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Mapping the scientific research in organic farming: a bibliometric review

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Abstract The main aim of this study was to analyze the scientific productivity, collaboration and impact of research on organic agriculture through bibliometric analyses of articles included in the Science Citation Index Expanded database for the period 1954–2013. A number of 1009 research articles were published in 359 journals belonging to several subject areas, being Agriculture Multidisciplinary, Agronomy and Environmental Sciences the most productive. A social network analysis of collaboration between small countries and co-words was performed in order to analyze the most powerful scientific cooperation. The results highlight the important of the collaboration between small countries from north and eastern of Europe, as well as four non-European countries along with the US: Canada, Australia, Brazil and China, which is consistent with the importance that the consumption of products derived from organic farming has in these countries.

Keywords Scientific research · Organic agriculture · Collaboration · Subject areas

Introduction

The term "organic" as applied to farming was first used in the US by Rodale in 1940. The Rodale Institute and their Organic Farming and Gardening magazine remains a primary source of organic information and advocacy. In England, the term was developed about the

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same time by Lord Northbourne who described an integrated farm as a "dynamic living organic whole" (Durham 2005). These workers shared an emphasis on the importance of soil organic matter for maintaining fertility, a rejection of chemical fertilizers and pesticides, and a reliance on livestock production as an essential component of the workings of the farm. Now, organic farming is practiced in approximately 100 countries throughout the world, with more than 24 million hectares under organic trade association (OTA).

Organic farming is a way of agriculture that relies on techniques such as crop rotation, green manure, compost, and biological pest control. Depending on whose definition is used, organic farming uses fertilizers and pesticides if they are considered natural, but it excludes or strictly limits the use of various methods for reasons including sustainability, openness, independence, health, and safety (Paull 2011). Organic agriculture is an ecological production management system that promotes and enhances biodiversity, biological cycles and soil biological activity. It is based on minimal use of off-farm inputs and on management practices that restore, maintain and enhance ecological harmony (Gold 2014). Organic agricultural methods are internationally regulated and legally enforced by many nations, based in large part on the standards set by the International Federation of Organic Agriculture Movements (IFOAM 2010).

Several studies have been conducted to better understand how farmers choose between organic and conventional production (Matthias et al. 2008), some of them based on qualitative analysis of in-depth interviews (Darnhofer et al. 2005; Duram 2000; Fairweather 1999; Fairweather and Campbell 2003; Lockeretz 1997), others on quantitative analysis of surveys (Burton et al. 1999; Midmore et al. 2001; Schneeberger et al. 2002) or farm accounting data (Pietola and Lansink 2001).

The desire for a sustainable agriculture is universal, yet agreement on how to progress towards it remains elusive. The extent to which the concept of sustainable agriculture has any operational meaning is discussed. Sustainability is considered in relation to organic farming a sector growing rapidly in many countries. The reason for the focus on organic agriculture is the rapid development of the organic sector in Europe and North America (Rigby and Cáceres 2001; Yuseffi 2004). The organic sector of the US agricultural and food industry is garnering increasing interest from producers, consumers, policymakers and those interested in farm, environmental and nutrition issues. Although it is not the only emerging niche in the food sector, it is one of the pioneering market segments over the past few decades. The innovative nature of organic marketing, together with a new national organic certification program, resulted in a high consumer profile and market presence. Thus, there may also be need for enhanced research, education and extension on production, marketing, policy and food science issues related to this sector (Thilmany 2006).

In numerous official documents, organic farming methods are said to contribute to food safety, greater product diversity, environmental benefits and provision of public goods linked to rural development (CEC 2002; LD 1999). Accordingly, policy makers actively seek to increase the number of organic farms through various initiatives. Proponents of organic farming argue that soil quality is best promoted in food production systems where biological, cultural, and physical practices are relied on to supply crops with adequate nutrition and suppression of pests (Badgley et al. 2007; Horrigan et al. 2002). Others maintain that the conventional farming systems which include the regular use of synthetic fertilizer and pesticides are the best option for providing an adequate global food supply while maintaining and even enhancing soil quality (Trewavas 2001, 2004; Conner 2008).

Recent published meta-analyses (De Ponti et al. 2012) suggest that widespread replacement of conventional with organic farming is not recommended if substantial increases in food production are needed to feed a population of 10 billion humans by 2050,

as some have projected (Lutz et al. 1997). Seufert et al. (2012) and De Ponti et al. (2012) reported an average yield drag of 20 % when crops were grown using organic compared with conventional methods. Still, Reganold (2012) argued that organic farming has a place in supplying a sufficient and nutritious food supply in the future, pointing out that high yields can be produced by organic farmers. In addition, organic farming may be a better strategy for promoting the environmental and socio-economic sustainability of agrarian life than conventional farming (Reganold 2012).

Given the emergent significance of this topic, the aim of this paper was to analyze the knowledge structure of scientific research on organic farming integrating the analyses of productivity, collaboration, and scientific impact with subject category analysis, keyword analysis, social network analysis (SNA), and co-word analysis. The identification of the knowledge structure of scientific research on organic farming can help neophytes and newcomers to enter this field or to provide sufficient insight to leap forward in a new competitively advantageous research direction.

