Article

Innovation and producers: a bibliometric analysis

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Abstract

This article presents a bibliometric mapping for innovation and producers concepts. The map allows you to observe the concepts and topics in the area as well as identify relationships between them. Two maps were generated, the first used 841 articles available in SCOPUS from 1974 to 2018 (September 27) with 285 key terms, the second used 434 articles that comprised the period from 2013 to 2018 (September 27) and 152 key terms. The VOSviewer program was used to create both maps, the key concepts and the organization of cluster co-occurrences. The results show that trends are to document innovations developed for producers, analyze the actor (producer) as a subject that adopts innovations, study different transfer strategies and disseminate innovations such as innovation systems and social networks. In the case of Mexico, the main publications were made by CIMMYT researchers and are focused on corn. It is concluded that this research topic is in force, especially to theorize on how the processes of transfer, dissemination, diffusion and adoption of innovations can be facilitated.

Keywords: adoption, diffusion, innovation system, networks, technology, transfer.

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Introduction

Innovation in agriculture arises under the justification of improving the competitiveness of production and producers. Innovating implied the introduction of new products, processes or services, could be from changing cultivation to developing new business models using innovative technologies. Therefore, innovating became the axis of development (Pisante *et al*., 2012). Under this premise, the research that has been carried out with respect to innovation in the area of primary production has had as a thread the processes of development, transfer, dissemination, diffusion and adoption of technology by users (Wigboldus *et al*., 2016).

The scientific production around innovations and producers is varied and abundant, which makes it difficult at first glance to understand the research needs in this area of knowledge. Publications have focused on documenting the limitations of small producers to adopt innovations (Shiferaw *et al*., 2009), the typology of producers during adoption processes (Abadi Ghadim and Pannell, 1999), decision-making processes of producers (Janssen and van Ittersum, 2007), to mention a few topics.

Under a context of abundance of scientific production relative to the subject of study, the objective of this research was to provide a general overview of the field of innovation and producers. However, the approach we use is different from other reviews or general essays on the subject. A bibliometric method is followed, which is based on the principle that the quantity and quality of published articles available in international databases is an indicator of the contributions that each country and institution makes to this area of knowledge (Peykari *et al*., 2015). Bibliometrics has been present in the literature for more than a century and consists of analyzing the information of publications with statistical methods to determine patterns (Hood and Wilson, 2001). Its use allows researchers to have a clear vision of a field of knowledge that has been highly prolific, which applies to research related to innovation in agriculture. Based on the generated maps and the bibliometric information it was possible to arrive at observations about the trends in this area of knowledge.

Materials and methods

In order to synthesize the existing research, determining patterns, issues and problems, as well as granting an acknowledgment of the conceptual content of the field that contributes to the development of a theory, it is necessary to carry out an adequate literature review. This process implies a methodical, organized, specific and reproducible design for the achievement of the identification, evaluation and interpretation of a body of existing documents. For the above, it relies on the use of quantitative methods, one of the performance that analyzes the publications according to authors, countries and institutes and another for the mapping of the science that uses bibliometric software (Tang *et al*., 2018).

The research of the publications was carried out using the meta-database of library services Scopus of Elsevier (www.scopus.com). Initially the search words were innovation and farmer within the title, summary and keywords, obtaining a total of 3 373 documents. Of these, it was

observed that several documents did not have a direct relationship with innovations and producers, so it was decided to restrict the search of the innovation concept to the title and farmer within the title, summary and keywords, which reduced the documents to 841. The period from which the analysis was conducted was from 1974 to 2018 (September 27, 2018). The type of documents were 633 articles, occupying 75%. Other documents were: book chapters (65), conference proceedings (59), reviews (46), articles in press (19), books (10), *erratum* (3), notes (3), conference reviews (2) and a short survey.

In order to establish the current trend of research in this area, the search period from 2013 to 2018 was limited (October 4, 2018). A total of 434 articles were obtained, of which 73% were articles, 10% book chapters, 5% conference abstracts, 5% reviews, 4% articles in press, 5 books, 2 reviews in conferences, 2 *erratum*, 2 notes and a small survey.

