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Bibliometric analysis of scientific research about agroecological strategies

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ABSTRACT

Objective: To analyze the spatio-temporal evolution of scientific production on the topic of agroecological strategies in the world, through text mining (bibliometrics) and coauthorship networks to determine gaps in research.

Design/methodology/approach: To compile the texts, the database of open-access articles from Web of Science was reviewed. The texts were collected in September 2021, and texts available until August 2021 were considered. The keyword used in the search was *strategies agroecological* identifying it in the titles and keywords of the publications.

Results: In the databases, 463 scientific texts were collected from bibliographic references of Web of Science within the period of 1987 to 2021. Of these, 90.93% (421) were concentrated in six countries: USA (34.77%, 161), Netherlands (19.22%, 89), England (15.55%, 72), Switzerland (12.53%, 58), France (4.54%, 21) and Germany (4.32%, 20).

Limitations on study/implications: Most of the studies have been centered on techniques for agricultural sustainability, so topics associated with the creation of early climate information systems and disaster prevention and mitigation projects are presented as an opportunity for the development of more research.

Findings/conclusions: The study shows that in developing countries such as those in Latin America, where Mexico, Argentina, Chile and Brazil are located, there is scarce research development in topics of agroecological strategies, leaving a wide margin to generate knowledge in the region.

Keywords: Author network, bibliometrics, scientific article, spatio-temporal, analysis, text mining.

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INTRODUCTION

Climate change and food security are currently two priority problems for society as a whole. The variations in temperature and rainfall have made food production increasingly unstable as a response to prolonged droughts or unpredictable flooding. In the presence of this panorama, agricultural production modes face the great challenge of producing without deteriorating the environment, in a sustainable manner. Altieri and Nicholls (2007) consider that the migration from current production systems where the use of chemicals that exhaust natural resources is prioritized, to production systems where natural resources are regenerated, can only be navigated through agroecological techniques where the use of chemicals is minimized.

Among the agroecological strategies that have traditionally been used to reduce agricultural vulnerability in the presence of climate variability, there are the following: crop diversification, maintenance of local genetic diversity, animal integration, addition of organic matter to the soil, water harvest, among others. Today, these innovations are the most stable link for communities vulnerable to climate variations to be able to apply resilient

agricultural production systems, while public policies to reduce the risks of traditional agricultural systems and to promote the creation of early climate information systems are designed, as well as disaster prevention and mitigation projects (Altieri and Nicholls, 2017).

To understand the advance in research of a sector in particular and to propose new strategies for its consolidation, bibliometric studies are a reliable tool that allows studying and analyzing the evolution of scientific activity through its publications (Cañas-Guerrero *et al.*, 2013). The publication of a scientific study is the most effective way of transmitting knowledge acquired from research, and its visibility is important for the researchers themselves, for the institutions where they work, and for the organizations that finance the research (Sanz-Valero and Wanden-Berghe, 2017). The growth of scientific production in recent decades and its indexing in automatized bibliographic databases have potentiated the use of bibliometrics and the generation of indicators to measure the results of scientific and technological activities (Allen *et al.*, 2009).

Bibliometric studies based on published scientific articles allow generating indicators and mathematical models to characterize the development and evolution of the frequency and quality of the publications (Malesios and Arabatzis, 2012). Under this context, the objective of this study was to analyze the spatio-temporal evolution of scientific production on the topic of agroecological strategies in the world, through text mining (bibliometrics) and coauthorship networks to determine the relevance of the topic and to spatially locate the countries that have developed more research on agroecological strategies.

MATERIALS AND METHODS

Origin of the information

To gather the texts, the open-access database of journal articles from Web of Science was used (CONACYT, 2021). The texts were collected in September 2021, and the texts available until August 2021 were considered. The keyword used in the search was *agroecological strategies* identifying it in the titles and keywords of the publications. The keyword was only used in English because it is considered that it is more likely for texts in English to be cited, which allows capturing most of the relevant publications (Leipold, 2014).

