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Identifying Themes and Patterns on Management of Horticultural Innovations with an Automated Text Analysis

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Abstract: This research provides an overview on horticulture innovations in the last decade through a literature review and the use of a computer qualitative data analysis. We used Leximancer text mining software to identify concepts, themes and pathways linked with horticulture innovations. The software tool enabled us to "zoom out" to gain a broad perspective of the pooled data, and it indicated which studies clustered around the dominant topic. It displays the extracted information in a visual form, to wit, an interactive concept map, which summaries the interconnected themes and demonstrates any interdependencies. The text mining analysis revealed that the themes strongly related to "innovation" are "water", "urban", "system", "countries" and "technology". The outputs identified have been interpreted to discover meaning from the content analysis, since the software can facilitate a comprehensive and transparent data coding but cannot replace researcher's interpretive work. Furthermore, we focused on the diffusion and the barriers for the spread of innovation, pointing out the differences about developing and advanced countries. This analysis allows the researcher to have a holistic understanding of the examination area and could lead to further studies.

Keywords: innovations; management; horticulture; content analysis; data mining

Citation: Spina, D.; Vindigni, G.; Pecorino, B.; Pappalardo, G.; D'Amico, M.; Chinnici, G. Identifying Themes and Patterns on Management of Horticultural Innovations with an Automated Text Analysis. *Agronomy* **2021**, *11*, 1103. https://doi.org/10.3390/agronomy11061103

Academic Editor: Marco Acutis

Received: 11 March 2021
Accepted: 27 May 2021
Published: 28 May 2021

1. Introduction

The food and the agriculture sectors are expected to provide healthy and safe nutrition for a growing population without exerting further pressure on the planet's natural resources [1]. This scenario heightens the critical role of innovation to make agriculture more competitive and sustainable. Although agricultural practices are nowadays the most harmful for the environment, it is increasingly recognized that agriculture can make a huge contribution to mitigate climate change, to reduce greenhouse gas emissions and to preserve the world's limited resources, such as water, land and loss of soil. To meet these challenges and respond to opportunities, the sector will need to embrace innovative approaches to improve productivity in a sustainable manner.

Innovation has more than one definition. It means different things to different people. In this work, we adopt a broad view of innovation, according to the understanding that it is a complex process that emerges from a nonlinear, social, institutional, as well as a technical process. Innovation is usually perceived as related to technology, but it is broader than that and its meaning goes far beyond the result of the research activity, especially in those countries farther away from the technological frontier. Agricultural innovation is the process whereby individuals or organizations bring new or existing products, processes, or ways of organization into use for the first time in a specific context, to increase effectiveness, competitiveness and resilience with the goal of solving a problem [2]. In general terms, it is a process by which something new is implemented in a given context; it is socially appropriate and provides benefits for the parties involved. It arises in a particular socioeconomic context and it is shaped by the presence (or absence) of favorable conditions in which it can thrive [3].

Horticulture, alongside many other agricultural sectors, has been facing increasing pressure due to the need to embrace sustainability and, at the same time, to reduce risks and costs and strengthen the resilience of the entire value chain. Nowadays, horticulture covers globally about 60 million hectares, resulting in an output of fresh products of 1130 million tons [4]. Cultivation techniques (fertilizer, irrigation, defense) require constant updating to meet environmental and economic sustainability. Farm innovation is now deemed as a crucial factor to address these technological, environmental and social changes [5]. In this context, the managerial and the entrepreneurial role of producers in horticulture has gained importance [6]. Innovation plays a significant role in productivity growth, with very different development rates in advanced and developing countries. In the latter, best practices focus on improving cold store storage, transport infrastructure and market access, which are necessary to reduce the number of agricultural products wasted after harvest. Post-harvest management represents a serious problem afflicting small farmers. In sub-Saharan Africa, about 40% of products fail to reach the market due to a poor transport network and lack of storage facilities [2]. Reducing agricultural losses on the farm and food lost throughout the agricultural value chain avoids wasted resources and unnecessary greenhouse gas emissions.

In developed countries, the use of new technologies in agriculture remains a strategic aspect for the competitiveness of the sector [7]. In these countries, the goals are: to make agriculture smarter, more sustainable and digital. However, the pace of the technology transfer from scientific research to agriculture is still slower than in other sectors. According to Sutherland et al. [8], the potential for innovation in agriculture has been weakened by the disconnection between scientific research and small farmers. This innovation process can be achieved through a cooperative approach, to wit, thanks to the interaction between farmers and other actors. The experiences mentioned in our body literature indicate that the ability to innovate is often related to collective actions and to the exchanges of knowledge among stakeholders.

In this study, a literature review and an automated content analysis have been carried out to identify the main innovations in horticulture over the last ten years. We present the advantage of text analytics as a method for contributing to qualitative data synthesis, which is labor intensive and requires novel approaches [9]. The academic community has long been engaged with analysis of text [10]. However, in the context of increasingly digitized information, a large amount of data and a complexity of perspectives, the automatic synthesis of literature is nowadays considered a crucial step in research. This approach has several advantages, since it is quick, easy to use and time saving. We used Leximancer text mining software to identify related concepts and themes and pathways linked with innovations in horticulture, including themes that might otherwise have been missed or overlooked through manual data analysis processes. This methodology has allowed us to cluster horticultural innovations around themes connected to the topic by the co-occurrence of the words in the text and to order hierarchically which aspects have been most investigated in the related literature. Themes identified have been interpreted to discover meaning from the textual analysis, since the software can facilitate comprehensive and transparent data coding but cannot replace researcher-led interpretive work. The output of Leximancer is a concept map that displays the most important concepts that occur within the text and their relationships. The concept map has the advantage to enable a quick reading of our literature. It lets us see what the dominant themes are without imposing our own interpretations on the data. The text mining analysis revealed that the themes strongly associated with "innovation" are "water", "urban", "system", "countries" and "technology". The proximity of two concepts has indicated how often they appear in similar conceptual contexts. In our work, this methodology has allowed us to cluster the innovations.

