strawberry – organic production will be positive for environment, society and economy?

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Abstract

Studies on the sustainability of strawberry organic production are reduced and do not always assess impacts in an integrated way. The central question of the thesis is whether strawberry production, namely organic production, will be positive for the Environment, Economy and Society.

To answer the central question is conducted an environmental, social and economic balance of organic strawberry production, analysis of a case study (organic strawberry farm) and main factors for its sustainability.

In economic terms, after analysis of production costs and comparison with conventional production costs, it concludes that although lower quantities, increased sales prices and low inputs, show a more profitable organic production.

For the environmental life cycle assessment (LCA) of the life cycle impacts of 1 kg strawberry production, the Simapro software was used, and the impacts were analysed several categories and comparing using different methods, “Impact 2002+”, “ILCD”, “ReCiPe Midpoind (H)” and “ReCiPe Endpoint (H)”.

It was confirmed that the impact of organic production in most of the categories and methods was lower, and in terms of human health, ecosystem quality, climate change and resources, organic production always obtained lower impact, having been estimated on conventional production three times more impacts than in organic strawberry production. Some changes were observed alternating methods, but overall water consumption, land use and fertilization have a important contribution, in some methods showing a bigger impact in organic production.

On the social aspect, after reviewing the literature and conclusions about its social importance, the impact of social terms in the production under study was analysed. Confirming a positive impact on the consumer, welfare of the farmer and local society in social aspects.

With this study, it was possible to conclude that the production of organic strawberry in social, environmental and economic terms is positive if developed at the usual time. If it is produced out of season this balance can be changed, which challenges new production methods in this situation and the consumer to prefer the consumption of organic strawberries during their usual production season.

Keywords: organic strawberry, Life cycle assessment, economic, environmental, social sustainability

1. Introduction

The dominant food system, based on intensive and large-scale agriculture combined with agro-industrial, is unsustainable; as it contributes to climate change, produces greenhouse gases and other pollutants, largely dependent on fossil energy, and produces health risks also generates social and territorial asymmetries, as part of an economy that is unsustainably exploiting the planet's resources.

From this observation, a change in production methods is necessary to preserve the environment, food quality, maintaining food sovereignty with the population increased. Organic farming (OF) is part of this new ecological logic of society, showing a significant growth in the last decades, both in Portugal and Europe [1], being increasingly on the agenda of European [2].

The strawberry has a set of qualities, which contribute to promote health [3]. On the one hand, named as the fruit with the highest pesticide residue recorded [4].

Organic strawberry production appears as a possibility of lower impact and healthier for strawberry production, but it is sometimes questioned whether the environmental, social and economic balance is positive and what are the main aspects that can contribute to a good balance and the sustainability of this mode of production.

2. Framework of requirements

2.1. European regulations and product labelling

Although OF has already been practised for a long time, only with the increased of demand and consumption comes the need for regulation in order to provide the expected consumer guarantee through labelling. Since it was the first European regulation for organic production in 1991 (Council Regulation (EEC) No 2092/91 of 24 June 1991), which, after successive amendments, was repealed by Regulation (EC) No 834/07, of the Council of 28 June 2007 on organic production and labelling; with a more logical structure and easier understanding. Composed by 7 titles, 42 articles and 1 annexe, arranged as shown in Table 1, with the differentiation of its objectives, principles and production rules.

Table 1 - Structure of Reg. (EC) Nº 834/2007

Title I - Objective, scope and definitions (Article 1 and 2).
Title II - Objectives and principles of organic production (art.3 to 7).
Title III - Production Rules
Chapter 1 - General rules applicable to production (art.8 to 10).
Chapter 2 - Agricultural production (art.11 to 17).
Chapter 3 - Production of processed animal feed (art.18).
Chapter 4 - Production of processed foodstuffs (articles 19 to 21).
Chapter 5 - Flexibility (Article 22).
Title IV - Labelling (Articles 23 to 26).
Title V - Controls (art.27-31).
Title VI - Relations with third countries (Articles 32 and 33).
Title VII - Final and transitional provisions (Articles 34 to 42).
Annex (referring to paragraph 1 of article 23).