Methods

Items under study were obtained from the Web of Science Core Collection (WOS) from Thomson Reuters. The terms used in the search strategy were Title = ("Ecolog* agriculture" OR "organic agriculture" OR "organic farm*"). To reach greater accuracy in the results, the search was conducted in the Title field because if applied in the Topic option, which includes the search fields Title, Abstract and Keywords (KW), many records obtained were not relevant. The terms were truncated using an asterisk to obtain all documents associated with the derived words (e.g., "organic farm*" allows for the recovery of items containing the terms "organic farm", "organic farms", "organic farmer", "organic farmers" and "organic farming". All records obtained were reviewed to ensure their relevance. The final records were exported to a relational database using the self-developed software *Bibliometricos*. We then proceeded to correct variations on signatures of names of the same institution to merge them into a single appellation and to standardise and group keywords in the records. We then analyse the records to identify in which journals the articles were published, the subject category of each article, the KW most frequently associated with subject categories, impact factor of journals and articles receiving higher citations. We used social network analysis (SNA) to identify the leading keywords, institutions and countries by means of quantifying the number of different co-occurrences in the set of papers revised. The software Pajek, specialized in the visualisation of networks, was used for the construction and graphical representation of the collaboration between institutions and countries, as well as the network of co-words (Batagelj and Mrvar 2002). The software VOSViewer was used for the construction of the density map of keywords. Data on country of publication of the journals and impact factor were extracted from the 2012 edition of the Journal Citation Reports.

Results

A set of 1009 published papers were collected: 916 original articles (90.8 %), 47 revisions (4.7 %), 4 notes (0.4 %), and 42 letters (4.1 %). The first article registered in WOS was published in 1954 (Fig. 1). The number of articles has increased steadily, from 34 in the

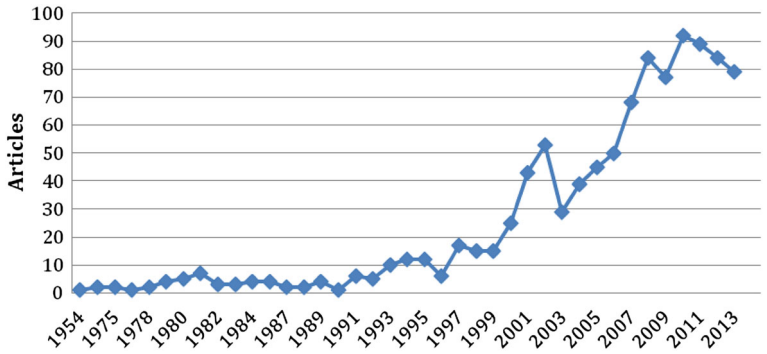

Fig. 1 Annual evolution of published papers

period 1954–1984 (3.4 %) to 675 in 2005–2013 (66.9 %). This growth is more striking for original articles than for reviews.

Papers were published in 359 different journals. Table 1 lists the 41 journals that published more than five articles distributed by country of publication, WoS subject categories, quartile and impact factor in 2013. The most productive journals were the Agriculture Ecosystems Environment ($n = 37$), Biological Agriculture Horticulture ($n = 33$) and Renewable Agriculture and Food Systems ($n = 26$) and Journal of Sustainable Agriculture ($n = 26$). The majority of these 41 journals were published in the Netherlands ($n = 11$), UK ($n = 11$), US ($n = 8$) and Germany ($n = 5$). Journals with higher impact factor (in addition to *Science*, with an IF = 31,477) were Journal of Applied Ecology (FI = 4.754), Soil Biology and Biochemistry (FI = 4.410), Agriculture Ecosystems and Environment (FI = 3.203), Land Use Policy (FI = 3.134) and Journal of Agricultural and Food Chemistry (FI = 3.107), all of which ranked in first quartile in Journal Citation Reports.

Table 2 shows WOS categories with most published articles, most frequent key words and journals with most articles in each area. The list is ranked by Agriculture, Multidisciplinary category ($n = 263$) with the key words "Organic agriculture", "Sustainable agriculture" and "Systems", and the journals Agriculture Ecosystems and Environment, Journal of Sustainable Agriculture and Renewable Agriculture and Food Systems. Other two areas with more than 100 published articles were Agronomy ($n = 138$) and Environmental Sciences ($n = 103$). In Agronomy, the key word "Organic agriculture" is followed by "Nitrogen" and "Management" while in Environmental Sciences the key word "Organic agriculture" is followed by "Biodiversity" and "Farming". Other represented areas were Environmental Sciences, Ecology, Soil sciences, Plant Sciences and Horticulture.

Papers that received 100 or more citations are shown in Table 3. Three papers stand out from the others with more than 300 citations. The more cited paper was published in 2002 by Mader et al. in *Science* ($n = 606$), a team of researchers belonging to the Research Institute of Organic Agriculture (Frick, Switzerland). The topic of this paper is about soil fertility and biodiversity in organic farming. The second most cited paper ($n = 349$), published in 2005 in the journal *Biological Conservation* by Hole et al., a British research team, discusses the question of whether organic farming benefits biodiversity. The third paper ($n = 334$), published in 2005 in the *Journal of Applied Ecology* by Bengtsson, Ahnstrom and Weibull, a team from the Swedish University of Agricultural Sciences—

Table 1 Journals of publication, WoS subject categories, quartile and impact factor