2. Materials and Methods

2.1. Selection of Horticultural Innovation-Based Literature

To investigate the innovations in the horticultural sector we conducted a content analysis of the peer review of journal articles from Scopus and Web of Science databases, published over a ten-year period, from 2010 to 2020. The selection criteria have been identified assuming a replicable, scientific and transparent procedure [11–15]. We adopted the Preferred Reporting Items for Systematic reviews and Meta-Analyses (PRISMA), as described in the Flow Chart diagram (Figure 1). To provide an overview of the current study, we first searched articles on indexed databases Scopus and Web of Science with the following keywords: "Innovations", "Management", and "Horticulture". This approach has been adopted to secure a much broader vision of the subject instead of restricting the field of research to a particular aspect related to innovation (e.g., technology). A total of 123 studies have been identified following the initial search and were subsequently screened. Our criteria of exclusion were: duplicates, not academic articles such as editorials, commentaries, conference papers, book chapters or research summaries (e.g., government reports), text not in English language and text not accessible. Of the remaining 38 studies retrieved, 6 were excluded after the full-text review because the outcomes did not comply with the objectives of the current study. Finally, 32 articles met the inclusion criteria in the review and were included in the final study (Table S1).

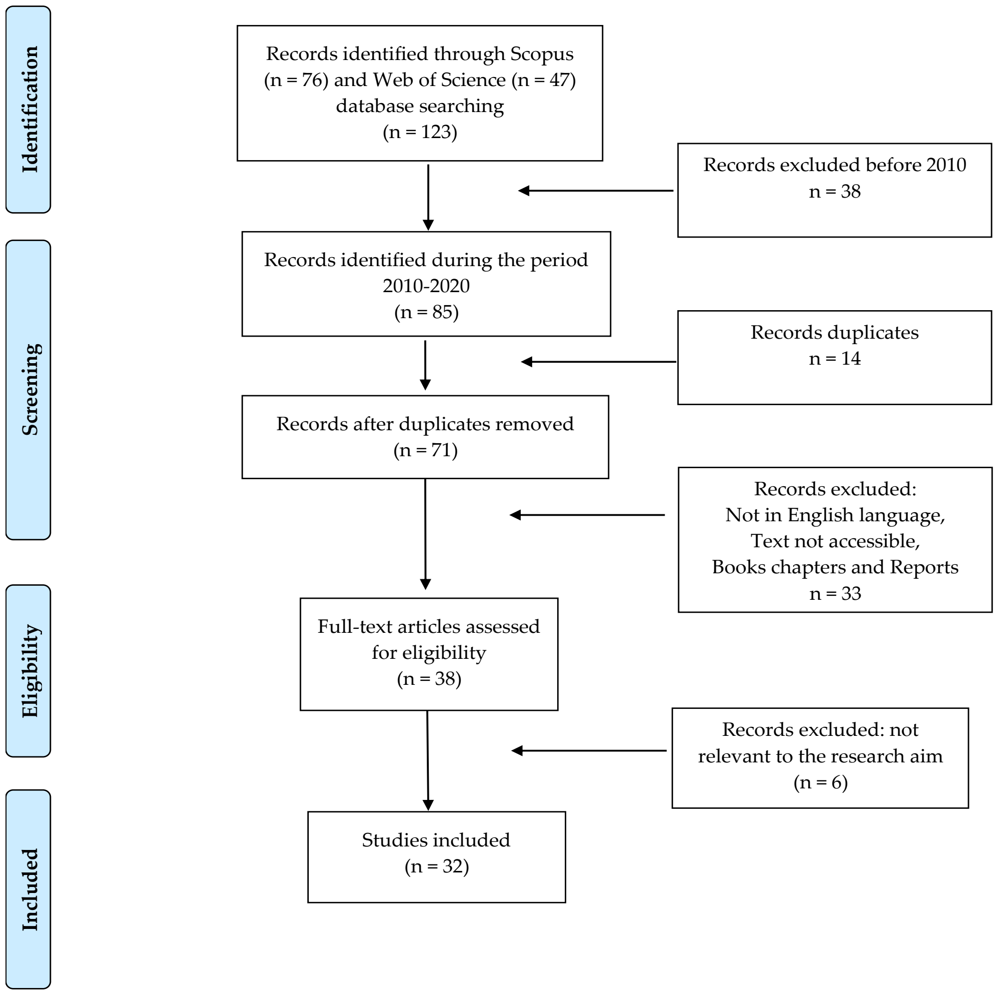

Figure 1. Flow chart diagram visualizing the database literature searching procedure. The exclusion criteria are indicated. (Source: our elaboration).

2.2. Descriptive Analysis

The number of studies on the topic published every year in the last decade is illustrated in Figure 2. It shows how the increasing interest of the academic community in the topic is relevant from 2019 to 2020, while from 2010 to 2012, any articles were published in the two electronic databases.

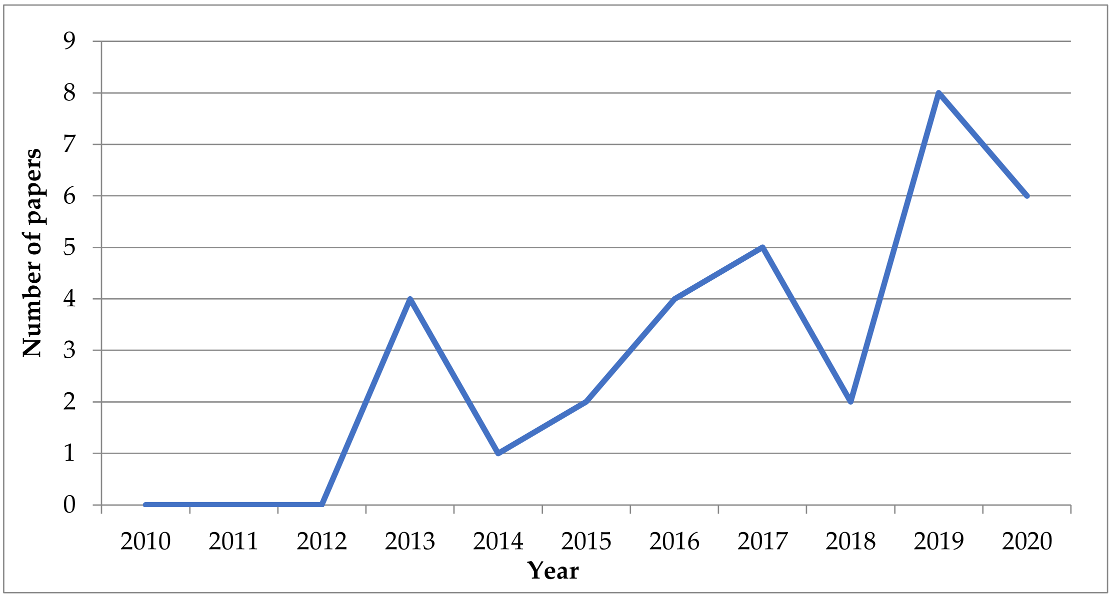

Figure 2. Number of publications per year (2010–2020). (Source: our elaboration).