Content analysis

For the analysis VOSviewer software version 1.6.9 was used (Center for Science and Technology Studies, 2018). An analysis of the co-occurrence of key words and academic terms in the titles and abstracts of the publications was carried out, following a co-occurrence method, showing only the elements connected with others, the normalization-strength of association method (FA), resolution of 1.00, 100% display scale, TLS weight, label variation size of 50% and core width of 30%. The complete counting method was established, with a number of records of each term ≥10 and a minimum cluster size of 15 (van Eck and Waltman, 2010). Based on the terminology retained, maps for the visualization of the network were prepared. The algorithm was designed so that the terms that co-occurred were positioned closer to each other, with larger bubbles those more frequently. Those irrelevant terms for the map were eliminated (Kan-Yeung *et al.*, 2017).

Results

In this section a bibliometric analysis is provided for publications related to innovations and producers.

Performance analysis

841 documents have been registered from 1974 to September 27, 2018. The distribution of the publications is presented in Figure 1. From the nineties to the year 2000, a relatively stable behavior can be observed with an average of 4 publications per year. As of 2001, the trend is growing, reaching in 2017 a total of 87 published documents, with an average for this period of 40 publications per year. This translates into being an issue that has become more relevant within different areas of knowledge, mainly in agricultural sciences (27% of the publications classified in this area) and social sciences (19%), in smaller media in the area environmental (13%), economic (9), business (7%) and engineering (5%), the rest in 20 different areas of knowledge.

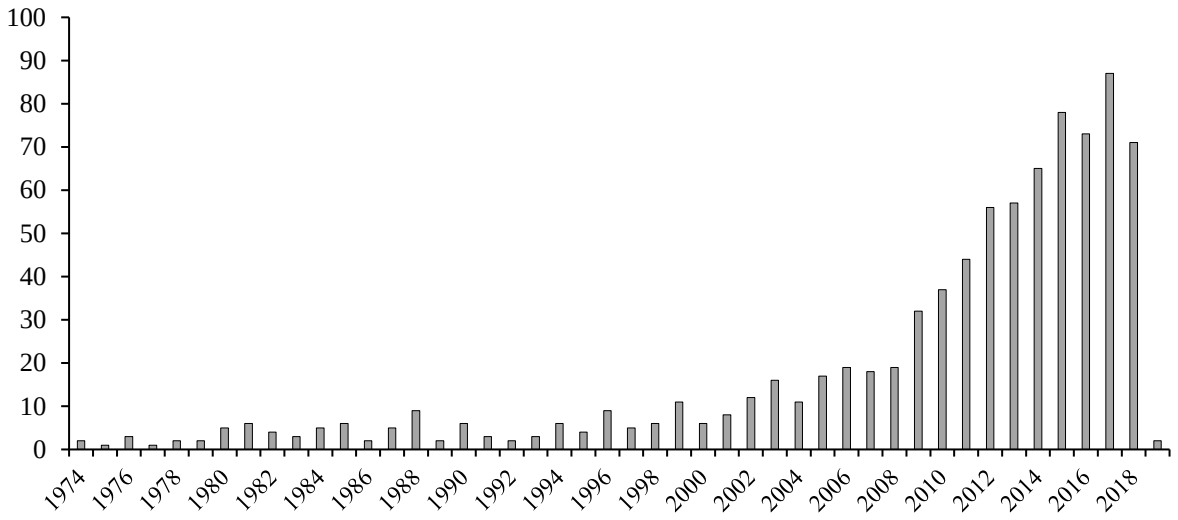


Figure 1. Distribution of publications on innovations of producers per year from 1974 to 2018 (September 27, 2018).

In the Table 1 shows the 10 main journals, countries or regions and institutes that have published issues related to innovation and producers. The five journals with the highest number of publications on the subject are: Agricultural Systems, Journal of Agricultural Education and Extension, International Journal of Agricultural Sustainability, Acta Horticulture and Experimental Agriculture. All of them are journals in the agronomic area, one focuses on extension and the rest are from the agricultural area, but with a holistic and multidisciplinary vision.

Table 1. Performance analysis: magazine, country and institute.