Bibliometric indicators

The variables analyzed from each of the texts published were: *country of journal editing*, *language of publication*, and *name of the journal*, which served to determine the profile of the journals that published studies related to the topic of *agroecological strategies*; and the spatial representation of the countries with the highest number of publications. The variables *first author* and *collaborators* served to understand the network of stakeholders involved in the research; the variable *year* to locate the information on a timeline. The *title*, *abstract* and *keywords* was used to categorize the topic approached by the publication according to the classification of Web of Science; and, finally, the impact of the publications was determined with *number of citations*.

The capture of variables for the bibliometric analysis was carried out in a worksheet. The original language of each of the texts was respected. During the capture of all the information, some records were standardized because the information available in the

texts was sometimes incomplete or had variants (Aguado-López *et al.*, 2009). In addition, special characters were eliminated or changed, such as: ñ (for n), accents, superindices, subindices, ®, ©, among others, to ease the analysis.

Analysis with text mining

With the help of the RcmdrPlugin.temis complement of the statistical R software (Bouchet-Valat and Bastin, 2013), the number of texts and bibliographic citations was obtained by: year, journal, research topic, and country where the study was published.

Network analysis

The interactions between the first authors and collaborators were analyzed with the Sci2tool software (Börner, 2011), with the aim of understanding the constancy in the researcher's work; that is, to evaluate if the author has published only in one year or else if they have published constantly throughout time, which gives an idea of their consolidation in the topic of *agroecological strategies*. The syntax used in the Sci2tool software was *Extract bipartite Network*, and the Gephi software was used for its visualization (Bastian *et al.*, 2009). Finally, the spatial representation of the number of articles per country where the research was published was made in the geographic package ARGIS® (ESRI, 2015).

RESULTS AND DISCUSSION

Spatio-temporal evolution

From 1987 to 2021 a total of 463 scientific texts were published in the databases for bibliographic references of the Web of Science (CONACYT, 2021), where the object of study was the agroecological strategies; this scientific production originated 29896 bibliographic citations (Figure 1). From the 463 texts, 414 (89.42%) were scientific articles, and 49 (10.58%) bibliographic reviews. The first recorded study dates from the year 1987,

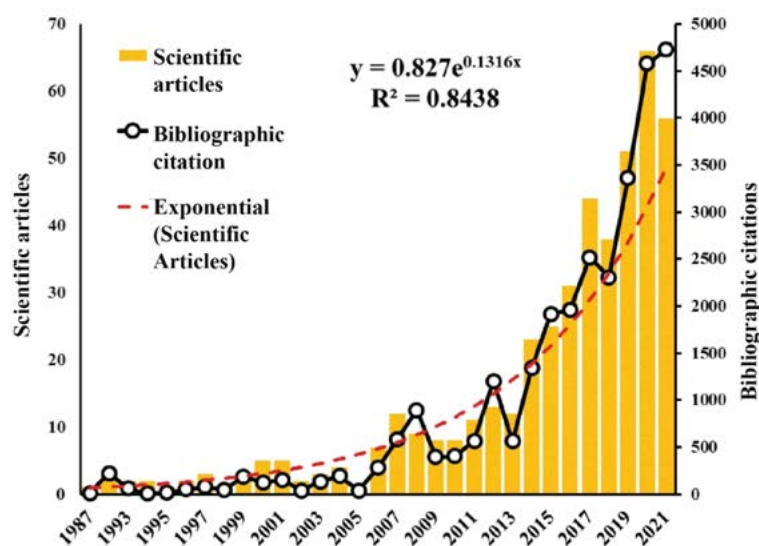


Figure 1. Temporal evolution of the scientific production and bibliographic citations in the topic of agroecological strategies in the world from 1987 to 2021.

although there has been a growing production for the topic of agroecological strategies since the year 2010.

The period of highest productivity was from 2010 to 2021 with 84.02% of the total (389 texts), which contributed to an exponential trend in the increase of publications ($R^2=0.8438$). The most cited studies were the ones published in the period 2014-2021 which in total represented 23625 bibliographic citations (79.02% of the total). The exponential trend in the publications denotes, according to Altieri and Nicholls (2017), the relevance that the topic of agroecological strategies currently has in the scientific community, as an alternative to adapt to the present climate variations.