2.2. Certification and control of organic production.

Firstly, he should have in mind that the option for organic production is itself a voluntary choice of the producer, independently of the reasons for its adoption.

With the development of the organic sector all over the world also globalization and international trade, the distance between the producer and the consumer has increased, leading to the need for "third party" entities to guarantee quality and respect of production standards.

The control and certification bodies must be able to demonstrate that they operate in

a non-discriminatory, independent, impartial, competent and efficient manner. Portugal has adopted the system operated by private bodies recognized by the competent authority.

The certification and control of farms are carried out and maintained with regular visits to ensure compliance with the rules and regulations, also a sampling of product for analysis, in order to guarantee the quality of the product.

3. Production, commercialization of strawberries and Impacts - state-of-the-art

3.1. Activities identification and production needs.

Organic farming is a production system that avoids or excludes almost all synthetic chemicals such as fertilizers, pesticides, growth regulators [5].

A research, based on 293 cases analysed worldwide, where comparisons were made between organic farming and other methods of food production, concluded that levels of organic farming have the ability to respond to the indices of world food needs and without negative impacts on the environment, and that agriculture can considerably limit the problem of global warming and climate change [6].

To be practicable to the full extent, organic farming systems rely on crop rotations, crop residues, animal manure, legume nitrogen "fixing" plants, green manures, all organic residues from the farm, biological control against pests and diseases and other cultural practices in order to maintain soil productivity.

Since 1999, organic production in Portugal increased from 0.3% to 6.7% of agricultural area used, being the fastest growing agricultural sectors, with an area of 250,000 hectares [2].

Conversion to OF is, of course, not only about N supply but rather an interaction of social, environmental and economic concerns and outcomes. Important issues include maintenance of soil conditions, provision of other nutrients other than N, human resources, pest management, disease and herbs, product quality and safety, and minimizing off-site environmental effects. [7].

Strawberry is an important fruit worldwide, produced in a conventional way as organic, in open field as in greenhouse, or tunnels. The intensive use of chemicals, such as fertilizers, pesticides and fungicides are present in conventional production, to achieve higher productivity and yield.

Similar to others organic productions, produce organic strawberry implies a whole system approach of the farm. Many of the practices are similar in conventional production such as organic ones, but the fundamental approach is creating the soil and controlling different imaginary pests. Production of organic strawberries depends on the construction of a biologically active soil with structure and nutrient reserve, and local control of weeds and soil-borne pests.

3.2. Environmental, social and economic impacts of the different life cycles of strawberry production and consumption

Considering OF in general before seeing the particular case of strawberry production. OF methods offer the possibility of greater ecosystem service in the soil compared to conventional methods, where OF increases organic C in soil (COS) stock, aggregated-associated COS, and concentrations of organic matter particles [8]. Organic methods are thought to be better for both human health [9] and perspective of natural conservation [10].

In social terms, studies reveal the role of farmers' moral and social concerns in shifting in production methods, where economic concerns have a strong role, and a large group of farmers attach great importance to moral and social issues, (eg, showing no commitment to the environment) lead to both IP and OF adoption; moral concerns (e.g., not feeling guilty about choices) increases the likelihood of just adopting organic farming; and farmers who (e.g. cutting production costs) are less likely to adopt OF [11].

The age distribution of farm managers with organic areas and properties with the conventional area are considerably different: farmers under 55 represent 61% of the organic sector, while they account for only 45% of the conventional sector [1], and OF farmers show high levels of satisfaction [11].

3.3. Production of conventional farming vs. organic farming

Organic farming refers to a system that improves soil fertility by maximizing the efficient use of local resources, while prior to the use of agrochemicals, the use of genetically modified organisms (GMOs) as many compounds used as food additives. Organic farming depends on a series of agricultural practices based on ecological cycles and aims to minimize the environmental impact of the food industry, preserving long-term soil sustainability and minimizing the use of non-renewable resources [12].