Pos	Journal	Pub	Country	Pub	Institution	Pub
1	Agricultural Systems	33	United States	111	Wageningen University and Research Centre	74
2	Journal of Agricultural Education and Extension	21	Netherlands	106	CIRAD Centre de Recherche de Montpellier	25
3	International Journal of Agricultural Sustainability	19	UK	76	CIRAD	20
4	Acta Horticulturae	17	France	73	INRA Institut National de la Recherche Agronomique	17
5	Experimental Agriculture	13	India	55	Universitat Bonn	16
6	Cahiers Agricultures	11	Germany	44	University of Bonn Center for Development Research	13
7	Journal of Rural Studies	10	China	37	University of Ghana	13
8	Food Policy	9	Australia	36	Innovation et développement dans l'agriculture et l'alimentation Innovation	11
9	Outlook on Agriculture	9	Italy	35	University of Zimbabwe	10
10	African Journal of Science Technology Innovation and Development	8	Canada	27	Gestion de l'Eau, Acteurs et Usages	10

SCOPUS (September 27, 2018).

Regarding the countries or region, the United States is the country with the highest number of contributions (111), this due to its focus on innovation and adoption of new technologies, secondly, the Netherlands (106 publications). Mexico registers 13 publications, occupying the 23rd place in the list of countries, second only in Latin America by Brazil with 21 publications. With regard to affiliation, 160 institutions are listed. Of the ten institutions with the highest number of publications, the universities and European institutions stand out. The institute with the largest number of publications is the Wageningen University and Research Center (74) in the Netherlands, CIRAD, INRA, Innovation et développement dans l'agriculture et l'alimentation Innovation et Gestion de l'Eau, Acteurs et Usages they are French (83), the Bonn University of Germany (29) and two African universities (23). This means that publications from European countries are concentrated in few institutions, contrary to the United States of America where publications come from different institutions. In the case of Mexico, there are two institutions: The International Maize and Wheat Center (CIMMYT) and the Autonomous University Chapingo (UACH).

In the Table 2 shows the ten most cited articles. Of the total of documents, 554 have been cited, accumulating a total of 8 152 citations. There are nine articles that have more than 100 appointments, 28 have between 50 and 99 appointments, 169 have between 10 and 49 appointments, 217 have between two and nine appointments and 131 articles have an appointment. 34% of the total has not been cited. On average, there are 14 citations per document for the period analyzed. The topics addressed by these articles in terms of innovation concepts are: organic production, agroforestry, biotechnology and land use conversion programs. While the adoption and users involve public policies, communication and historical studies. It should be noted that three of them focus on producers from developing countries.

Table 2. The 10 most cited articles on innovation and producers.

Pos	Authors (year)	Title	Journal	Quotes
1	Padel (2001)	Conversion to organic farming: a typical example of the diffusion of an innovation?	Sociologia Ruralis	237
2	Bennett (2008)	China's sloping land conversion program: institutional innovation or business as usual?	Ecological Economics	232
3	Janssen *et al.* (2010)	Assessing farm innovations and responses to policies: a review of bio-economic farm models	Agricultural Systems	227
4	Morgan and Murdoch (2000)	Organic *vs* conventional agriculture: knowledge, power and innovation in the food chain	Geoforum	225
5	Giller *et al.* (2011)	Communicating complexity: integrated assessment of trade-offs concerning soil fertility management within African farming systems to support innovation and development	Agricultural Systems	163
6	Mercer (2004)	Adoption of agroforestry innovations in the tropics: a review	Agroforestry Systems	151
7	Abadi Ghadim and Pannell (1999)	A conceptual framework of adoption of an agricultural innovation	Agricultural Economics	117

