Sustainability **2014**, *6*, 7967-7981; doi:10.3390/su6117967

OPEN ACCESS

sustainability

ISSN 2071-1050

www.mdpi.com/journal/sustainability

Article

Economic Sustainability of Italian Greenhouse Cherry Tomato

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External Editor: Marc A. Rosen

Received: 27 August 2014; in revised form: 2 November 2014 / Accepted: 5 November 2014 / Published: 12 November 2014

Abstract: Greenhouse tomato cultivation plays an important role in Sicily, being the primary production area in Italy, due to its favorable pedo-climatic conditions that permit extra-seasonal productions. In Sicily, more than half of greenhouse tomato production is derived from the Province of Ragusa on the southeastern coast, where especially cherry tomato typologies are cultivated. Over the last decade, the Ragusa Province has registered a decrease both in terms of greenhouse tomato area and harvested production due to several structural problems that would require restructuring of the tomato supply chain. Thus, since recognition of real costs and profitability of tomato growing is a vital issue, both from the perspective of the farm, as well as from that of the entrepreneur, the aim of this paper was to analyze the economic sustainability of Sicilian greenhouse cherry tomato cultivated in the Ragusa Province. In particular, an economic analysis on 30 representative farms was conducted in order to estimate production costs and profits of greenhouse cherry tomato. According to our results, the lack of commercial organization, which characterizes the small farms we surveyed, determines low contractual power for farmers and, consequently, low profitability.

Keywords: farming operations; production cost; profit; Sicily; supply chain

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1. Introduction

Indigenous of Latin America and introduced into Europe at the beginning of sixteenth century, nowadays tomato (*Solanum lycopersicum* L.) is one of the most widely grown vegetables in the world [1,2]. According to the latest available data, in 2012, tomato area in the world amounted to 4.8 million hectares, denoting, during the last ten years (2012–2003), an increase of 17.3% [3]. This increase was due essentially to the African (+34.9%) and Asian (+30.8%) continents, which in 2012, represented, respectively, 21.0% and 58.8% of world tomato areas, while Europe (−23.8%) and America (−11.6%) denoted a significant decrease with respect to 2003. In the last few years, in fact, tomato is cultivated, increasingly, in new-producer countries to the detriment of the traditional growing areas. This occurs, firstly, due to the low costs of human labor and for the continuous investments that, in recent years, have affected, not only cultivation techniques, but also commercial and marketing strategies, improving the tomato supply chain management [4,5]. China (1,000,000 ha) and India (870,000 ha) represented the two main producer countries, covering 38.9% of world tomato area, followed by Turkey (6.3%), Nigeria (5.6%), and Egypt (4.5%). With regards to world tomato production, in the last ten years, it increased by 35.4%, reaching a value of 161.8 million tons in 2012. China, in addition to growing area, was the top country for harvested quantities (50.0 million tons), followed by India (17.5 million tons) and the USA (13.2 million tons); these three countries reached 49.9% of the total world tomato production (Figures 1 and 2).

Figure 1. World tomato area in 2012.

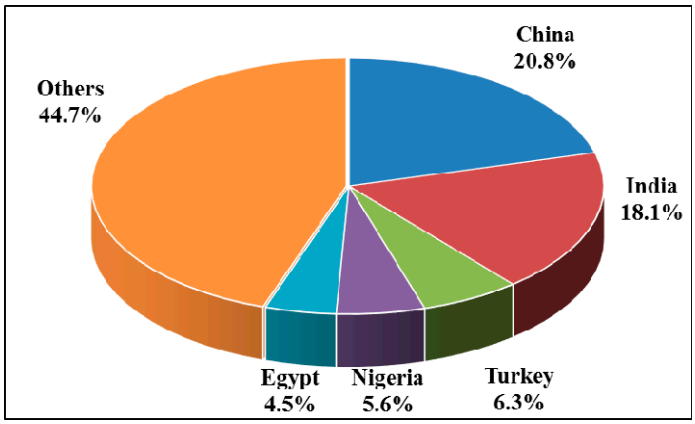
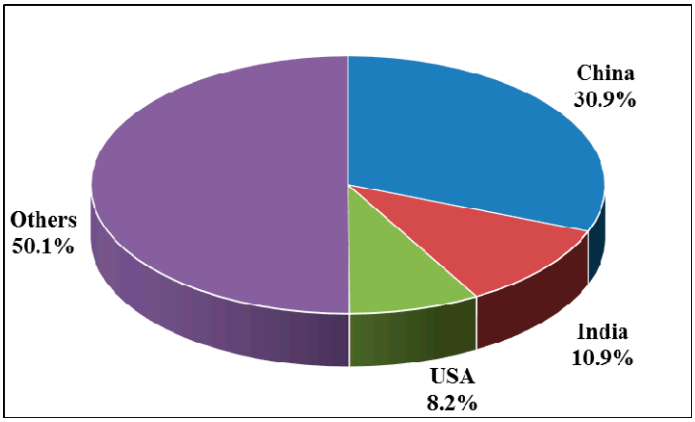


Figure 2. World tomato production in 2012.