The papers were also analyzed to find out in which journals they had been published over the years (Figure 3).

Journal											
Agricultural and Food Sciences										1	
Agricultural Economics							1				
Agricultural Systems						1		1		1	1
Agriculture											1
AgroLife Scientific Journal											1
Agronomy for Sustainable Development				1			1	1			
Crop Protection								1			
European Journal of Agronomy											1
India Journal of Agricultural Sciences										1	
International Journal of Agricultural Sustainability				1	1						
International Journal of Innovation in Science and Mathematics Education										1	
International Journal of Mechanical and Mechatronics Engineering				1							
Journal of Cleaner Production									1	1	
Journal of Horticultural Sciences										1	
Journal of Innovation and Entrepreneurship							1				
Land Use Policy								1			
NJAS - Wageningen Journal of Sciences								1			
PLoS ONE											1
Science of The Total Environment										1	1
Scientia Horticulturae						1					
Sensors				1							
Sustainability										1	
Urban Forestry & Urban Greening							1				
Water									1		
Sub Total	**0**	**0**	**0**	**4**	**1**	**2**	**4**	**5**	**2**	**8**	**6**
Year	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020

Figure 3. Number of papers per journal and per year. (Source: our elaboration).

Figure 4 shows the subject areas of the journals in which the articles examined were published. It can be seen that the subject area under analysis covers different subject area category (Table S2). The analysis carried out shows that:

- 23 papers fall under the subject area "Agricultural and Biological Science" with 9 categories (Agronomy and Crop Science, Animal Science and Zoology, Aquatic Science, Ecology, Evolution, Behavior and Systematics, Food Science, Forestry, Horticulture, Plant Science, Soil Science);
- 10 papers fall under the subject area "Environmental Science" with 9 categories (Ecology, Environmental Chemistry, Environmental Engineering, Environmental Science (Miscellaneous), Management, Monitoring, Policy and Law, Nature and Landscape Conservation, Pollution, Waste Management and Disposal, Water Science and Technology);
- 6 papers are included within the subject area "Social Science" with 4 categories (Development, Education, Geography, Planning and Development, Sociology and Political Science);
- 4 papers fall into the subject area "Economics, Econometrics and Finance" with the category "Economics and Econometrics" and in "Engineering" with 3 categories (Electrical and Electronic Engineering, General Engineering, Industrial and Manufacturing Engineering);
- 3 papers are included within the subject area "Business, Management and Accounting" with 3 categories (Management Information Systems, Management of Technology and Innovation, and Strategy and Management) and in the subject area "Energy" with 2 categories (Energy Engineering and Power Technology, Renewable Energy, Sustainability and the Environment).

There are, as Figure 4 shows, journals with a reduced number of papers per subject area having specific analysis categories.

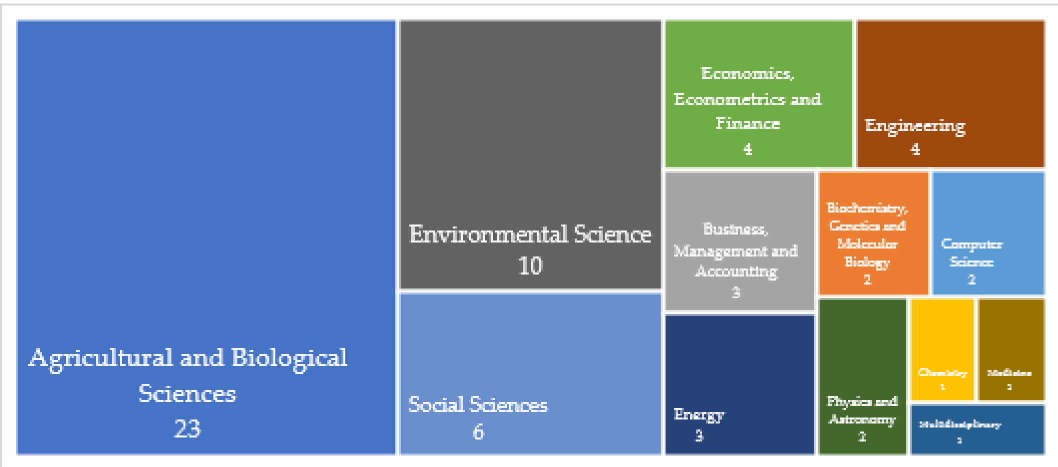

Figure 4. Number of papers per subject area of the journal. (Source: our elaboration).

The studies analyzed in this review were carried out worldwide (Figure 5). The majority of research was conducted in Australia (6 studies) and in European countries, specifically in Spain (6 studies). Developing countries are also well represented with case studies conducted in South America, East Asia, West and East Africa.