Journal	*n*	Country	Language	WoS subject categories	Quartile	Impact factor
Agriculture Ecosystems and Environment	37	Netherlands	English	Agriculture, Multidisciplinary; Ecology; Environmental Sciences	Q1; Q2; Q1	3.203
Biological Agriculture and Horticulture	33	England	English	Agronomy; Horticulture	Q3	0.514
Journal of Sustainable Agriculture	26	US	English	Agriculture, Multidisciplinary; Agronomy	Q2; Q3	0.849
Renewable Agriculture and Food Systems	25	England	English	Agriculture, Multidisciplinary	Q1	1.530
Landbauforschung	20	Germany	Multi-language	Agriculture, Multidisciplinary	Q4	1.280
Soil Use and Management	17	England	English	Soil Science	Q2	1.968
Journal of Food Agriculture and Environment	17	Finland	English	Food Science and Technology	Q4	0.435[a]
Sociologia Ruralis	15	Netherlands	English	Geography; Sociology	Q2; Q1	1.362
Ecological Economics	14	Netherlands	English	Ecology; Environmental Sciences	Q2	2.517
Berichte Uber Landwirtschaft	13	Germany	Multi-language	Agriculture, Multidisciplinary	Q4	0.125
Agriculture and Human Values	13	Netherlands	English	Agriculture, Multidisciplinary; History and Philosophy of Science	Q1	1.359
European Journal of Agronomy	13	France	English	Agronomy	Q1	2.918
Science	12	US	English	Multidisciplinary Sciences	Q1	31.477
Veterinary Record	12	England	English	Veterinary Sciences	Q1	1.633
Acta Veterinaria Scandinavica	12	Denmark	Multi-language	Veterinary Sciences	Q2	1.382
Journal of Plant Diseases and Protection	12	Germany	English	Agriculture, Multidisciplinary; Plant Sciences	Q3; Q4	0.611
Journal of Agricultural and Environmental Ethics	12	Netherlands	English	Agriculture, Multidisciplinary; Environmental Sciences; History and Philosophy of Science	Q2; Q3; Q1	1.250
Journal of Agricultural and Food Chemistry	11	US	English	Agriculture, Multidisciplinary; Chemistry, Applied; Food Science and Technology	Q1	3.107
Journal of The Science of Food and Agriculture	11	England	English	Agriculture, Multidisciplinary; Chemistry, Applied; Food Science and Technology	Q1; Q2	1.879
Land Use Policy	10	England	English	Environmental Studies	Q1	3.134

Table 1 continued

Journal	*n*	Country	Language	WoS subject categories	Quartile	Impact factor
Agricultural Systems	10	Netherlands	English	Agriculture, Multidisciplinary	Q1	2.453
Njas-Wageningen Journal of Life Sciences	10	Netherlands	English	Agriculture, Multidisciplinary	Q2	1.143
Agronomy For Sustainable Development	10	France	Multi-language	Agronomy	Q1	2.841
Journal of Soil and Water Conservation	9	US	English	Ecology; Soil Science; Water Resources	Q3; Q2	1.811
Bodenkultur	8	Austria	Multi-language	Agriculture, Multidisciplinary	Q4	0.062[b]
Biocycle	8	US	English	Agriculture, Soil Science; Ecology	Q4	0.039[c]
Acta Agriculturae Scandinavica Section B-Soil and Plant Science	8	Norway	English	Agronomy; Soil Science	Q3; Q4	0.650
Nutrient Cycling in Agroecosystems	8	Netherlands	English	Soil Science	Q2	1.733
Journal of Plant Diseases and Protection	8	Germany	English	Agriculture, Multidisciplinary; Plant Sciences	Q3; Q4	0.611
Euphytica	7	Netherlands	English	Agronomy; Horticulture; Plant Sciences	Q1; Q2	1.692
Journal of Applied Ecology	7	England	English	Ecology	Q1	4.754
Food Policy	7	England	English	Agricultural Economics and Policy; Food Science and Technology; Nutrition and Dietetics	Q1; Q3	2.331
Journal of Rural Studies	7	England	English	Planning and Development	Q1	2
Journal of Environmental Protection and Ecology	7	Bulgaria	English	Environmental Sciences	Q4	0.338
Communications in Soil Science and Plant Analysis	6	US	English	Agronomy; Chemistry, Analytical; Plant Sciences; Soil Science	Q4	0.423
Journal of Agricultural Science	6	England	English	Agriculture, Multidisciplinary	Q1	2.891
Soil Biology and Biochemistry	6	England	Multi-language	Soil Science	Q1	4.410
Agricultural Economics-Zemedelska Ekonomika	6	Czech Republic	English	Agricultural Economics and Policy	Q4	0.325

Table 1 continued

Journal	*n*	Country	Language	WoS subject categories	Quartile	Impact factor
European Review of Agricultural Economics	6	England	English	Agricultural Economics and Policy	Q1	1.467
Soil and Tillage Research	6	Netherlands	English	Soil Science	Q1	2.575
Field Crops Research	6	Netherlands	English	Agronomy	Q1	2.608
Horttechnology	6	US	English	Horticulture	Q3	0.619
Zemdirbyste-Agriculture	6	Lithuania	Lithuanian	Agriculture, Multidisciplinary	Q3	0.523
Journal of Plant Nutrition and Soil Science	6	Germany	Multi-language	Agronomy; Plant Sciences; Soil Science	Q2; Q3	1.663
Spanish Journal of Agricultural Research	6	Spain	Multi-language	Agriculture, Multidisciplinary	Q3	0.514

N number of published articles

[a] 2010 impact factor

[b] 2004 impact factor

[c] 2003 impact factor

SLU (Uppsala, Sweden), is a meta-analysis on the effects of organic agriculture on biodiversity and abundance.