Italy, with 91,850 ha and 5.1 million tons, in 2012, represented the ninth country for world tomato area and the seventh for harvested production. Greenhouse tomato cultivation played an important role, involving 7558 hectares (7.3% of Italian tomato area) with a production of 512,330 tons (8.6% of harvested tomato) [6]. Sicily was the first region both for cultivated area (48.7% of Italian greenhouse tomato cultivation) and harvested production (39.9%), because of its favorable pedo-climatic conditions that allow farmers to obtain extra-seasonal productions, as well as for other protected crops [7–9]. Sicilian farms that cultivated tomato under greenhouses amounted to 3809 units, averaging 1.26 hectares in size [10]. If we analyze the distribution of Sicilian tomato farms according to class of utilized agricultural area (UAA), 1594 units (41.8% of Sicilian tomato farms) were under one hectare in size, while farms under five hectares amounted to 3352 units, representing 88.0% of Sicilian farms that cultivate tomato in greenhouses. In Sicily, over half the greenhouse tomato production comes from the Ragusa Province on the southeastern coast, where, especially, cherry tomato typologies are cultivated. They are produced in cold greenhouses with production cycles that span the whole year [11]. The vast majority of Mediterranean greenhouses, in fact, are of low cost and low technology with respect to the greenhouses of Northern Europe [12,13], having plastic coverings and few climate control systems [14,15]. Ragusa Province, despite being the primary Sicilian production area, during last ten years, showed a decrease both in terms of greenhouse tomato area (−7.3%) and harvested production (−27.4%) for several structural and commercial problems. Therefore, in order to better understand the profitability of Sicilian greenhouse cherry tomato production and determine its weaknesses, an economic analysis of farms is needed, as was done in similar studies [16–19], since economic sustainability is the most important factor for the adoption of a crop, as it ensures the farm's long-term competitiveness [20–24]. In this context, the aim of this paper was to analyze the economic profitability of Sicilian greenhouse cherry tomato cultivated in the Ragusa Province. In particular, an economic analysis on 30 representative farms was performed in order to estimate the production costs and profits of greenhouse cherry tomato. Recognition of real costs and profitability of tomato growing, in fact, is vital both from the perspective of the farm, as well as from that of the entrepreneur, whose production also depends upon climate, soil, market conditions (competitors), which together determine the positioning of the company within an increasingly globalized and competitive market.

2. Materials and Methods

Since Sicily represents the primary production area of Italian greenhouse cherry tomato cultivation, the economic analysis was conducted on a representative sample of 30 farms located in the Ragusa Province, which accounts for more than half of Sicilian cherry tomato production.

For research purposes, a purposive sample of farms was chosen [25–27]. The characteristics taken into consideration in the selection of the sample units were those most frequently observed in Sicilian greenhouse tomato farms according to the most recent Italian Agricultural Census data, *i.e.*, small farm size, farm managed directly by farmer's family, low mechanization of farming operations, and local sales modality.

The technical-economic data were collected through a questionnaire by means of direct interviews of farmers, which provided the information regarding costs and revenues of cherry tomato production [28–30]. In particular, the questionnaire included several questions and was divided into

two main parts. The first gathered structural and management data (farm size, tomato protected area, farm investments, sales modality of production), while second focused on the tomato production process (farming operations, inputs required for crop growing, workload) and farmer's revenues (yield, sales price).

The surveyed farms had an average protected area of 1.67 ha, ranging between a minimum of 0.60 ha and a maximum of 3.00 ha (Table 1).

Table 1. Surveyed farms.