Studies have shown that soil organic matter increases in no-tillage systems, without soil ploughing, associated with both the decreases in total sediment losses and the annual amounts of C in soil lost through runoff. Although the reduction of soil ploughing in conventional systems is relatively straightforward due to the use of herbicide-resistant crops, reducing ploughing in organic systems is complicated because of lack of herb control [13].

Long-term studies in central Europe reveals that some species of arbuscular mycorrhizal fungi present in natural ecosystems are kept under organic farming but severely depressed under conventional agriculture, including potentially problematic loss of ecosystem function in this type of agriculture, which fungi have a key role in nutrient acquisition and soil fertility [14].

In addition to the positive effect on the environment, numerous studies emphasize other environmental benefits of organic farming, such as the effects on the dynamics of pollinators [15], on the floristic composition of the landscape [16], as on soil microbial diversity [17], [18].

By comparing the performance of organic and conventional farming practices, it has been shown that organic generally, for a wide range of parameters, is better or much better for a wide range of parameters [12].

There is increasing evidence that organic production is rapidly expanding in the economic sector. Contrary to expectations, certified organic farmers do not make a significantly larger profit than conventional farmers. Although organic producers get higher profits. In particular, certified organic producers spend significantly more on labour, insurance and marketing charges than conventional farmers [19].

In terms of life cycle assessment of strawberry production, there are very few case studies comparing and analysing their impacts on the world in general and especially in Europe. In comparative terms of organic strawberry production with conventional strawberry, due to its scarcity it worth mentioning the study [20], where it was estimated the environmental impacts of a cradle-to-gate life cycle assessment for conventional and organic strawberry cultivation in a province in Iran, revealing that the impacts of the two scenarios used in all impact categories, impact environmental conditions of the conventional cultivation method were higher compared to the organic method, with 611.09 and 320.2 kg CO2 eq per ton strawberry, respectively.

4. Production and marketing of strawberries and good practices

4.1. Main activities and balance

Organic food is the one that has the best control over pesticides, since, in addition to being analyzed by official organisms in conjunction with other foods, they have analyzes carried out for certification purposes. This is also the main type of analysis carried out for this purpose.

Biodiversity also contributes to a more efficient and more sustainable agriculture, in particular, Environmental area. It provides ecological services such as phytosanitary protection against pests or improvement of soil fertility, allowing to save energy in the

production of factors of production and labour in the application of these factors.

Mitigation of climate change, improved efficiency in the use of natural resources, in particular water and nutrients, and better ecosystem services justify the greater sustainability of organic farming based on the following strategies [21]: diversification (multiactivity, multipurpose and multifunctionality), differentiation (certification, breeds and native cultivars, traditions), verticalization (transformation and distribution), multifunctionality (services, commerce) and efficiency (professional management, knowledge, technology).

Industrial farming systems are finally at risk of collapse for the worst reasons. Scarcity of resources, high fuel values and environmental impacts require a change in strategy with the vital use of animals in an efficient role of recycling of alternative resources, making it essential to consider the balance between products entering the farm and the products obtained in the global system, without neglecting the environmental and social implications of the model adopted [22].

4.2. Good sustainability practices

The strawberry is a plant adapted to a wide variety of climates. However, most production regions are in temperate and Mediterranean climates. The vegetative organs of the strawberry are very sensitive, being destroyed temperature below 0ºC. The plant is very sensitive to waterlogging and salinity (soil and water)[23].

The management of soil fertility, choice of species and varieties, multi-annual crop rotation, recycling of organic material and cultivation techniques are essential elements of the organic crop production management system. Fertilizers, soil improvers and plant protection products should only be used if they are compatible with the objectives and principles of organic production. For the purposes of organic farming, the use of certain plant protection products, fertilizers, soil improvers and the certain non-organic material is permitted under well-defined conditions.

In the particular case of organic farming, where fast-acting nitrogenous and phosphate fertilizers are not used, organic fertilizers (vegetable or animal) and slower-acting minerals (natural phosphate, potassium and magnesium sulphate, limestone), it is necessary to create conditions for the plant to feed well without the application of soluble fertilizers from conventional agriculture. This is only possible with the improvement of soil fertility, and with a great biological activity of it - a living soil that will feed the plant.