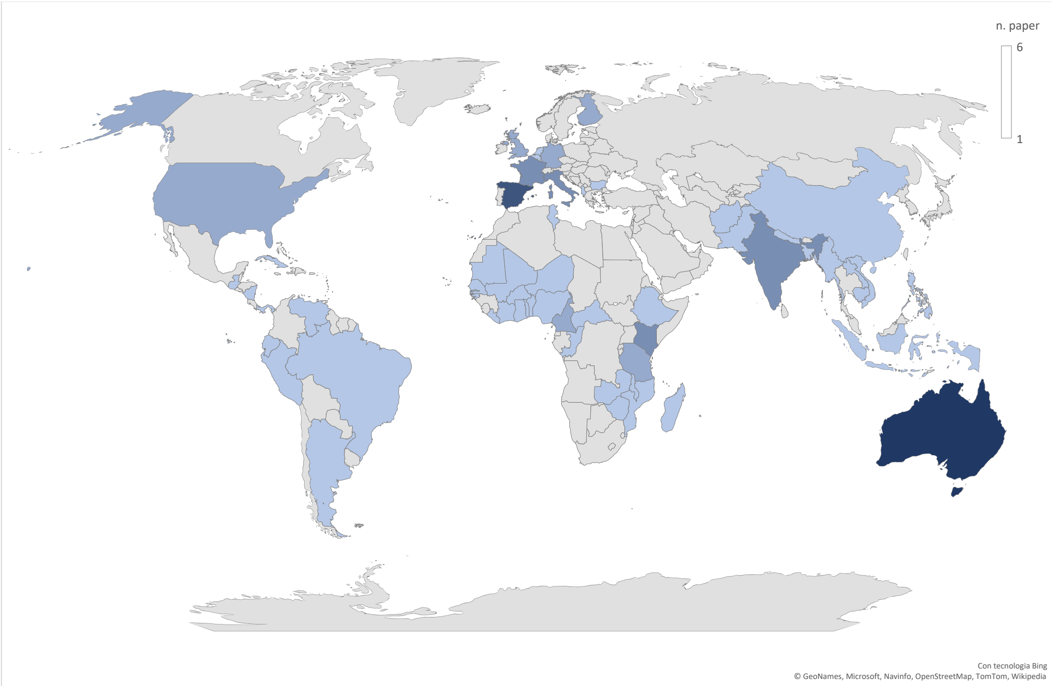

Figure 5. Countries where the selected studies were conducted. (Source: our elaboration).

2.3. Automated Content Analysis

The use of Computer-Assisted Qualitative Data Analysis Software (CAQDAS) has grown systematically to enhance the research and analysis processes [16]. The method used for text mining in this paper is based on machine learning approaches. Machine learning is an application of artificial intelligence (AI) that provides a system with the ability to automatically learn and improve from experience without being explicitly programmed. The process of learning starts with observations of a data set in order to identify patterns and make better decisions in the future based on the outputs. Using the classic algorithms of machine learning, text is considered as a sequence of keywords [17].

In textual analysis, words tend to correlate with other words over a certain range within the text stream [18]. An automated system for content analysis of documents is useful for several reasons [19]. One of its goal is a reduction in costs in terms of time and to facilitate the analysis of a large amount of document sets for the identification of concepts and themes in the data, without a priori assumptions or theoretical frameworks [20].

Leximancer [21] is a CAQDAS that can be adopted to "text mine" the content of substantial documents as a lexicographic tool that can visually display the selected information. In the software, the terms are words in the text that have been examined for frequency of co-occurrence with other words and synonyms from the thesaurus and are weighted or scored according to evidence that a concept is present in a sentence. Concepts are collections of words or "terms" that travel together within the text. They are parent terms that have been identified through semantic and relational word extraction that share similar meaning and/or space within the text. Themes are concept groups that are highly connected. Finally, the hierarchy of "importance" indicates concept connectedness. It weighs these terms according to how frequently they occur in sentences containing the concept [9]. These data are used to identify the most frequently used concepts within a body of text and the relationships between these concepts. During the learning process, words highly relevant to the seed are continuously updated and eventually form a thesaurus of terms for each concept. The advantage is that the software extracts a populated list from the text document that displays the weighted term classifications and connections between key words. From this list, it creates concept maps that illustrate the level of connections between key words in the text being analyzed [16,22]. The visual lexical map creates a "helicopter" view of data. Themes are summarized into circles and identified by the largest numbers of "dot" within the group; the larger the dot is, the more prominent the concept. Concepts that attract each other and are clustered together are grouped into themes, which are displayed as colored circles. The size of the circle is not relevant; instead, it is the color of the themes that demonstrates their prominence. Hot colors (such as red and orange) depict the most important themes, and cool colors (blue, green) denote those less important related to our selection of papers. An advantage is that the map is interactive and allows the research to further explore the concept and their connectivity, linking the software findings back to the site in the original text [23]. Themes and concepts that are meaningless can be removed to attach value and relevance to those useful for the analysis. Therefore, choices at each stage of the process are reversible so it is possible to refine the analysis and the presentation graphics in order to adequate it to the task of the research. In Figure 6, we illustrate the process of the automated content analysis, divided into three stages: identification concepts, definition concepts and classification concepts. When the process is complete, the final output is a concept map.

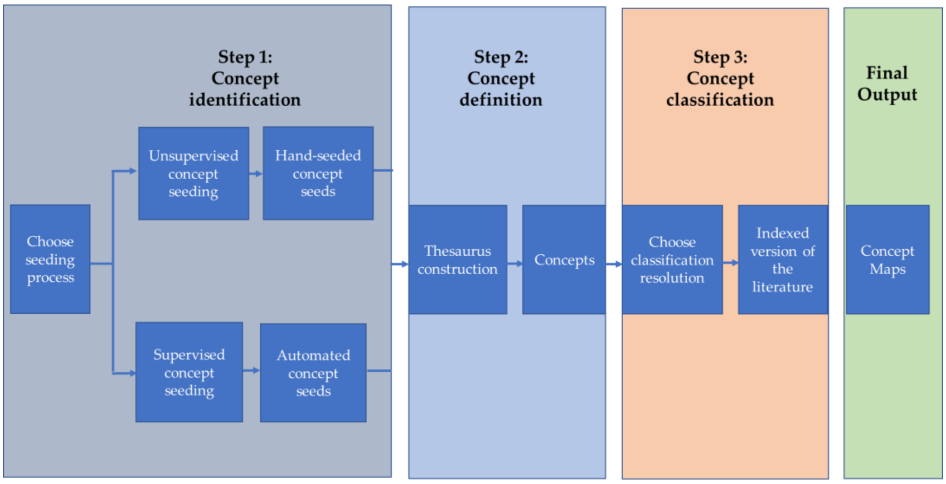

Figure 6. Workflow of the stages of the automated content analysis. (Source: our elaboration).

3. Results

The Leximancer analysis of all 32 papers included in our horticulture innovation literature has produced six main themes, as shown in the histogram bar (Figure 7), which ranks their relative importance.