Farms (No.)	Protected area (ha)	Tomato area (ha)	Tomato yield (kg/m^2)	Workload (h/m^2)
1	0.60	0.60	16.7	0.8
2	0.80	0.70	16.6	0.7
3	1.50	1.00	16.3	0.8
4	1.40	1.00	16.6	0.9
5	2.00	1.20	16.8	1.1
6	3.00	2.00	16.4	0.9
7	1.70	0.70	16.8	0.7
8	0.90	0.90	17.0	1.0
9	2.80	2.00	16.7	0.9
10	3.00	1.00	16.4	0.8
11	0.65	0.65	16.4	0.7
12	0.70	0.70	16.3	0.7
13	2.00	1.10	16.7	0.9
14	2.80	1.80	16.8	0.8
15	2.40	1.40	17.3	1.0
16	1.30	0.80	16.4	0.7
17	1.10	1.10	16.6	1.0
18	3.00	2.00	16.5	0.8
19	2.50	1.90	17.0	0.9
20	0.90	0.90	16.4	0.8
21	1.00	0.50	16.9	0.8
22	1.20	0.60	16.6	0.7
23	1.30	1.30	17.8	1.3
24	1.60	0.90	16.4	0.7
25	2.80	1.80	16.4	0.7
26	0.95	0.95	16.5	0.8
27	2.10	2.00	16.9	0.9
28	2.20	1.20	16.3	0.6
29	0.80	0.80	16.8	0.9
30	1.00	0.50	16.1	0.6
Min	0.60	0.50	16.1	0.6
Max	3.00	2.00	17.8	1.3
Average	1.67	1.13	16.6	0.8

All farms were specialized in the production of protected crops under plastic-covered greenhouses with production cycles that span the whole year. Tomato growing ranged from 0.50 to 2.00 ha and represented 71.4% of protected area of our sample, while, in the remaining part, zucchini, peppers,

lettuce, and eggplants were cultivated. In all surveyed farms, the variety of cherry tomato cultivated was Creative F1.

The production process begins in August with soil preparation and terminates in June when tomato plants are grubbed up. The workload required for the production process ranged from 0.6 to 1.3 h/m^2 and it correlated, especially, with tomato yield as harvest proves to be the most labor-intensive farming operation.

Seedlings are transplanted at the end of August in double rows with a plant spacing of 80 × 40 cm and tomato plants are espaliered.

This farming system entails that the plants, after the differentiation of the 4th–5th floral clusters, rather than being linked to the nylon support in the vertical direction, are inclined 60–65° and linked to the support of the next plant by means of plastic hooks (Figure 3).

Thereby, full advantage of the greenhouses height is taken and each tomato plant is able to reach a production of 20–22 productive clusters, with an annual average yield of 16.6 kg/m^2, ranging from 16.1 to 17.8 kg/m^2.

The farming operations following transplantation call for the elimination of lateral shoots and pollination of flowers, performed by bumblebees (*Bombus terrestris*). Tomatoes are cultivated in a plastic mulched/drip irrigated production system. In all farms, drip irrigation for tomatoes has gained popularity because of water-use efficiency and because it allows for the application of fertilizers in irrigation water, leading to greater tomato yield and efficiency of fertilizer use than soil application methods [31–33]. During winter, a single daily irrigation suffices, whereas, as spring approaches, the number of daily irrigations is usually 4–5, only one of which also provides fertirrigation. Each irrigation ranges between 1000 and 1500 L/1000 m^2.

Figure 3. Cherry tomatoes cultivated in plastic-covered greenhouses.

Harvest is performed manually, starting about 90 days after transplanting and continues from November to June. The choice not to use the summer months for the production process is due to the

fact that farmers, in this way, produce extra-seasonal cherry tomatoes, obtaining higher sales prices with respect to summer productions. However, tomatoes are sold directly to local fruit and vegetable markets in 500–1500 g plastic boxes instead of Large Organized Distribution (LOD), determining low contractual power during price negotiations. This kind of commercialization also characterizes most farms that cultivate protected crops in the territory.

Since, among surveyed farms, there was a low variability in terms of farming operations and sales modality, the economic analysis was referred to the average of the data collected from each farm.

The economic results referred to m^2 in order to make comparisons between the greenhouse tomato farms surveyed [34] and both yield and cost items were determined according to current prices of the most recent crop year (2013/2014). In order to evaluate the profitability of cherry tomato farms, specific indicators were utilized, such as net profit per unit area and the net profit per unit yield [35].

Profit was calculated by subtracting total production cost of cherry tomato from gross production value [36].

Gross production value was calculated according to the average tomato production per crop cycle in the reference year, considering the weighted average sales price reported by the farmers.

The costs of tomato production included variable costs and fixed costs [37]. In the farms surveyed, specializing in cherry tomato growing, determination of fixed and variable costs did not prove difficult, inasmuch as the fixed costs were directly attributable to the crop. In the case of farms that also cultivated other products, variable costs were determined by considering only costs directly attributable to the crop, while fixed costs were calculated by means of a coefficient expressing the ratio of tomato area to total farm area [38].