There are several strawberry production technologies. Their choice will depend essentially on the requirements of the market destination, varieties and soil and climatic conditions prevailing at the place of production.

Crop rotation as great importance in organic farming, and has been losing it in "conventional" agriculture because of the popularization of synthetic fertilizers and pesticides. Rotation is an effective means of substantially reducing the occurrence of weeds, pests and diseases, as well as increasing soil fertility. It is also a way to reduce soil impoverishment since the different layers of soil are explored in depth, by roots with different characteristics.

In strawberry cultivation in successive years in the same plot increases the degree of soil infestation, jeopardizing the economic yield of the crop.

Ground cover with plastic material has become a common practice because of its advantages. About the soil, it increases its temperature and keeps its physical structure and humidity constant. In turn, the plant benefits from better rooting conditions, contributing to a higher precocity of production. Other advantages are the reduction of soil water loss by evaporation, which results in water savings and effectiveness in weed control, as opaque films are usually used.

The density of planting depends on the varieties. In the varieties with the greatest vegetative vigour, a greater distance between plants, usually of 0,30 m x 0,30 m,

is chosen, which corresponds to a density of 50 000 plants per hectare [23].

The raw materials authorized in organic farming as fertilizers are those which comply with existing Community legislation - Regulation (EC) No 889/2008. Annexe I to this Regulation includes a positive list of raw materials that may be used directly as fertilizers or the manufacture of organic or mineral fertilizers and correctives.

The moisture content of the soil must be maintained within the limits where the water is easily available to the plants, avoiding situations of water stress or waterlogging. The strawberry is very sensitive to the waterlogging conditions.

The adventitious flora, present in the strawberry fields, uses the water and the nutrients available, damaging strongly the development of the strawberries. In addition, weeds can serve as alternating hosts of various phytopathogenic organisms, namely fungi, nematodes and viruses, and contribute to the increase of entomofauna and acarofauna present in plantations.

Organic farming seeks to increase natural limitation, in particular by favouring the auxiliary organisms and by implementing various cultural measures - rotations and combinations, composting, balanced fertilization without excess nitrogen and resistant varieties, solarization and biofumigation, and non-chemical protection barriers.

Priority measures include the following non-chemical protection measures: biological control; Microbiological fight; Biotechnology fight.

Prophylactic priority measures may also be considered, the application of products that favour the resistance of the plant to the disease. They are so-called resistance inducers, not marketed with pesticides for agricultural use, but as fertilizers.

Only in case of immediate danger to the crop and where the priority measures referred to above are not sufficient, authorized agricultural pesticides apply [5].

Being in the organic agriculture of strawberry, techniques/practices as Organisms of the biological fight, consonants, packings, hedges, pheromones, pollination.

Strawberry production is sensitive and delicate due to its fragility and demanding maintenance; by the system in conventional ways, these challenges are solved with resources to enormous amounts of fertilizers, pesticides, insecticides, fungicides and processes, restricted in organic production been necessary to adopt different techniques, processes and products.

In order to produce significant quantities similar to conventional methods, and superior quality without using methods not allowed. The practices for organic strawberry production are altered, leading to an increase in workload and requiring a better knowledge and rigour in the techniques used. The soil and the environment of production are complex, where the organic materials and organisms that inhabit it are in a constant interception. The understanding of these interactions and techniques are the basis of organic farming and only with their knowledge enables the analysis and understanding of the factors that determine the strawberry production and analyse their sustainability and impacts in the various aspects (Economic, Environmental and Social).

5. Case study analysis

5.1. Production and data

The main objective of this analysis was to demonstrate the technical, economic and ecological viability of the strawberry crop according to the organic production method.

The strawberry production under study was cultivated according to European regulation. Having been the data obtained from an agricultural holding in the Municipality of Alpiarça.

The strawberry cultivar was "Omarosa". The soil preparation, background fertilization, irrigation application and soil cover were carried out, with the necessary

phytosanitary treatments applied. Obtaining a corresponding yield of 2.78 kg / m2.