Collaborative networks between institutions are shown in Fig. 2. The network with 8 components is mainly composed of Danish institutions and has Aarhus University as center. Other participating Danish centers are Technical University of Denmark, University of Copenhagen and National Environmental Research Institute. Aarhus University is connected with other four foreign centers: Robert Gordon University (UK), China Agricultural University, Australian National University (ANU) and Empresa Brasileira de Pesquisa Agropecuária—Embrapa. The second network integrates three centers form Switzerland (Research Institute of Organic Agriculture-FiBL, University of Basel and Swiss Federal Research Station for Agroecology and Agriculture) and two from The Netherlands (Wageningen University and Louis Bolk Institute). The network with four components is integrated by French centers that have Institut National de la Recherche Agronomique-INRA as central institution. The two networks with three components correspond to Spanish and Swedish centers. The largest number of articles published in collaboration has occurred between Louis Bolk Institute and Wageningen University ($n = 6$), INRA—Institut National de la Recherche Agronomique and ISARA Lyon ($n = 5$), and Lund University with Swedish University of Agricultural Sciences—SLU ($n = 5$).

Papers productivity by countries is as follows: USA ($n = 152$; 14.3 %), Germany ($n = 77$; 7.6 %), UK ($n = 77$; 7.6 %) and Denmark ($n = 70$; 7 %). In the network of collaboration between countries (Fig. 3) emerge 16 countries. The country establishing more collaborative relationships with other countries is Germany, with 10 relations,

Table 2 WoS subject categories, most frequent key words and most productive journals in each category

WoS subject categories	*n*	Kw 1	*n*	Kw 2	*n*	Kw 3	*n*	Most productive journals
Agriculture, Multidisciplinary	263	Organic agriculture	138	Sustainable agriculture	39	Systems	39	Agriculture Ecosystems and Environment; Journal of Sustainable Agriculture
Renewable Agriculture and Food Systems								
Agronomy	138	Organic agriculture	46	Nitrogen	29	Management	20	Biological Agriculture and Horticulture; European Journal of Agronomy; Agronomy for Sustainable Development
Environmental Sciences	103	Organic agriculture	53	Biodiversity	23	Farming	17	Agriculture Ecosystems and Environment; Ecological Economics; Journal of Agricultural and Environmental Ethics
Ecology	97	Organic agriculture	31	Biodiversity	24	Farming	21	Agriculture Ecosystems and Environment; Ecological Economics; Journal of Soil and Water Conservation
Soil Science	92	Organic agriculture	37	Nitrogen	26	Management	18	Soil Use and Management; Journal of Soil and Water Conservation; Nutrient Cycling in Agroecosystems
Plant Sciences	55	Organic agriculture	26	Nitrogen	10	Management	10	Zeitschrift Fur Pflanzenkrankheiten Und Pflanzenschutz-Journal of Plant Diseases and Protection; Journal of Plant Diseases and Protection; Euphytica
Horticulture	51	Systems	8	Organic agriculture	6	Nitrogen	5	Biological Agriculture and Horticulture: Euphytica; Horttechnology
Economics	50	Organic agriculture	30	Adoption	8	Models	8	Ecological Economics; Food Policy; European Review of Agricultural Economics
Veterinary Sciences	46	Organic agriculture	13	Animal health	6	Animal welfare	5	Veterinary Record; Acta Veterinaria Scandinavica; Italian Journal of Animal Science
Sociology	45	Agriculture	15	Organic agriculture	13	California	10	Sociologia Ruralis; Agriculture and Human Values; Society and Natural Resources
Food Science and Technology	41	Organic agriculture	21	Agriculture	7	Organic	4	Journal of Food Agriculture and Environment; Food Policy; Fleischwirtschaft
Environmental Studies	40	Organic agriculture	22	Agriculture	9	Sustainable agriculture	9	Ecological Economics; Land Use Policy; Society and Natural Resources
Agriculture, Dairy and Animal Science	30	Organic agriculture	16	Milk production	5	Nitrogen	5	Livestock Production Science; Journal of Animal and Feed Sciences; Italian Journal of Animal Science