According to the country where scientific texts were published, the 463 works were originated in 27 countries. Of these, 90.93% (421) were concentrated in six countries: USA (34.77%, 161), Netherlands (19.22%, 89), England (15.55%, 72), Switzerland (12.53%, 58), France (4.54%, 21) and Germany (4.32%, 20) (Figure 2). Figure 2 also shows that most of the research developed around the topic of agroecological strategies has happened in USA and European countries with consolidated economies.

According to Gersbach and Schneider (2015), the economic development of a country is directly related to the quality of the research it performs; countries with consolidated economies invest more in their research centers, which allows for greater technological development, compared to underdeveloped economies such as the Latin American, where investment in research is lower. Therefore, agricultural competitiveness in a country is directly related to the quality of the research conducted in the sector.

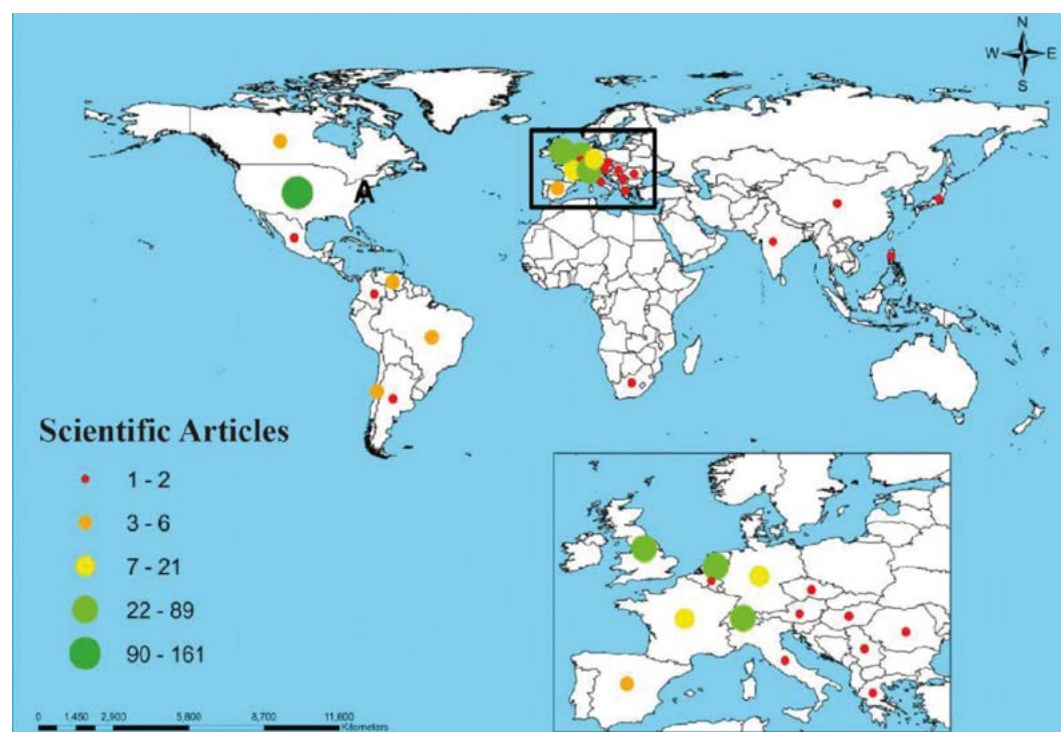


Figure 2. Spatial location of scientific production in the topic of agroecological strategies in the world from 1987 to 2021.