5.2. Environmental assessment

In order to compare the environmental impact of a strawberry production in organic versus conventional production. A cradle-to-gate-farm lifecycle assessment was performed. The functional unit of 1kg of strawberry produced. Using Simpro software and Ecoinvent database.

Considering the durability of a strawberry production three years, the field preparation and planting were amortized over this period in terms of the estimation of emissions.

In the calculation of the impacts, the IMPACT 2002+ method was used because it was the combination of IMPACT 2002, Eco-Indicator 99, CML and IPCC,[24].

Having analysed 15 impact categories carcinogens, non-carcinogens, respiratory inorganic, ionizing radiation, ozone layer depletion, respiratory organics, aquatic ecotoxicity, terrestrial ecotoxicity, terrestrial acid/nutri, land occupation, aquatic acidification, aquatic eutrophic, global warming, non-renewable energy and mineral extraction. Obtaining the results described in table 2.

In terms of ecosystem services, unlike conventional agriculture, the organic production plays a huge role in its preservation and development, positive impacts that are not considered in the life cycle assessment.

Table 2 - Indicators of Life Cycle Impacts per kg of Product.

Impact Category	Unit	Strawberry Organic production	Strawberry Conventional production
carcinogens	kg C2H3Cl eq	0,0036	0,0139
non-carcinogens	kg C2H3Cl eq	0,0038	0,0068
respiratory inorganic	kg PM2.5 eq	0,0001	0,0005
ionizing radiation	Bq C-14 eq	1,8575	2,4869
ozone layer depletion	kg CFC-11 eq	0,0000	0,0000
respiratory organics	kg C2H4 eq	0,0001	0,0002
aquatic ecotoxicity	kg TEG water	16,2959	16,5419
terrestrial ecotoxicity	kg TEG soil	8,7690	3,6567
terrestrial acid/nutri	kg SO2 eq	0,0022	0,0142
land occupation	m2org.arable	0,0170	0,2574
aquatic acidification	kg SO2 eq	0,0006	0,0026
aquatic eutrophic	kg PO4 P-lim	0,0000	0,0002
global warming	kg CO2 eq	0,1145	0,3276
non-renewable energy	MJ primary	1,9728	5,4014
mineral extraction	MJ surplus	0,0078	0,0448

Having a positive effect on the number of species It incorporates in the soil more OM beyond crop residues and improves soil biological conditions for carbon preservation compared to the soil in the conventional mode of production. E enhances pollinating agents.

Using the same parameters but different impact methods “ILCD”, ReCiPe Midpoint and Endpoint (H), the overall results were similar, with special note for terrestrial

ecotoxicity not been a significant impact in any other method and special contribution in water consumption having bigger impacts in all methods and land use in some methods, with ionizing radiation having a small difference to conventional systems in all methods.

5.3. Economic analysis

The analysis of production costs allows:

Using production costs as an instrument for quantifying costs due to the needs of the organic production method. That is, by analyzing the quantity consumed of the various factors of production as the indication of the standard times.

The biggest cost is due to the labour force that this mode of production absorbs practically all its operations. It is the fight against weeds (since it does not proceed to chemical weeding) and essentially the harvest that absorbs more hours. The following are the raw materials since the needs of organic matter raise the costs of fertilization. However, the costs of phytosanitary treatments are lower than those used in conventional agriculture, as can be observed by crop accounts (study conducted by DRAALG).

Also, analyse the profitability of strawberry culture. In the case study, strawberry presents not only high and positive gross margins but also provides a high economic return on the holding (Table 17).

It is important to highlight that the results obtained were extrapolated to the area of one hectare from the areas presented in the field characterization, and as such the values do not represent reality, even as, as described in the crop accounts, the costs of production, do not include the costs of the structures, the depreciation of the machine park and the irrigation system, the packaging of the product (such as packaging), general expenses, the employer's remuneration and other costs.