Table 3 Most cited papers

Authors	Title	Source	Times cited
Mader P; Fliessbach A; Dubois D; Gunst L; Fried P; Niggli U	Soil fertility and biodiversity in organic farming	*Science* 2002; 296: 1694–1697	606
Hole, DG; Perkins, AJ; Wilson, JD; Alexander, IH; Grice, PV; Evans, AD	Does organic farming benefit biodiversity?	*Biological Conservation* 2005; 122(1): 113–130	349
Bengtsson, J; Ahnstrom, J; Weibull, AC	The effects of organic agriculture on biodiversity and abundance: a meta-analysis	*Journal of Applied Ecology* 2005; 42(2): 261–269	334
Oehl, F; Sieverding, E; Mader, P; Dubois, D; Ineichen, K; Boller, T; Wiemken, A	Impact of long-term conventional and organic farming on the diversity of arbuscular mycorrhizal fungi	*Oecologia* 2004; 138(4): 574–583	164
Brandt, K; Molgaard, JP	Organic agriculture: does it enhance or reduce the nutritional value of plant foods?	*Journal of the Science of Food and Agriculture* 2001; 81(9): 924–931	159
Bond, W; Grundy, AC	Non-chemical weed management in organic farming systems	*Weed Research* 2001; 41(5): 383–405	151
Lundquist, EJ; Scow, KM; Jackson, LE; Uesugi, SL; Johnson, CR	Rapid response of soil microbial communities from conventional, low input, and organic farming systems to a wet/dry cycle	*Soil Biology and Biochemistry* 1999; 31(12): 1661–1675	144
Gosling, P; Hodge, A; Goodlass, G; Bending, GD	Arbuscular mycorrhizal fungi and organic farming	*Agriculture Ecosystems and Environment* 2006; 113(1–4): 17–35	140
Badgley, Catherine; Moghtader, Jeremy; Quintero, Eileen; Zakem, Emily; Chappell, M Jahi; Aviles-Vazquez, Katia; et al.	Organic agriculture and the global food supply	*Renewable Agriculture and Food Systems* 2007; 22(2): 86–108	140
Stockdale, EA; Lampkin, NH; Hovi, M; Keatinge, R; Lennartsson, EKM; Macdonald, DW; et al.	Agronomic and environmental implications of organic farming systems	*Advances in Agronomy* 2001; 70: 261–327	121
Rigby, D; Caceres, D	Organic farming and the sustainability of agricultural systems	*Agricultural Systems* 2001; 68(1): 21–40	119
Gunapala, N; Scow, KM	Dynamics of soil microbial biomass and activity in conventional and organic farming systems	*Soil Biology and Biochemistry* 1998; 30(6): 805–816	112
Barberi, P	Weed management in organic agriculture: are we addressing the right issues?	*Weed Research* 2002; 42(3): 177–193	110
Hansen, B; Alroe, HF; Kristensen, ES	Approaches to assess the environmental impact of organic farming with particular regard to Denmark	*Agriculture Ecosystems and Environment* 2001; 83(1–2): 11–26	103

Table 3 continued

Authors	Title	Source	Times cited
Padel, S	Conversion to organic farming: A typical example of the diffusion of an innovation?	*Sociologia Ruralis* 2001; 41(1): 40–61	101
Watson, CA; Atkinson, D; Gosling, P; Jackson, LR; Rayns, FW	Managing soil fertility in organic farming systems	*Soil Use and Management* 2002; 18: 239–247	100
Berry, PM; Sylvester-Bradley, R; Philipps, L; Hatch, DJ; Cuttle, SP; Rayns, FW, et al.	Is the productivity of organic farms restricted by the supply of available nitrogen?	*Soil Use and Management* 2002; 18: 248–255	100

followed by UK and The Netherlands, both with 8. Other countries that hardly stand in the network are Denmark, Switzerland and Sweden.

Figure 4 corresponds to a density collaboration map between key words. This map is useful to obtain a general scope of the key words that represent the documents and allow appreciating the weight that some concepts have in the published articles and the relations with other concepts. The names of the words whose papers have set more relations with other ones are shown with different black intensity. The warmer colours (red) indicate a higher density whereas the colder colours represent lower densities. The map highlights the place of greatest centrality in organic agriculture, and other relevant words are management and systems agriculture. Around organic agriculture the related key words are crooping system, quality, crops and soil. Related with management are found nitrogen and biodiversity. Finally, related to agriculture systems are sustainable agriculture, organic and nitrogen.

Discussion

This work has enabled to characterize the global scientific production, impact, main topics covered and collaborations between institutions and countries in the scientific literature published on organic agriculture included in Web of Science.

Some of the most striking results are the increasing number of published articles and that two-thirds of the articles have been published in the last decade, especially since the early 2000s. This growth is in line with the increased interest in organic agriculture shown by most of the countries and the rapid development of the organic sector in Europe, North America and Australia (Rigby and Cáceres 2001; Yuseffi 2004). According to The World of Organic Agriculture 2014 report, edited by the Research Institute of Organic Agriculture (FiBL) and the International Federation of Organic Agriculture Movements (IFOAM), Australia is the country with most million hectares of organic agricultural land ($n = 12$), followed by Argentina ($n = 3.6$), USA ($n = 2.2$), China ($n = 1.9$) and Spain ($n = 1.6$). The observed positive trend remains unbroken and consumer demand increases (with 10 % market growth in the world's largest organic market, the US); more farmers cultivate organically (+5 %) and a bigger land surface is organically certified (+0.5 %) (FIBL and IFOAM 2014).

One of the important reasons that could have contributed to this growth may be the health benefit of organic agriculture. Recently, an international team of experts led by