Variable costs represented the component of the total production cost that varies with the produced quantity or the cultivated area [39,40]. The variable costs associated with tomato growing were all represented by materials and services coming from outside the farm related to the production process (fertilizers, pesticides, fuels and lubricants, seedlings, repair and maintenance of greenhouses and farm machines, soil disinfestations, plastic boxes, transport, *etc.*), human labor required for the farming operations during tomato production (transplanting, hoeing, elimination of lateral shoots, harvest, packaging, *etc.*), and interest on current costs. The latter were determined by charging a simple interest rate of 5%, anticipated for three months on average, relative to the period of tomato production and marketing.

Fixed costs included all cost items which are not directly attributable to the productive process [41,42]: depreciation and maintenance quotas of durable capital (greenhouses, irrigation equipment, agricultural machines, farming buildings), compensation for intellectual work (administration and direction expenses), taxes, and interest on both durable capital and land value.

In particular, in order to evaluate the depreciation quota relative to greenhouses, an economic life of 15 years was considered.

3. Results and Discussion

The average total production cost of cherry tomato cultivated under greenhouses of 30 surveyed farms was equal to 20.87 €/m^2, of which 78.1% was represented by variable costs (Table 2). Among the latter, labor was the main cost item (41.6% of total production cost), followed by materials and

services (35.5%) and interest on current costs (1.0%). Labor expenses, in fact, strongly influence farm profitability and, therefore, its economic sustainability, and due to this specific farming system these costs cannot be reduced to improve profit margins [43]. In particular, the high incidence of costs related to labor highlighted that cherry tomato cultivated under greenhouses required many manual farming operations during the crop year. This aspect is common to many other studies where the cost of labor is usually hard to decrease when it is conditioned by the specific nature of the production process [44–46]. This cropping system, in fact, on the one hand allows a large number of productive cycles per year, but on the other hand requires considerable workload [47,48]. As has been reported in other studies [49,50], this is attributable essentially to the harvest that, with an average cost of 3.40 €/m^2, represented the main farming operation required during tomato production.

Table 2. Production costs of greenhouse cherry tomato (average).

Cost items	€/m^2	€/kg
1. Materials and services	7.41	0.45
seedlings	1.13	0.07
fertilizers	0.94	0.06
pesticides	0.37	0.02
irrigation water	0.16	0.01
greenhouse coverage	0.60	0.04
mulch	0.19	0.01
supports and plastic hooks	0.08	0.00
fuel and lubricants	0.01	0.00
maintenance and repair	0.97	0.06
soil disinfestation	0.50	0.03
packaging	2.47	0.15
2. Labor	8.67	0.52
harvest	3.40	0.20
other farming operations	5.28	0.32
3. Interest on current costs	0.21	0.01
(A) Total variable costs	**16.29**	**0.98**
1. Quotas of durable capital	2.39	0.15
greenhouses	1.25	0.08
irrigation equipment	0.30	0.02
agricultural machines	0.69	0.04
farming buildings	0.15	0.01
2. Intellectual work	0.84	0.05
3. Taxes	0.25	0.01
4. Interest on durable capital	0.30	0.02
5. Interest on land value	0.80	0.05
(B) Total fixed costs	**4.58**	**0.28**
(C) Total production cost (A + B)	**20.87**	**1.26**

Packaging is very important to maintain postharvest texture, flavor, and eating quality for productions [51,52], and it increasingly determines the success and survival of crops and their growers because it is a crucial factor in consumers' choice [53].

Plastic boxes, in fact, were another significant cost item for cherry tomato producers and reached 11.8% of total production cost, followed by seedlings (5.4%), maintenance and repair of greenhouses and farm machines (4.6%), and fertilizers (4.5%). Fixed costs represented 21.9% of total production costs and, among these, the quotas relative to durable capital were the main cost items with an average value of 2.39 €/m^2. The majority of this value was due to greenhouse depreciation (1.25 €/m^2) that represented the most expensive investment for tomato producers [54]. Intellectual work and interest on land value showed a similar incidence, equal to 4.0% and 3.8%, respectively, followed by interest on durable capital (1.4%) and taxes (1.2%).

Gross production value of surveyed farms showed an average value equal to 21.08 €/m^2, deriving from the average cherry tomato yield of 16.6 kg/m^2 and the weighted average sales price of 1.27 €/kg (in the crop year 2013/2014 it ranged from 0.80 to 1.45 €/kg), according to the data provided by the farmers (Table 3).