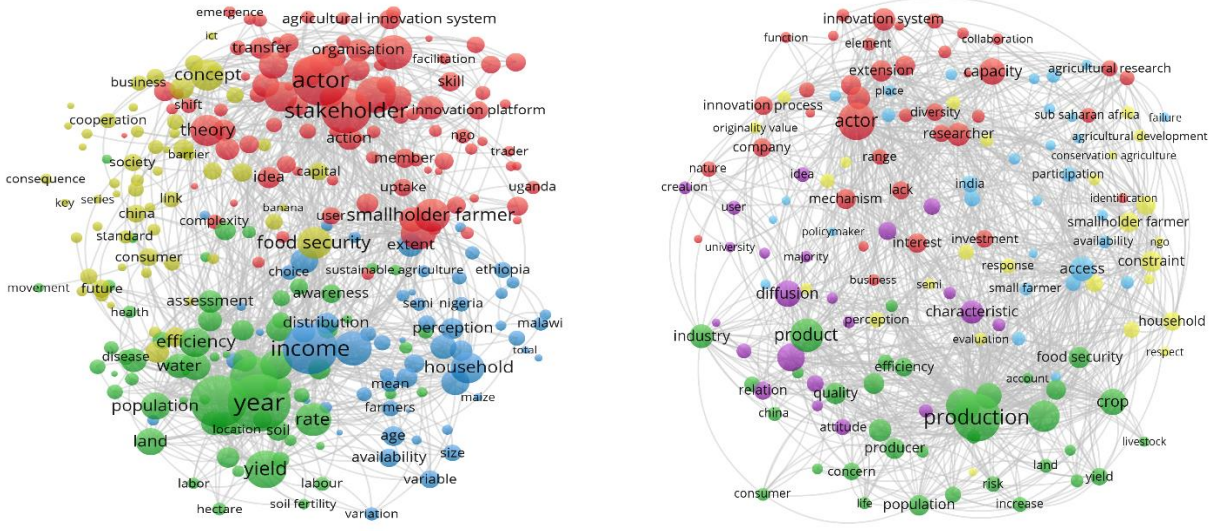
Pos	Authors (year)	Title	Journal	Quotes
8	Falck-Zepeda *et al.* (2000)	Surplus distribution from the introduction of a biotechnology innovation	American Journal of Agricultural Economics	114
9	Van Der Weide *et al.* (2008)	Innovation in mechanical weed control in crop rows	Weed Research	96
10	Guerin and Guerin (1994)	Constraints to the adoption of innovations in agricultural research and environmental management: A review	Australian Journal of Experimental Agriculture	96

SCOPUS (September 27, 2018).

Mapping of science

The analysis of words co-occurrence of terms provides an overview of research trends by reflecting the topics addressed. In analysis, it was carried out using VOSviewer software (van Eck and Waltman, 2010).

The results of VOSviewer establish 285 terms, of which those that had occurrences greater than 10 were conserved, organized in four clusters with 19 810 links. In Figure 2a, the clusters are observed: one referring to innovation in the development of new crops, another on the actor and innovation systems, the third on the characteristics of those that adopt and the fourth one that considered diverse topics such as society, government policies, entrepreneurs, sustainable development, supply chain, rural development, all related issues but that fail to consolidate as a cluster in the individual.



a) 1974-2018 (September 27) b) 2013-2018 (september 27)

Figure 2. Visualization of the innovation network and producers using the VOSviewer program. the following terms were eliminated: chapter, questionnaire, respondent, sample, theory, variable, methodology, review, literature, design methodology approach, author, concept.

Discussion

Research on innovations and producers have followed some general trends, on the one hand they document innovations developed for producers and on the other hand the processes of transfer, dissemination, diffusion and adoption of innovations. As a product of both, different strategies have emerged such as innovation systems or the use of social capital theory and social networks. These paradigms are briefly discussed in the light of the scientific evidence published during the period under review, with an emphasis on the last five years.

The development of innovations

The analyzed publications document innovations that have been introduced in agriculture such as: disease-resistant or flood-tolerant varieties, no-tillage techniques, permaculture, automated milking systems (Wigboldus *et al.*, 2016), mechanization (Van Der Weide *et al.*, 2008), transgenic (Falck-Zepeda *et al.*, 2000), pest management (Pisante *et al.*, 2012), among others.

Unfortunately, the available innovations have not managed to go from technological development in a laboratory and become processes on a social scale that allow producers to access new technologies, especially small producers (Röling, 2009). This is because researchers generally do not consider environmental, economic, institutional, social and cultural factors when proposing the transfer, dissemination, diffusion and adoption of their technological developments (Mercer, 2004; Wigboldus *et al.*, 2016).