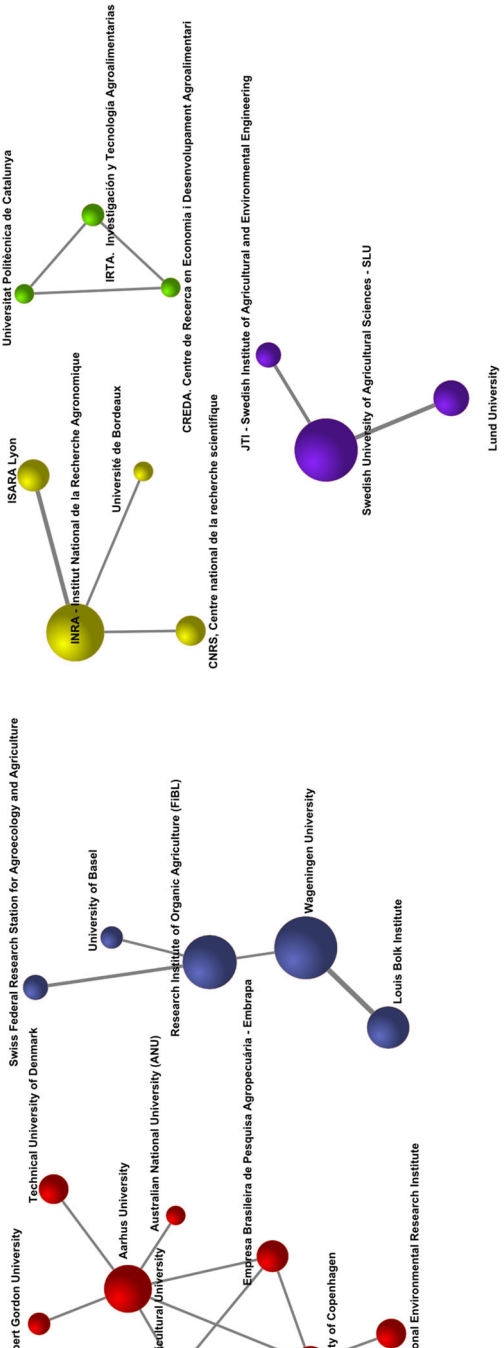

Fig. 2 Network of collaboration between institutions that collaborate in 3 or more papers (networks with 3 or more research centers)

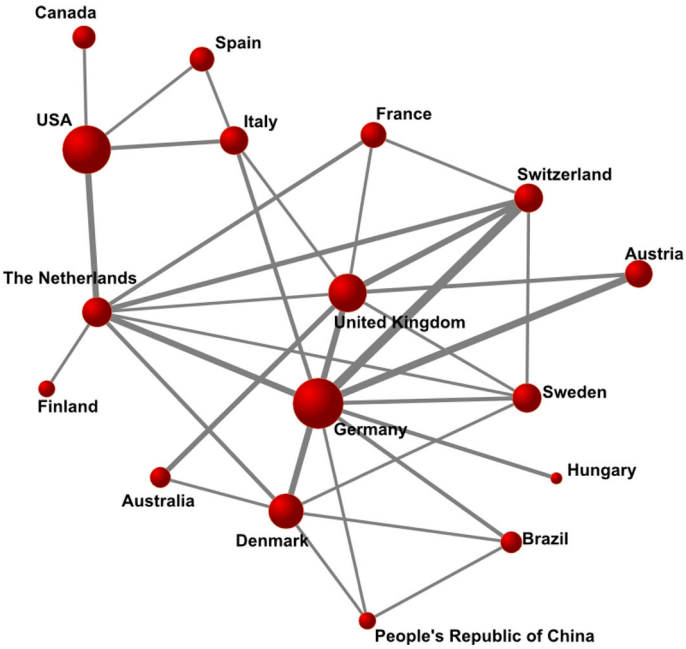

Fig. 3 Network of collaboration between countries

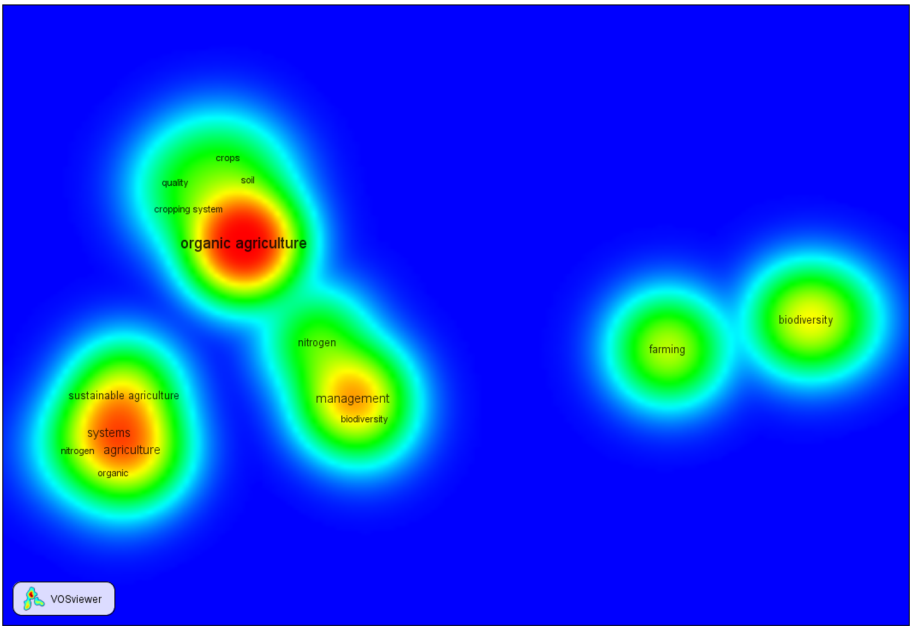

Fig. 4 Density map of key words that appears in more than 20 papers. (Color figure online)

Newcastle University (UK), has proved in a meta-analyses based on 343 peer-reviewed publications that organic crops and organic crop-based foods are up to 60 % higher in a number of key antioxidants than conventionally grown crops. The meta-analysis also reported lower Cadmium concentrations (Baranski et al. 2014). As it is well known, numerous studies have linked antioxidants to a reduced risk of chronic diseases, including cardiovascular and neurodegenerative diseases and certain cancers (German and Walzem 2000; Ruf 2003; Guilford and Pezzuto 2011; Giacosa et al. 2012; Aleixandre et al. 2013).