This high yield, with respect to other countries in which production ranges from 12.9 to 15.2 kg/m^2 [55,56], has been reached thanks to the positive effects of drip irrigation, plastic mulch, sandy soils and Sicilian climatic conditions that grant a rapid tomato growth [57–63].

In sum, average profit obtained from cherry tomato cultivated under greenhouses was 0.21 €/m^2, a figure that underscores the modest income for farmers.

Table 3. Economic analysis of greenhouse cherry tomato (average).

Items	€/m^2	€/kg
(A) Gross production value	21.08	1.27
(B) Variable costs	16.29	0.98
(C) Fixed costs	4.58	0.28
(D) Total production cost (B + C)	20.87	1.26
(E) Profit (A − D)	0.21	0.01

As is evident from the data on net profit per unit yield, just equal to 0.01 €/kg, even a slight decrease in cherry tomato yield or sales prices would result in negative profits for farmers. This is attributable to structural and commercial problems of greenhouse cherry tomato farms that negatively affect their export potential and competitiveness. Consequently, tomato commercialization is practically limited to local and regional markets, as occurs in other production areas [64,65]. In fact, farmers sell cherry tomatoes directly to local wholesalers that later resell them to fruit and vegetable markets and/or to Large Organized Distribution (LOD). This sales modality determines a weakened contractual power during price negotiations [66–69], that causes an uncertainty of economic returns and an increase of business risk [70,71]. Moreover, the small size of the surveyed farms and their production process limit a higher degree of mechanization of farming operations, with a negative impact on production cost, also hindering the introduction of technological innovations [72–74].

Therefore, considering the difficulties that farms have in being competitive (high production costs, low negotiation power, small farm size), process innovation [75,76], and the aggregation of productive supply via forms of farmer association, could represent ways of improving profit margins [77–81]. The above highlights how a modernization and restructuring of the supply chain and a change of entrepreneurial strategies of farmers [82] appear necessary so as to favor a more sustainable economic

development of farms [83–85]. Commercial reorganization and process innovation, in fact, are the main levers to regain market shares from international competitors that, despite their small-sized farms, are able to meet the growing demand of fresh out-of season tomato [86–88]. Indeed, profitability is an indispensable prerequisite for long-term competitiveness of farms in an increasingly globalized and competitive market, representing production units that could thereby provide income and job opportunities for a given rural context [89–91]. This is a key success factor especially for small-sized farms, for which the loss in profitability is generally greater than for large farms, as the latter are more efficient in their use of labor and other inputs, enabling them to reach scale economies that afford higher incomes and profits [92–95].

4. Conclusions

Sicily is the first Italian production area of greenhouse tomato and more than half the production comes from the Ragusa Province on the southeastern coast, where cherry tomato typologies are especially cultivated. However, in recent years tomato cultivated under greenhouses has experienced a process of downsizing in terms of both area and harvested quantities. This situation is essentially attributable to structural problems and socio-economic characteristics of greenhouse tomato farms that, frequently, have to compete with other countries that benefit from lower production costs and more effective commercial organizations.

The results of our economic analysis, in fact, showed that if sales prices of cherry tomato remain at current levels revenues barely cover production costs, which equates to a modest income for farmers. Considering that tomato producers operate in a competitive market and, therefore, are subject to the selling price (*i.e.*, are price takers), a restructuring of the tomato supply chain appears warranted, as highlighted by the critical points and weaknesses identified.

In the surveyed farms, in fact, where process innovation is difficult due to their small size, only farmer association can ensure an increase in profit margins. This would guarantee an aggregation of the productive supply that would increase producer negotiation power, allowing them to place their product on national and international markets thanks to an improved commercial organization. Without this entrepreneurial strategy, farms are destined to remain excluded from markets because, even if they are able to survive in the short-term, should their revenues equal or slightly exceed costs, this will not be the case in the long-term.

Thus, horizontal integration represents a path towards process innovation, aggregation of the productive supply and increased strength on the market, determining higher farm profitability and economic sustainability of a given rural territory.

Author Contributions

This paper is a result of the full collaboration of all the authors. However, Salvatore Tudisca wrote the Conclusions, Anna Maria Di Trapani elaborated the Introduction, Filippo Sgroi wrote the Results and Discussion, while Riccardo Testa elaborated the Materials and Methods.

Conflicts of Interest

The authors declare no conflict of interest.

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