These models: linear, technological push or technology transfer; They emphasize investing in agricultural research and technology development regardless of the impact on the adoption of technology by producers or the importance of institutions and public policies (Röling, 2009; Shiferaw *et al*., 2009).

The adoption of innovation by the actors

Since the end of the nineties, Abadi-Ghadim *et al*. (1999) observed that much of what had been done regarding this research topic had been to determine what makes a producer adopt an innovation and the innovation patterns that producers follow. This topic is still valid, since many of the research generated in the last five years are related to the same topic. For example, the importance of knowledge, attitudes and perceptions of small producers regarding agricultural and agroforestry innovations (Meijer *et al*., 2015), their abilities as administrators and their preferences of aversion or non-risk (Abadi Ghadim and Pannell, 1999 ; Ghadim *et al*., 2005), the expected gains (Mercer, 2004), as well as the producers' perceptions of their biophysical and socio-economic situation affect their decisions to participate in new practices (Nhantumbo *et al*., 2016). On the other hand, there are studies that address patterns of adoption-diffusion of innovations (Reinhardt and Gurtner, 2015), confirming or rejecting (Padel, 2001) the model proposed by Rogers (1983).

Another of the most relevant issues for the adoption of innovations was to make typologies of producers (Choi, 2016). These are carried out with the objective of proposing tailored interventions according to the group of producers, which allows more effective extension services (Nhantumbo *et al.*, 2016). In summary, the investigations focused on the actors.

Agricultural innovation systems

Since the nineties, researchers have pointed out the need to have a systemic vision when it comes to innovation proposals in agriculture (Frank, 1997). Schut *et al*. (2014) establish that the paradigm from the 1950s to the 1980s was to transfer technology to increase agricultural productivity. During the eighties, what was sought was to create typologies to overcome the limitations of producers, so that agricultural research was contextualized. In the following decade, what was promoted were agricultural knowledge systems and information systems, which sought to integrate different types of knowledge for sustainable development. Finally, since the last decade, the paradigm changed to agricultural innovation systems (AIS), this vision sought to generate and respond to changes with a systemic vision, involving institutions and actors.

Under this approach, innovation is considered the result of a process of networking and interactive learning among heterogeneous groups of actors, such as producers, industries, processors, marketers, researchers, extension agents, government officials and NGOs (Klerkx *et al*., 2010). This approach has generated research that seeks to explore and understand the multi-level interactions, for example, the effect of taxes on the import of steel in the development of agricultural machinery at the local level (Schut *et al*., 2014) or the role of the government in the development of knowledge for the integration of producers in experiments and innovations (Leitgeb *et al*., 2011).

Networks and innovation

Informal or formal personal networks or links allow, facilitate or stop the adoption of innovations, since weak networks do not allow resources between actors to complement each other and therefore innovation does not crystallize, and strong networks create blindness to developments from abroad, which also affects innovation systems (Musiolik *et al*., 2012). So, documenting the networks of producers has become an important current for this area of knowledge.

For example, researchers found that innovative producers and early adopters had larger and more varied networks compared to less innovative ones, so these must be identified to be diffusers of innovations among producers (Brown and Roper, 2017). Once they adopted an innovation, it spread; through their networks, which allowed to influence other producers socially, resulting in a social learning system (Oreszczyn *et al.*, 2010).

Other research has pointed out the importance of the networks of producers in innovation processes, highlighting the importance of cooperatives, the government, lenders, civil society actors and the market (traders and brokers), since these support the exchange of: knowledge of production, information, supplies, materials, credit, financing, price information and markets (Spielman *et al.*, 2011).

Regions where this topic has been studied

Innovation and producers, as an area of knowledge has been studied worldwide, however, it highlights the case of Africa under various themes such as: degradation (Barbier, 1998) and soil fertility (Giller *et al*., 2011), green revolution (Dawson *et al*., 2016), livestock (Dugue *et al*., 2004), cotton (Fok, 2002), agroforestry (Gladwin *et al*., 2002), rice (Teeken *et al*., 2012) and plantain (Tomekpe *et al.*, 2011) to name a few. Most studies document technical innovations.

