainable entrepreneurship in the wine industry? exploring Sicilian wineries participating in the Sostain program. *Wine Economics and Policy* **5**(1), 14–23.

Sgroi, F., Candela, M., Di Trapani, A.M., Foderà, M., Squatrito, R., Testa, R. & Tudisca, S. 2015a. Economic and financial comparison between organic and conventional farming in Sicilian lemon orchards. *Sustainability* **7**(1), 947–961.

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

Spampinato, D., D'Amico, M. & Rapisarda, P. 2013. Intervention policies and Italian viticulture *Quality – Access to Success* **14**(1), 272–278.

Stillitano, T., De Luca, A.I., Falcone, G., Spada, E., Gulisano, G. & Strano, A. 2016. Economic profitability assessment of Mediterranean olive growing systems. *Bulgarian Journal of Agricultural Science* **22**(4), 517–526.

Stillitano, T., De Luca, A.I., Iofrida, N., Falcone, G., Spada, E. & Gulisano, G. 2017. Economic analysis of olive oil production systems in southern Italy. *Quality – Access to Success* **18**(157), 107–112.

Strano, A., Stillitano, T., De Luca, A.I., Falcone, G. & Gulisano, G. 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.

Strano, A., Falcone, G., Nicolò, B.F., Stillitano, T., De Luca, A.I., Nesci, F.S. & Gulisano, G. 2017. Eco-profiles and economic performances of a high-value fruit crop in southern Italy: a case study of bergamot (Citrus bergamia Risso). *Agroecology and Sustainable Food Systems* **41**(9–10), 1124–1145.

Tamis, W.L.M. & Van Den Brink, W.J. 1999. Conventional, integrated and organic winter wheat production in The Netherlands in the period 1993–1997. *Agriculture, Ecosystems and Environment* **76**(1), 47–59.

Taxidis, E.T., Menexes, G.C., Mamolos, A.P., Tsatsarelis, C.A., Anagnostopoulos, C.D. & Kalburtji, K.L. 2015. Comparing organic and conventional olive groves relative to energy use and greenhouse gas emissions associated with the cultivation of two varieties. *Applied Energy* **149**, 117–124.

Testa, R,, Foderà, M., Di Trapani, A.M., Tudisca, S. & Sgroi, F. 2015. Choice between alternative investments in agriculture: The role of organic farming to avoid the abandonment of rural areas. *Ecological Engineering* **83**, 227–232.

Timpanaro, G., Di Vita, G., Foti, V.T. & Branca, F. 2013. Landraces in Sicilian peri-urban horticulture: a participatory approach to Brassica production system. *Acta Horticulturae* **1005**, 213–220.

Van der Werf, H.M. & Petit, J. 2002. Evaluation of the environmental impact of agriculture at the farm level: a comparison and analysis of 12 indicator-based methods. *Agriculture, Ecosystems & Environment* **93**(1), 131–145.

Wood, R., Lenzen, M., Dey, C. & Lundie, S. 2006. A comparative study of some environmental impacts of conventional and organic farming in Australia. *Agricultural systems* **89**(2), 324–348.

Yilmaz, I., Akcaoz, H. & Ozkan, B. 2005. An analysis of energy use and input costs for cotton production in Turkey. Renewable Energy **30**, 145–55.

Zanoli, R., Gambelli, D. & Vairo, D. 2012. Scenarios of the organic food market in Europe. *Food Policy* **37**(1), 41–57.

Zarbà, A.S., Di Vita, G. & Allegra, V. 2013. Strategy development for Mediterranean pot plants: a stakeholder analysis. *Quality Access-to Success* **14**(S1), 52–58.