As observed, journals with most published articles are devoted to the main aspects covered by the organic farming, such as agriculture, environment, ecology, agronomy and soil, among others. This is the case of the most productive journal, *Agriculture, Ecosystems and Environment.* It publishes scientific articles dealing with the interface between agroecosystems and the natural environment, specifically how agriculture influences the environment and how changes in that environment impact agroecosystems. The second ranked journal, *Biological Agriculture and Horticulture,* aims to study alternative systems of husbandry, and particularly the biological approach to food production. Other relevant publishing journals deal with renewable and sustainable agriculture, soil use, ecology and food science and technology, among others. Particularly striking is the presence of the multidisciplinary high-impact factor journals such as *Science*, which may be due to the importance and interest that is currently drawing the organic agriculture as highest area of research. The diversity of subject categories of journals contributes to understand these features.

The subject analysis has revealed that the key words prioritization in organic agriculture-related scientific journals depends on the addressed subject area. In the subject categories Agriculture, Multidisciplinary and Environmental Studies is frequent the key word "sustainable agriculture"; in Agronomy, Soil Science, Plant Sciences, Horticulture, Agriculture, and Dairy and Animal Science, a common word is "Nitrogen"; for Environmental Sciences and Ecology, an important word used is "Biodiversity"; Agronomy, Soil Science and Plant Sciences have however the key word "management" as most usual.

The topic analysis of the most cited papers allows knowing which topics attract more interest in the research. As we can see, these are issues that are linked to the relationship between organic farming and biodiversity, the possibility that enhance or reduce the nutritional value of plant foods, the organic farming as a global food supply, the agronomic and environmental implications and impact, the sustainability of agricultural systems and the innovation in the conversion to organic farming, among others.

It is striking that the most productive institutions belong to north Europe small countries such as Denmark, The Netherlands or Sweden. This is consistent with the importance that the consumption of products derived from organic farming has in these countries (Oesch and Schaer 2008). The countries of northern and central Europe such as Germany, UK, The Netherlands, Denmark, Sweden and Switzerland are leaders in the EU in consumption of organic products; being USA the leader country within the global framework. Only Denmark alone consumes about 7 % of the European total (European Union 2010). The same applies to the network of collaboration between countries, since these are the countries with major number of papers written in cooperation. This network highlights four non-European countries along with the US: Canada, Australia, Brazil and China, the latter two included within the BRIC emerging countries.

It must be understood that some research limitations are inevitable in this kind of analysis. For example:

1. The purpose of this study was to characterise knowledge structures generated by research papers on organic farming, integrating subject categories of journals, key

words of papers and social network analysis. However, this method is only an approach which could be complemented by a deeper analysis, for example analysing the content of papers.

2. The quality of the results extracted from the co-word analysis and the validity of maps depend on the quality of KW chosen to conceptualise the scientific papers by the authors or indexers.

Future research in this area must focus on the process of more professional journals from other bibliographic databases and on the study of the thematic content of the papers, which will enable a wider analysis. It will also be interesting to see whether the growth trend remains in the coming years, as well as the consolidation of current research groups and the emergence of new groups and countries involved in this field.

Conclusions

The interests of producers, consumers, policymakers, and the widespread belief in the beneficial health effects of organic agriculture in modern society encourages a greater allocation of resources for research in this area, resulting in a greater number of publications. This research has taken place in recent years. The issue of organic farming has thus become an emerging field of research that requires a systematic analysis of the structure of knowledge. This study contributes to a better understanding in this field and identifies the main lines of research, the sources chosen for their scientific dissemination and the major scientific players.

References

Aleixandre, J. L., Aleixandre-Tudó, J. L., Bolaños, M., & Aleixandre-Benavent, R. (2013). Mapping scientific research on wine and health. *Journal of Agricultural and Food Chemistry, 61*(49), 11871–11880.

Badgley, C., Moghtader, J., Quintero, E., Zakem, E., Chappell, M. J., Aviles-Vazques, K., et al. (2007). Organic agriculture and the global food supply. *Renewable Agriculture and Food System, 22*, 86–108.

Baranski, M., Srednicka-Tober, D., Volakakis, N., Seal, C., Sanderson, R., Stewart, G. B., et al. (2014). Higher antioxidant and lower cadmium concentrations and lower incidence of pesticide residues in organically grown crops: A systematic literature review and meta-analyses. *British Journal of Nutrition, 112*, 794–811.

Batagelj, V., & Mrvar, A. (2002). Pajek—Analysis and visualization of large networks. *Lecture Notes in Computer Science, 2265*, 477–478.

Burton, M., Rigby, D., & Young, T. (1999). Analysis of the determinants of adoption of organic horticultural techniques in the UK. *Journal of Agricultural Economics, 50*(1), 47–63.

CEC: Commissions of the European Communities. (2002). *Analysis of the possibility of a European action plan for organic food and farming*. Commission staff working paper. Brussels.

Conner, D. J. (2008). Organic agriculture cannot feed the world. *Field Crops Research, 106*, 187–190.

Darnhofer, I., Schneeberger, W., & Freyer, B. (2005). Converting or not converting to organic farming in Austria: Farmer types and their rationale. *Agricultural Human Values, 22*(1), 39–52.

De Ponti, T., Rijk, B., & van Ittersum, M. K. (2012). The crop gap between organic and conventional agriculture. *Agricultural Systems, 108*, 1–9.