Bibliometric indicators

Of the texts, 97.19% (450 texts) were published in English, 1.30% (6) in Spanish, 0.86% (4) in French, 0.43% (2) in Portuguese, and 0.22% (1) in German. According to Li and Zhao (2015), English is the language adopted as universal by the scientific community, which is why the publications in English have a greater probability of dissemination among the international community. Table 1 shows that the sectors where the most research has been developed are those related with the topics of Agriculture (185 texts, 39.96%) and Ecology (125, 27.00%); this agrees with what was reported by Altieri and Nicholls (2017) who found that among the main agroecological strategies that have been implemented, there are the following: diversification of crops, maintenance of local genetic diversity, animal integration, addition of organic matter to the soil, and water harvest.

However, Altieri and Nicholls (2013) highlight the importance of developing research in topics such as the creation of early climate information systems, disaster prevention and mitigation projects, which as Table 1 shows are incipient topics: Geography (8 texts, 1.73%), Geology (4, 0.86%) and Meteorology (2, 0.43%); therefore, they represent an area of opportunity for the development of more research in these sectors.

The 463 studies analyzed were published in 250 scientific journals. A total of 115 articles, 24.84%, and 8127 bibliographic citations, 27.18%, were concentrated in 10 journals with impact factors higher than 3 (Table 2). Among these 10 main journals, 3 are edited in America, specifically in USA and 7 in Europe (Switzerland 5, United Kingdom 1, and Netherlands 1), where the main editorial houses Elsevier (4), Springer (3) and MDPI (2) coordinate the works for publication; according to Santillán-Fernández *et al.* (2021), this

Table 1. Sectors of research where scientific texts have been published with the topic of agroecological strategies in the world from 1987 to 2021.

Sector	Scientific Articles		Bibliographic Citations	
	Number	%	Number	%
Agriculture	185	39.96	11256	37.65
Ecology	125	27.00	8949	29.93
Entomology	26	5.62	1528	5.11
Botany	20	4.32	1287	4.30
Food	19	4.10	1263	4.22
Biotechnology	17	3.67	960	3.21
Livestock	17	3.67	966	3.23
Anthropology	11	2.38	684	2.29
Biodiversity	10	2.16	640	2.14
Rural Development	8	1.73	558	1.87
Geography	8	1.73	535	1.79
Medicine	5	1.08	294	0.98
Molecular Biology	4	0.86	530	1.77
Geology	4	0.86	250	0.84
Forest	2	0.43	70	0.23
Meteorology	2	0.43	126	0.42
Total	463	100.00	29896	100.00

Table 2. Bibliometric indicators of the main journals that published scientific articles about agroecological strategies in the world from 1987 to 2021.

Journal	Articles		Bibliographic Citations		Journal Information		
	Number	%	Number	%	Factor JCR	Editorial	Country of publication
Agroecol Sust Food	26	5.62	1479	4.95	3.039	Taylor and Francis Group	United Kingdom
Sustainability-Basel	23	4.97	1924	6.44	3.251	MDPI	Switzerland
Agr Ecosyst Environ	13	2.81	717	2.40	5.567	Elsevier	US
Agron Sustain Dev	13	2.81	1590	5.32	5.832	Springer	Switzerland
Agr Hum Values	11	2.38	737	2.47	3.295	Springer	Switzerland
Agr Syst	7	1.51	434	1.45	5.37	Elsevier	US
Agroforest Syst	6	1.30	312	1.04	2.549	Springer	Switzerland
Agronomy-Basel	6	1.30	356	1.19	3.417	MDPI	Switzerland
Eur J Agron	5	1.08	265	0.89	5.124	Elsevier	Netherlands
Int J Food Microbiol	5	1.08	313	1.05	5.277	Elsevier	US
Other (240)	348	75.16	21769	72.82			
Total (250)	463	100	29896	100			

helps to maintain the impact of the publications by increasing the probability of reaching a higher number of users.