Table 3 – Gross yields and production costs per hectare of the strawberry crop produced in Organic / Conventional Farming.

	product	Quantity (kg/ha)	Price (Euros/kg)	Grosse yields (Euros/ha)	Production costs (Euros/ha)
Organic farming	strawberry	27 778	2,5	69 445	23 749
Conventional Farming		30 000	1,1	33 000	32 577

5.4. Social analysis

In social terms, it is revealed that the moral and social concerns of farmers in adopting the method of production, despite economic concerns have a strong role. Although the production of an organic product was also seen as a form of the financial viability of the agricultural option, including in a niche market, which in the case of study at the time of conversion was rather restricted, while remaining a niche market with little competition.

Concerning the workers and the owner, a great satisfaction is felt, considering a contribution to society in preserving the environment and offering a product without chemical waste. Obtaining a social recognition by the consumer that values the product that not only preserves the environment but also contributes positively to the health of consumers and workers.

6. Discussion of results

6.1. Organic Farming vs Conventional Farming

The economic analysis reveals that in comparative terms with conventional

productions, it is financially feasible, including positive to produce organic strawberry. Despite lower incomes and higher labour costs, it has a higher market value and requires fewer inputs, primarily in phytosanitary treatments.

In environmental terms, through the values obtained in Table 1 by the Life Cycle Assessment with the IMPACT 2002+, conventional production reveals three times more impacts than biological production (respectively, 149 µPt and 48.2 µPt). Being less harmful to human health, ecosystem quality, climate change and resource.

Considering that in the 14 impact categories only terrestrial ecotoxicity obtained an estimated value higher than the conventional production.

6.2. Production of strawberry outside usual season

The production outside the usual season need to have a greenhouse to protect from climatic conditions. So is needed to have greenhouse materials and energy supply.

When carrying out a comparative life cycle evaluation between organic production in greenhouse and open field, it was verified that strawberry organic production in greenhouse, has an impact higher than 50% compared to the production in the open field, and with 0.201 kg CO2 eq. / kg (57% of the open field value of 0.115 kg CO2 eq. / kg).

6.3. Approach and limitations

In terms of approach, it was considered that the difference in modes of production is only significant during the production phase, and distribution channels and other fields do not have significant differences between methods of production.

Several adjustments and assumptions were necessary to achieve the estimation by simplifying some processes. Being suggested for future studies, starting from this basis, considering that studies in this type of biological production are almost non-existent, and perform a more realistic and complex LCA.

As well as economic analysis of all the costs unrelated to the biological production, with machine park, amortizations and costs associated to the certification.

7. Conclusions

With this study, it was possible to conclude that the production of organic strawberry in social, environmental and economic terms is positive if developed at the usual season. If it is produced outside of season this balance can be changed, which challenges new production methods in this situation and the consumer to favour the consumption of organic strawberries during their usual production season.

References

[1] D. European Commission (2016)., Facts and figures on organic agriculture in the European Union, no. 10, pp. 1–44

[2] Willer, Helga and Julia Lernoud (Eds.) (2018): The World of Organic Agriculture. Statistics and Emerging Trends 2018. Research Institute of Organic Agriculture (FiBL), Frick, and IFOAM – Organics International, Bonn.

[3] Hannum, S. M. and Hannum, S. M. (2010). Potential Impact of Strawberries on Human Health: A Review of the Science Potential Impact of Strawberries on Human Health : A Review," vol. 8398,?

[4] EWG's (2017). Shopper's Guide to Pesticides in Produce," [Online]. Available: https: "Press | //www.ewg.org/foodnews/press.php #.We8k1WhSw2w. [Accessed: 24-Oct-2017].

[5] J. Ferreira *(coord)*, (2012). As Bases da Agricultura Biológica. Edibio Edições

[6] C. Badgley *et al.* (2007). Organic agriculture and the global food supply, *Renew. Agric. Food Syst.*, vol. 22, no. 02, pp. 86–108.

[7] Connor, D. J. (2008) "Organic agriculture cannot feed the world," *F. Crop. Res.*, vol. 106, no. 2, pp. 187–190.