Duram, L. A. (2000). Agents: Perceptions of structure: How Illinois organic farmers view political, economic, social, and ecological factors. *Agricultural Human Values, 17*(1), 35–48.

Durham, L. A. (2005). *Good growing: Why organic farming works*. Lincoln, NE: University of Nebraska Press.

European Union. (2014). European Commission Directorate-General for Agriculture and Rural Development. An analysis of the EU organic sector. http://ec.europa.eu/agriculture/markets-and-prices/more-reports/pdf/organic_2010_en.pdf. Consulted 25 October 2014.

Fairweather, J. R. (1999). Understanding how farmers choose between organic and conventional production: Results from New Zealand and policy implications. *Agricultural Human Values, 16*(1), 51–63.

Fairweather, J. R., & Campbell, H. R. (2003). Environmental beliefs and farm practices of New Zealand farmers: Contrasting pathways to sustainability. *Agricultural Human Values, 20*(3), 287–300.

FIBL and IFOAM. (2014). The World of Organic Agriculture 2014. Statistics and emerging trends. Available at: http://www.organic-world.net/2613.html. Consulted 25 October 2014.

German, J. B., & Walzem, R. L. (2000). The health benefits of wine. *Annual Review of Nutrition, 20*, 561–593.

Giacosa, A., Adam-Blondon, A. F., Baer-Sinnott, S., Barale, R., Bavaresco, L., Di Gaspero, G., et al. (2012). Alcohol and wine in relation to cancer and other diseases. *European Journal of Cancer Prevention, 21*, 103–108.

Gold, M. (2014). What is organic production? National Agricultural Library. USDA. Retrieved 1 March 2014.

Guilford, J. M., & Pezzuto, J. M. (2011). Wine and health: A review. *American Journal of Enology and Viticulture, 62*, 471–486.

Horrigan, L., Lawrence, R. S., & Walker, P. (2002). How sustainable agriculture can address the environmental and human health harms of industrial agriculture. *Environmental Health Perspectives, 110*, 445–456.

IFOAM. (2010). The principles of organic agriculture. Bonn, Germany: IFOAM. LD (Ministry of Agriculture) 1999, St.meld. nr. 19 (1999–2000). Om norsk landbruk ogmatproduksjon (White paper No. 19 (1999–2000) on Norwegian agriculture and food production), Oslo: Det Kongelige Landbruksdepartement.

Lockeretz, W. (1997). Diversity of personal and enterprise characteristics among organic growers in the Northeastern United States. *Biological Agriculture and Horticulture, 14*(1), 37–41.

Lutz, W., Sanderson, W., & Scherbov, S. (1997). Doubling of world population unlikely. *Nature, 387*, 803–804.

Matthias, K., Flaten, O., & Lien, G. (2008). Factors influencing the conversion to organic farming in Norway. *International Journal Agricultural Resources, Governance and Ecology, 7*(1/2), 75–94.

Midmore, P., Padel, S., McCalman, H., Isherwood, J., Fowler, S., & Lampkin, N. (2001). *Attitudes towards conversion to organic production systems: A study of farmers in England*. Aberystwyth: Institute of Rural Studies, The University of Wales.

Oesch vd, S., & Schaer B. (2008). Specialised organic retail report in europe. Practical compendium of the organic market in 27 European countries. Organic Retailers Association (ORA). Available at: www.ecozept.com. Consulted 4 Nov 2014.

Paull, J. (2010). From France to the World: The International Federation of Organic Agriculture Movements (IFOAM). *Journal of Social Research and Policy, 1*(2), 93–102.

Paull, J. (2011). Nanomaterials in food and agriculture: The big issue of small matter for organic food and farming. In *Proceedings of the third scientific conference of ISOFAR (International Society of Organic Agriculture Research)* (Vol. 2, 96–99), 28 September–1 October, Namyangju, Korea.

Pietola, K. S., & Lansink, A. O. (2001). Farming response to policies promoting organic farming technologies in Finland. *European Review of Agriculture Economics, 28*(1), 1–15.

Reganold, J. P. (2012). The fruits of organic farming. *Nature, 485*, 176–177.

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

Ruf, J. C. (2003). Overview of epidemiological studies on wine, health and mortality. *Drugs Under Experimental Clinical Research, 29*, 173–179.

Schneeberger, W., Darnhofer, I., & Eder, M. (2002). Barriers to the adoption of organic farming by cash-crop producers in Austria. *American Journal of Alternative Agriculture, 17*(1), 24–31.

Seufert, V., Ramankutty, N., & Foley, J. A. (2012). Comparing the yields of organic and conventional agriculture. *Nature, 485*, 229–232.

Thilmany, D. (2006). *The US organic industry: Important trends and emerging issues for the USDA* (pp. 1–10). Agribusiness Marketing Report (AMR), Cooperative Extension, Colorado State University.

Trewavas, A. (2001). Urban myths about organic farming. *Nature, 410*, 409–411.

Trewavas, A. (2004). A critical assessment of organic farming-and-food assertions with particular respect to the UK and the potential environmental benefits of no-till agriculture. *Crop Protection, 23*, 757–781.

Yuseffi, M. (2004). Development and state of organic agriculture worldwide. In H. Willer, & M. Yussefi (Eds.), *The world of organic agriculture—statistics and emerging trends* (pp. 13–20). Bonn, Germany: International Federation of Organic Agriculture Movements.