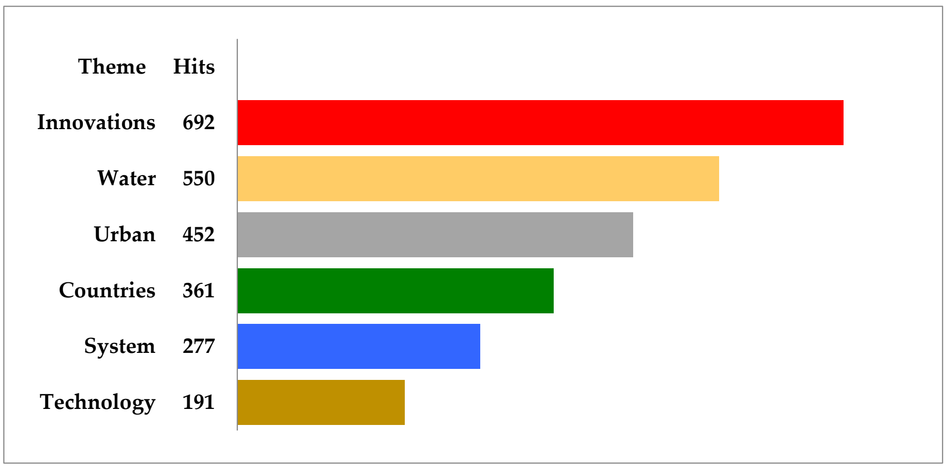

Figure 7. Themes identified by Leximancer.

After running the learning process and developing a list of concepts contained in the text, their relationship to each other is graphically displayed in a Concept Map (Figure 8). In the map, each cluster is related to other clusters, and the circles are overlapping, indicating a strong interaction between them. The software enabled us to "zoom out" to familiarize ourselves with and gain a broad perspective of the pooled data. It indicates which studies are clustered around the dominant topic [9].

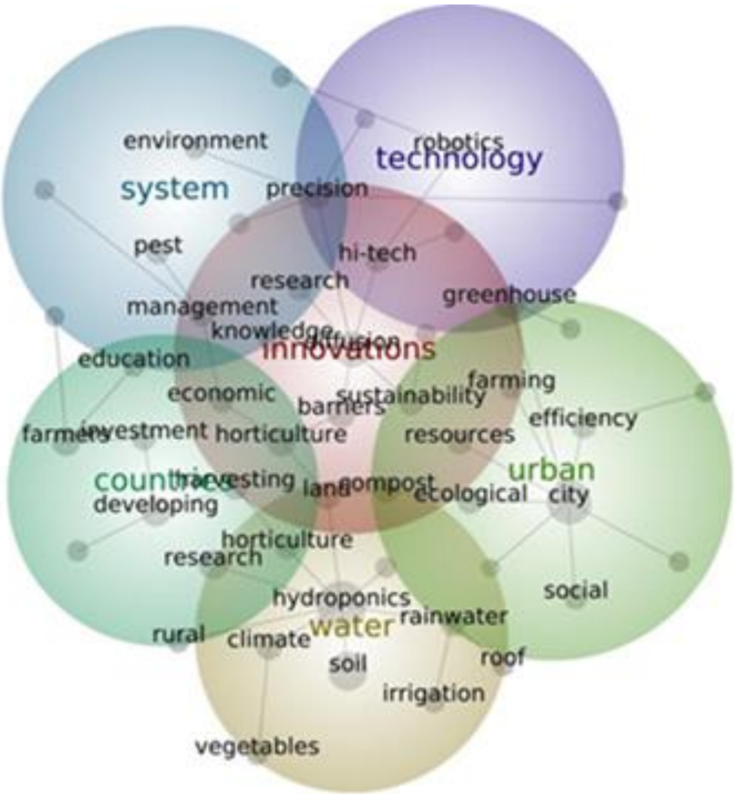

Figure 8. Leximancer concept map. The theme size is set to 52%.

3.1. 1st Theme: Innovations

The most important theme in the literature examined is "innovation" (darkest red circle). It consists of concepts including "knowledge", "diffusion", and "barriers", indicating that the focus of the literature is the adoption and constraints for the spread of innovation. Already in 1992, Jones [24] explored the concepts of innovation and diffusion of innovations, which entail the concepts of diffusion and dissemination of an innovative idea, product or practice in a social system within a defined geographical territory. The concept of the diffusion of innovation is variable depending on the territorial and social context. It is perceived at different scales, to wit, some welcome innovation more quickly than others. From a temporal standpoint, innovations can be characterized by having a phase of slow diffusion, a subsequent phase of rapid diffusion and a third phase of slow growth and even deceleration [25]. The scientific literature has found fertile ground in exploring the role played by stakeholders in the dissemination of innovation by increasing both the technology transfer and the innovative performance of organizations [26,27]. The concept "Knowledge" is not the same of information. Midgley [28] uses the term "knowledge" in a wide sense to mean any understanding, which includes perceptions, unconscious motivations and behavioral habits. The theme of innovation is linked to all the other circles through the co-occurrence concepts of "sustainability", "resources", "research", "management", "economic", "horticulture", "land", "compost", "greenhouse", and "hi-tech". According to Bal et al. [29], the more complex an innovation, the more difficult its transfer and adoption by farmers. The main reason for the rejection of an innovation is the farmer's perception of the risk involved in the change, that is the farmer's uncertainty about the potential advantages of the change and how much it will cost [30]. The adoption of a new technology or an innovative practice has been strongly debated by sociologists and economists in the agricultural domain [31]. Growers may be more averse to the risk associated with adopting new innovations when traditional inputs and traditional process are available [32]. In the process of innovation-decision, individuals move from a knowledge phase in which they notice an innovation for the first time, to a persuasion phase in which they form an attitude towards innovation, to the final decision to adopt or reject it [33]. In most innovations, farmers perceive innovation as the motivation to collect information, probably driven by their relatively stable values and general beliefs [33–36]. Psychological and sociological aspects provide important mechanisms for driving intention to change. Cost, lack of knowledge, lack of cooperation, apathy, awareness, and credibility are some of the factors that could influence the acceptation of an innovation [37]. For many farmers, asking them to adopt unfamiliar or alternative practices is a serious request, as they have likely spent years developing a set of systems and routines that work best for their business and their land. To shift away from these habitual behaviors sometimes requires a shift in attitudes and perceptions to convince individuals that a change is necessary and beneficial [38]. Even Buurma and Van der Velden [39] claimed that adoption of new knowledge into practice is still a challenge in agricultural research and innovation. The European Commission [40] framed the challenge as "closing the research and innovation divide". It observed that, despite the continued generation of knowledge through scientific projects, research results are often insufficiently exploited and taken up into practice. The Standing Committee on Agricultural Research [7] pointed out that "new knowledge is generated by farmers, researchers (basic and applied) and private companies". The old "linear" model of technology transfer (from scientists to the users) is therefore outdated and should be replaced by an interactive model of networking systems that integrates knowledge production, adaptation, advice and education [39].