[8] H. Blanco-Canqui, C. A. Francis, and T. D. Galusha, “Does organic farming accumulate carbon in deeper soil profiles in the long term?,” *Geoderma*, vol. 288, pp. 213–221, 2017.

[9] M. K. Magnusson, A. Arvola, U. K. K. Hursti, L. Åberg, and P. O. Sjödén, “Choice of organic foods is related to perceived consequences for human health and to environmentally friendly behaviour,” *Appetite*, vol. 40, no. 2, pp. 109–117, 2003.

[10] V. Seufert, N. Ramankutty, and T. Mayerhofer, “What is this thing called organic? “ How organic farming is codified in regulations,” 2017. Food Policy

[11] N. Mzoughi, “Farmers adoption of integrated crop protection and organic farming: Do moral and social concerns matter?,” *Ecol. Econ.*, vol. 70, no. 8, pp. 1536–1545, 2011.

[12] T. Gomiero, D. Pimentel, and M. G. Paoletti, “Environmental impact of different agricultural management practices: Conventional vs. Organic agriculture,” *CRC. Crit. Rev. Plant Sci.*, vol. 30, no. 1–2, pp. 95–124, 2011.

[13] E. Larsen, J. Grossman, J. Edgell, G. Hoyt, D. Osmond, and S. Hu, “Soil biological properties, soil losses and corn yield in long-term organic and conventional farming systems,” *Soil Tillage Res.*, vol. 139, pp. 37–45, 2014.

[14] F. O. Ewald, S. Paul, M. David, D. Kurt, I. Thomas, and B. A. Wiemken, “Impact of long-term conventional and organic farming on the diversity of arbuscular mycorrhizal fungi,” *Oecologia*, vol. 138, pp. 574–583, 2004.

[15] G. Andersson, f M. Rundlo, and H. Smith, “Organic Farming Improves Pollination Success in Strawberries,” 2012.

[16] T. Aavik and J. Liira, “Quantifying the effect of organic farming, field boundary type and landscape structure on the vegetation of field boundaries,” *Agric. Ecosyst. Environ.*, vol. 135, no. 3, pp. 178–186, 2010.

[17] R. Li, E. Khafipour, D. O. Krause, M. H. Entz, T. R. de Kievit, and W. G. D. Fernando, “Pyrosequencing Reveals the Influence of Organic and Conventional Farming Systems on Bacterial Communities,” *PLoS One*, vol. 7, no. 12, 2012.

[18] P. Mäder, A. Fließbach, D. Dubois, L. Gunst, P. Fried, and U. Niggli, “Soil fertility and biodiversity in organic farming,” *Science (80-.).*, vol. 296, no. 5573, pp. 1694–1697, 2002.

[19] H. Uematsu and A. K. Mishra, “Organic farmers or conventional farmers: Where’s the money?,” *Ecol. Econ.*, vol. 78, pp. 55–62, 2012.

[20] S. Mafakheri, H. Veisi, and A. Mahdavi, “Environmental Impact Assessment of Strawberry Production in Two Conventional and Organic Production Systems (Case Study : Kurdistan Province) Environmental Impact Assessment of Strawberry Production in Two Conventional and 0rganic Production Systems ,” no. January, 2017.

[21] A. . Sendim, “Comercialização de Produtos diferenciados na perspetiva do produtor,” in *Reunião da Sociedade Portuguesa de Ovinotecnica e Caprinotecnica*, 2011.

[22] S. Silva, “Utilização dos recursos locais para uma pecuária sustentável,” *O segredo da Terra 32*, 2011.

[23] M. da G. Palha, “Manual do Morangueiro.” pp. 3–6, 2005. Projecto PO AGRO DE&D nº193

[24] M. Owsianiak, A. Laurent, A. Bjørn, and M. Z. Hauschild, “IMPACT 2002+, ReCiPe 2008 and ILCD’s recommended practice for characterization modelling in life cycle impact assessment: A case study-based comparison,” *Int. J. Life Cycle Assess.*, vol. 19, no. 5, pp. 1007–1021, 2014.