Coauthorship network

In the 463 texts analyzed, 429 different first authors were found, and between first author and coauthors there was a total of 1942 different individuals. The network of authors and coauthors (Figure 3) was made up of 1942 nodes (authors) and 1708 aspects

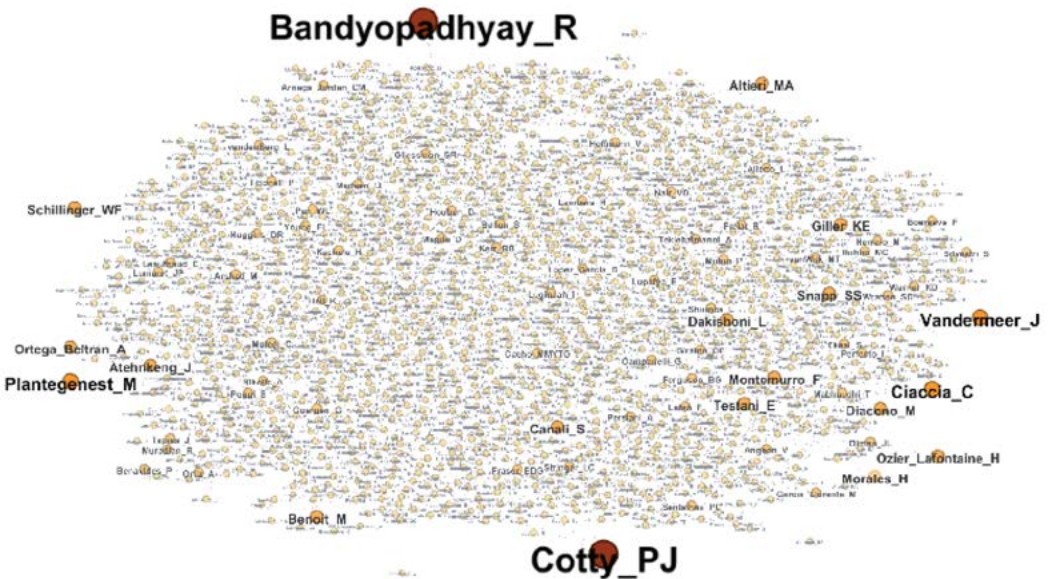


Figure 3. Network of authors and coauthors in the world who have published scientific articles about agroecological strategies from 1987 to 2021. The size of the node corresponds to their productivity.

(links). The links in a coauthorship network analysis are important because it is through them that an author can reach certain ideas, knowledge and information that is socially distant from him (Granovetter, 1973). The main authors who developed research in the area of agroecological strategies from 1987 to 2021 were Cotty_PJ (10 texts) from the University of Arizona (USA), and Bandyopadhyay_R (9) from the International Institute of Tropical Agriculture (Nigeria); both authors have focused their studies on the agricultural sector.

The density of the network had a value of 0.002, which implies that for the topic of agroecological strategies there is not much collaboration between the authors. The density is an indicator in the analysis of coauthorship networks that implies that the nodes interact (are linked) between one another; mathematically, it is a value within the interval [0 to 1], and the closer to 1, the interaction in the network is greater (Aguilar-Gallegos *et al.*, 2016). The low connection of the authors in the research network was evident since a coauthorship mean of 3.83 and a mode (49) of one author per text were found; 98 texts presented more than 6 authors, with extreme values (3 texts) of more than 24 authors.

CONCLUSIONS

The exponential growth that the publication of scientific articles has sustained in topics of agroecological strategies since the year 2010 is a reflection of the importance the topic has acquired among the scientific community as a way of generating knowledge, with the aim of seeking strategies to sustain and even increase the current production of foods, without exhausting natural resources and adapting the modes of production to the present and future climate variations. However, most of the studies have been centered on techniques for agricultural sustainability such as diversification of crops, maintenance of local genetic diversity, animal integration, addition of organic matter to the soil, and water harvest; this leaves a gap in the generation of knowledge in topics such as the creation of early climate information systems and disaster prevention and mitigation projects. Therefore, these areas represent an opportunity for a greater development of research.

The study also found that consolidated economies (USA and European countries) have promoted the development of research about the topic of agroecological strategies to strengthen food quality, while in developing countries such as the Latin American, where Mexico, Argentina, Chile and Brazil are located, it seems that the priority is food security, leaving a wide margin for the development of research in the region.

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