3.2. 2nd Theme: Water

The second most prominent theme (golden circle) highlights the area of research of water management to contribute to the mitigation of negative issues related to climate change, with the concepts "hydroponics", "rainwater harvesting", and "irrigation". Water is fast becoming a scarce resource in many areas of the world [41], and its management is one of the most critical issues of the twenty-first century [42]. At present, agriculture is the largest user of water globally. The development of protected cultivation systems with innovative horticultural techniques arises in response to traditional cultivation systems that are highly demanding in water and other natural resources. Greenhouse systems and soilless culture system (SCS) can allow for obtaining high yields and improving water use efficiency, especially in marginal and arid regions [43]. Currently, about 3.5% of the worldwide area cultivated under tunnels and greenhouses for vegetable production adopts the soilless agriculture techniques based on hydroponic solution, such as floating systems, nutrient film technique or aeroponics [44]. Hydroponic cultivation is gaining attention worldwide thanks to very efficient resource management and to the high yield and quality of food production without forgetting the safety of vegetable produce as well [45]. This kind of system can be applied with the aim of cultivating in areas with scarce availability of arable land or even within big cities/metropolis [46], where vertical farms are spreading. They allow growers to obtain good production in small areas, also in multiple layers, with less inputs, such as water and nutrients. García-Caparrós et al. [47] strongly recommend the setting up of some water treatments in areas with water scarcity, such as in the Mediterranean Basin, whereby the blending of drainage with water of low electrical conductivity and the sequential reuse of the drainage water are innovative technologies to manage salts in agricultural drainage. In recent years, fertigation is one of the most widely adopted agro-techniques that provides a very good opportunity to minimize water and nutrient losses simultaneously [47]. In Israel, water use efficiency is increased by implementing automatic valves and computerized controllers, using micro-irrigation systems or vegetal indicators such as leaf water potential and fruit growth rate to achieve further precision and regularity in water and nutrient application [48]. Precision irrigation has been the subject of a great advance in research in the last decade both in open-field and in greenhouse conditions, and it is likely the most recognized and applicable practice/technology aimed to foster water saving through increasing the water use and irrigation efficiency [49–51]. Trentacoste et al. [52] has raised the question whether row orientation of hedgerows in horticultural could be a design strategy to achieve advantages in management, water use, production and quality. Deligios et al. [53] studied innovative water management systems based on precision irrigation techniques and on evaporative cooling application in order to improve crop physiological status with positive impacts on earliness, total heads yield and water saving. Amos et al. [54] has investigated the potential of using roof harvested rainwater to support urban agriculture, highlighting that there is a considerable potential to supply water to urban agriculture using tailored roof rainwater harvesting (RWH) system designs and that slums in Kenya already practice it. In his study, he reports that up to 41% of urban horticulture sites in Rome could be sustained by water harvested from local roofs. Irrigating a small garden (20 m^2) with harvested rainwater can increase the yield by about 20% meeting the caloric requirements of a typical Indian household; however, there is still a lack of initiatives to utilize it in urban agriculture. The concept "soil" within the theme water indicates that a number of papers investigate also the use of wasted food through composting. De Corato [55], in his work, has underlined that on-farm composting is a viable option thanks to benefits on soil quality and plant health which valorize underused biomass. Compost application has many benefits against plant pathogens and diseases due to innovative tailored formulates. It can be also employed as a bioremediation agent for recovering and cleaning marginal soils by heavy metals and organic pollutants contamination [56]. Sotamenau et al. [57] highlighted how in sub-Saharan Africa local composts are far less common and its adoption should be part of an agricultural waste recycling commodity chain involving farmers, waste collection services, municipalities, non-governmental organizations and researchers.

3.3. 3rd Theme: Urban

Theme 3 (biggest green circle) shows contributors of researcher on urban farming, highlighting that cities are facing pressing challenges in terms of sustainable development. The contemporary academic literature considers Urban Agriculture (UA) a possible underpinning to improve sustainable urban development [58,59]. The Food and Agriculture Organization estimates that more than 800 million people engage in urban agriculture producing more than 15% of the world's food [60]. The underlying idea that accompanies this interest is that urban agriculture can decrease greenhouse emissions, help solve food security for growing urban populations and provide chemical-free food with no risk of pests and diseases. UA activities range from educational projects (e.g., school gardens) and food security and community-directed projects (such as neighborhood gardens) to commercial farming ventures [61]. Research on UA recognized potential benefits in all three dimensions of sustainability [62]. On the social level, UA seems to be advantageous for the provision of education and for linking consumers to their food sources. With regard to the environmental dimension, UA creates benefits consequential to reduction in food miles and transport emissions as well as the saving and recycling of local resources [63]. In economic terms, UA can potentially strengthen local economies and small businesses and provide commodity outputs. In Australia, urban agriculture has many definitions but can be described simply as "agriculture within an urban or peri-urban setting" [64]. It may include trees, bees, vegetables, pulses, and may also be conducted in conjunction with animal production, especially chickens and sometimes fish [65]. In developing countries, urban agriculture plays a significant role in providing food security and, in many cases, also income [64,66]. Developed countries generally lack the desperate need for food, and income from small-scale agriculture is minimal, and so the motivation has been more ideological [66–68]. For these countries, it often represents a healthy lifestyle, purely therapeutic or a way to get involved for social interaction, or as part of an education program at school [54].

3.4. 4th Theme: Countries

Theme 4 (smaller green circle) demonstrates interest in literature on "developing countries". The most relevant concepts within the theme are "education", "investments" and "post-harvest losses". Improvements must be targeted throughout every part of the value chain: better harvesting and storage practices, advances in the cold chain and in the transportation infrastructures, reductions in waste at the processing and retail levels [69]. Decreasing loss and waste on a wide scale depends also on government investments in public goods, such as infrastructures. Pretty et al. [70] and Gilioli et al. [71] made the following recommendations to improve the innovation process and development efforts in Africa: creation of new social infrastructure that builds trust among individuals and agencies; improvement of farmer knowledge and capacity through the use of farmer field schools and modern information and communication technologies; engagement with the private sector for supply of goods and services; a focus on women's educational, microfinance and agricultural technology needs; ensuring the availability of microfinance and rural banking; ensuring public sector support for agriculture. It is worth noting that even in advanced countries, such as Australia, education and training in horticultural workforce have a lower proportion compared to the broader agricultural sector [72]. Therefore, building human resource capacity, business skills and leadership in production and processed horticulture is of fundamental importance to the ongoing success and growth of this sector. It is worth nothing that drivers and constraints to agricultural productivity are quite different across countries. In East Asia, crop yields have increased six-fold in the past few decades. In sub-Saharan Africa and parts of South Asia, it has only doubled [73]. Moreover, problems connected to climate change and the deteriorating natural resource base will impact more on the poor and vulnerable contexts.

Osano and Koine [74], in their study, investigated the role of foreign direct investment on technology transfer and economic growth in Kenya. Foreign firms in Kenya have played a major role in enhancing economic growth in the agriculture sector, especially in horticulture. Over a long period of time, foreign direct investment (FDI) has been found to create many externalities in the Kenyan economy in the form of benefits available through transfers of general knowledge, specific technologies in production and distribution, industrial upgrading, work experience for the labor force, the establishment of finance-related and trading networks, and the upgrading of telecommunications services. In countries such as Tanzania, horticulture is the fastest growing agricultural sub-sector with an annual average growth rate of 11% [75]. Some bottleneck still stems from the perishable nature of produce which results in a high level of post-harvest losses [76]. In this regard, the most common innovations are addressed to post-harvest management, through motor van equipped with cold storage facilities and improved packaging material. In India, to reduce PH losses and improve the supply chain management, important interventions are established for pre- and short-term storage facilities through evaporative cooling/refrigeration mechanism at the farm gate. Moreover, an integrated radio frequency identification (RFID) system, along with the sensor for ethylene, temperature and RH monitoring, is likely to help in easy tracking and traceability of the fresh produce [77]. In Tunisia, in addition to water-related problems, there is also a progressive salinization of soils, which is determining the application of soilless culture system. Interesting experiments have been made concerning the use of substrates deriving from "local wastes", such as palm trees compost, compost of oasis wastes and animal manure, or sand and coconut fiber for tomato production [78]. Radhouani et al. [79] performed a trial on muskmelon cultivated in soilless system, using sand and compost of dry palm compared to perlite, and the experiment led to good quality products, opening future scenarios more environmentally friendly. Soilless cultivation is practiced at a large scale in arid regions, but this technique is not only useful in the case of water scarcity, low-quality water or lack of fertile soils. Dupré et al. [80] investigated how farmers in La Reunion Island have reduced synthetic inputs by adopting alternative practices. The most frequently employed were mowing, weeding with tillage, spot application of herbicides, use of manure or compost, biopesticides and chemical traps. The rarest were insect-proof nets and sprinkler irrigation for the control of certain pests, as well as plastic mulching, restitution of crop residues, release of natural enemies and cover crops.

3.5. 5th Theme: System

Theme 5 shows the importance of the "system" from the point of view of social and institutional dimension in order to create an enabling environment for progress [81]. Local industries need a supportive institutional environment [82]. From our body of literature, it emerges that innovation can be achieved through interaction and cooperation between different actors, with a view to develop an agricultural system that must involve both result-oriented research and the dissemination of these results.

Juntti and Downward [83], referring to "Almerian miracle", underline that one of the strengths of the Spanish province was its "capillary system". The majority of producers belong to a co-operative that provides stable economic arrangements and ensures access to technological development and training by small farmers [84]. The proximity between growers, co-operatives and supply companies has been crucial to the emergence of a number of technological solutions that increase sustainability without compromising the productivity of the sector. In Tunisia, the growing demand for irrigation water has triggered the implementation of collective irrigation systems, promoting user participation, reformulating the water pricing system and stimulating the adoption of water saving technologies at farm level [85]. Lewin and Grabbe [86] sustained that the process of change modifies the value system of an individual. Usually the individual needs to refer to a group of individuals in order to establish a new value system. The group acts as a reducer of uncertainty. According to the World Bank [73], an innovation system is a "network of organisations, enterprises and individuals focused on bringing new products, new processes and new forms of organisation into use, together with the institutions that affect their behaviour and performance". The Agriculture Innovation System (AIS) belongs to a family of system approaches that have arisen in response to perceived inadequacies with the linear model of innovation that dominated until the late 1980s [73,87]. Whilst a linear view of innovation sees research as the primary driver of innovation [73], innovation systems frameworks perceive innovation as a process involving the co-evolution of technological and non-technological elements [88]. In the agricultural framework, new machinery, cultivars, agricultural inputs and practices are examples of technological change, whilst social and economic arrangements, such as new institutional environments and social norms, are examples of non-technological change [89]. These changes take place across multiple levels, from field to farm to region [90–92]. As such, innovation is as much about institutional change and social processes as the development of new technology [81,88,91,92]. Innovation relies on interaction between a group of heterogeneous actors, such as farmers, researchers, agronomists and advisors, processors, input suppliers and civil society [73,81,90,93]. Rathore et al. [94] discussed Integrated Farming System (IFS) in arid and semi-arid regions as a key of farming intensification necessary for achieving future food security and environmental sustainability. The author argues that promoting adoption of IFS in the future is linked directly with coherent policy, institutional commitment, infrastructure development, better coordination among different agricultural and rural development programs and agencies, and a stimulus package of incentives. Schut et al. [88], in their work, have showed that the potential of the system approach remains largely unexplored for crop protection innovation. Several publications focus on cropping or farming "systems", while "innovation" often equals the development, transfer, adoption and diffusion of crop protection technologies at farm level. They highlight that there is relatively little attention for the institutional and political dimensions of crop protection and the interactions between farm, regional and national levels in crop protection systems. A critical concept within the theme "system" is "pest", as several papers of our selection [37,39,94–96] discussed new approaches for pest management as Area Wide Management (AWM) that go beyond individual farms and involves coordinated activities implemented over an extended area. The Eu framework directive 128/2009/EC on the sustainable use of pesticides also emphasized that top-down initiative for integrated pest management (IPM) needed to be transformed into a bottom-up co-innovation process through which agricultural producers transform their pest management approaches [97], with the direct involvement of farmers at all stages of the innovation process to ensure relevance, applicability and adoption [98].

3.6. 6th Theme: Technology

This theme recognizes the relevance of "technology" in the field of innovation horticulture. High technology, digital, organizational and product-related innovations can increasingly favor the multifunctionality of agricultural and food systems. In some countries, agriculture reached a very high technological level. In Israel, the advanced greenhouse currently used includes curtains, skylights and shade netting which move automatically in reaction to sunlight. The structures are 5 m high at their lowest point in order to provide the best light and working space, while ventilation is provided by the installation of thermal coverings [99]. Gruda et al. [100] presented some adaptation strategies to meet the challenges of the impact of climate change on protected cultivation in terms of sufficient cooling and improvement of natural and additional light for winter production, technical and conceptual innovations as the semi-/closed greenhouse based on mechanical cooling and dehumidification and passively ventilated greenhouses and screenhouses. At the same time, the number or agricultural robots, agrobots, is increasing each year with new technology. Thanks to the use of cameras and image recognition algorithms, the robots that the researchers are developing will be able to identify weeds, insects or diseased plants and accurately treat the target. This means a lower consumption of products, which translates into lower costs for the farmer and a higher level of sustainability [101]. Agrobots are employed for harvesting or picking, planting, weeding, pest control, spraying, and cultivating; they use GPS and sensors for navigation [102]. They work completely under the control of a computer program and they often use sensors to gather data about their surroundings in order to navigate. Robots used to combat plant diseases that cause a lot of damage to crops, treat just the plants that are infected, instead of covering the entire crop with fungicide. They are also able to remove pests from the crops without using chemicals, sucking them up with a vacuum. In this way, they kill the insects without chemicals. Electronic nose technologies are also applied in agriculture, including horticulture sector. These aroma-detection applications have improved plant-based product attributes, quality, uniformity, and consistency in ways that have increased the efficiency and effectiveness of production and manufacturing processes [103].

4. Conclusions

Innovation plays a key role in increasing production, improving post-harvest handling, as well as reducing the environmental footprint to deliver greater value to consumers. It is not surprising that the issue of water resources has proved to be very intertwined with innovation. Agriculture is a hydrovorous sector, which consumes 70% of the planet's water resources (FAO, AQUASTAT). Water management is a strategic area to ensure sustainability and competitiveness. At the same time, the use of precision farming tools allows us to improve production, optimize the distribution of fertilizers and pesticides. In most advanced countries, technology is making excellent headway. Fertilizer, weeding and collection are already managed by artificial intelligence, through state-of-the-art robots. However, innovation is much more than the successful application of research results [104]. An important point of reflection we focused on was the problem associated with the dissemination of innovations and the importance of a system-wide approach. Innovation processes generally arise in response to different needs, whether from the market, technology, society or the environment; regardless of origin, they always require the presence of favorable conditions. For this reason, it is important to ensure an enabling environment. The awareness of growers, supply chain partners, research institutes and governments are fundamental for the future development of horticulture, especially in developing countries where the primary sector is the backbone of their economy. Researchers are encouraged to move beyond their traditional roles of knowledge producers or trainers and work more closely with actors involved in supporting innovation. Knowledge sharing is a key step in this direction as it may unleash the performances of the agriculture of the future. In addition, especially in poor countries, policy tools are critical to reducing restrictions on market participation, removing onerous regulations and to address R&D spending targeted to the needs of the farmers. It should also be highlighted that in these countries there is a lack of managerial knowledge that should be bridged alongside the adoption of new technologies [105].

In this paper, innovation in horticulture is addressed from various angles to capture the different dimensions that innovation entails. The research papers examined in this work address the topic from an organizational, economic, agronomic, technological and social point of view. This variety indicates that the horticultural sector is very dynamic and that the room for maneuver, in terms of new scientific research, is wide. The automated content analysis has provided an analytic tool to understand and to synthetize the state of the art of horticultural innovations. Results of our study highlight that the field of innovation in horticulture has a multidisciplinary nature and a higher complexity and suggest opportunity for further investigations, especially in socio-economic aspects of innovations.

Leximancer has proved to be a software with a lot of potential, characterized by the validity, reproducibly and reliability of the results [19]. It provides a holistic understanding of the issue analyzed as the concept map has the advantage to enable a quick reading of the literature. It lets us see what the dominant themes are, without imposing a priori our own interpretations on the data. Furthermore, this approach can be applied by researchers in preliminary studies to become familiar with a new domain and indicate where the attention is at the moment. It can be complementary with manual content analysis. The research process has required a deep understanding of the data and, therefore, it is more correct to view this approach as a tool to support human abilities rather than replacing researcher's work. Despite several advantages, this methodology presents some pitfalls. The quality of outputs depends on the quality of the dataset. Our case study was limited by the small pool of publications since it was restricted to English language papers and it has excluded grey literature.

Supplementary Materials: The following are available online at https://www.mdpi.com/article/10.3390/agronomy11061103/s1, Table S1. Overview of selected papers; Table S2. Overview of selected papers per subject area category.

Author Contributions: The work is a result of equal contribution and collaboration between the authors in each part of the paper. Conceptualization, M.D., G.C. and G.V.; methodology, D.S. and G.V.; software, D.S. and G.V.; validation, D.S., G.C. and G.P.; formal analysis, D.S., G.C., M.D. and G.V.; investigation, G.P. and B.P.; resources, G.P. and B.P.; data curation, G.C. and D.S.; writing—original draft preparation, G.C., D.S., M.D. and G.V.; writing—review and editing, G.P. and B.P.; visualization, G.C.; supervision, G.P.; project administration, M.D.; funding acquisition, G.C. and M.D. All authors have read and agreed to the published version of the manuscript.

Funding: "Cette publication a été réalisée avec le soutien financier de l'Union européenne dans le cadre du Programme IEV de Coopération Transfrontalière Italie-Tunisie 2014–2020 à travers le projet INTEMAR-IS_2.1_073 *Innovations dans la lutte intégrée contre les ravageurs et maladies récemment introduits sur cultures maraîchères*. Son contenu relève de la seule responsabilité du bénéficiaire principal et ne reflète pas nécessairement les opinions de l'Union européenne et celles de l'Autorité de Gestion (Grant Numbers E64I18002460007)". This research was funded by the project "Economic assessments of the sustainability of agri-food systems" by UNICT 2016–2018 "Piano per la Ricerca. Linea di intervento 2-Seconda annualità P7/WP2 (5A722192141)". Project leader: Gaetano Chinnici.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: The data presented in this study are available on request from the corresponding author.

Conflicts of Interest: The authors declare no conflict of interest.

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