With regard to individual countries, China stands out with topics such as: use of pesticides (Li *et al*., 2014), conservation agriculture (Lu *et al*., 2013), technological innovation in cooperatives (Luo *et al*., 2017) and social networks (Wu and Pretty, 2004; Wu and Zhang, 2013).

Among the publications for Latin America, Brazil has contributions in the area of bioenergy (Zapata *et al*., 2014), sustainability (das Chagas Oliveira *et al*., 2012), credit (Fernandes *et al*., 1978) and dairy products (Novo *et al*., 2015), to mention a few. In the case of Mexico, contributions are made on topics such as: corn (Zarazúa *et al*., 2012; Camacho-Villa *et al*., 2016; Roldan-Suárez *et al*., 2018), dairy products (Cortéz-Arriola *et al.*, 2015), livestock (Cuevas *et al.*, 2013; Gómez *et al.*, 2013), conservation agriculture (Díaz-Jose *et al.*, 2016), institutions (Dutrenit *et al.*, 2012), wheat (Reynolds and Borlaug, 2006) and shrimp (Lebel *et al*., 2016).

Conclusions

A bibliometric analysis was carried out for the concepts of innovation and producers. The analysis was first done for the period from 1974 to 2018 (September 27) with 285 key terms based on 841 articles. As it was observed that more than fifty percent of the articles were from the last five years, a second analysis was carried out that included 434 articles, generating 152 key terms. In both cases, the VOSviewer program was used. The issues that stood out and that were discussed were the development of innovations that are sometimes disarticulated from the processes of transfer, dissemination, diffusion and adoption of innovations by producers.

Another important issue that remained valid in both analyzes was that of the actors, understanding their attitudes and perceptions that limit or facilitate innovations. For the last years, the research deals with agricultural innovation systems and networks. The first emphasizes the idea that innovations should be analyzed under a systemic approach considering the various stakeholders. The second makes use of the theory of social capital and networks to understand how social innovations are disseminated who are the key actors and their practical implications.

The issue has been important at a global level, with documented studies mainly in Africa, China and India. In the case of Latin America, the country with the most contributions was Brazil. In the case of Mexico, the main publications were made by CIMMYT researchers and are focused on corn.

It is concluded that this research topic is in force, especially to theorize on the way in which the processes of transfer, dissemination, diffusion and adoption of innovations by agricultural producers can be facilitated. An urgent issue for the case of Mexico, where the innovation development centers are still unlinked from the end users.

Cited literature

Abadi, G. A. K. and Pannell, D. J. 1999. A conceptual framework of adoption of an agricultural innovation. Agric. Econ. 21(2):145-154.

Barbier, B. 1998. Induced innovation and land degradation: Results from a bioeconomic model of a village in West Africa. Agric. Econ. 19(1-2):15-25.

Bennett, M. T. 2008. China's sloping land conversion program: institutional innovation or business as usual? Ecol. Econ. 65(4): 699-711.

Brown, P. and Roper, S. 2017. Innovation and networks in New Zealand farming. Australian J. Agric. Res. Econ. 61(3):422-442.

Camacho, V. T. C.; Almekinders, C.; Hellin, J.; Martinez, C. T. E.; Rendon, M. R.; Guevara, H. F.; Beuchelt, T. D. and Govaerts, B. 2016. The evolution of the MasAgro hubs: responsiveness and serendipity as drivers of agricultural innovation in a dynamic and heterogeneous context. J. Agric. Educ. Ext. 22(5):455-470.

Centre for Science and Technology Studies. 2018. VOSviewer. Vol. 1.6.9. Leiden University, The Netherlands.

Choi, H. 2016. A typology of agro-innovation adoptions: the case of organic farming in Korea. Regional Environmental Change. 16(6):1847-1857.

Cortez, A. J.; Rossing, W. A. H.; Massiotti, R. D. A.; Scholberg, J. M. S.; Groot, J. C. J. and Tittonell, P. 2015. Leverages for on-farm innovation from farm typologies? An illustration for family-based dairy farms in north-west Michoacán, Mexico. Agric. Systems. 135:66-76.

Cuevas, R. V.; Baca, Del M. J.; Cervantes, E. F.; Espinosa, G. J. A.; Aguilar, A. J. and Loaiza, M. A. 2013. Factors which determine use of innovation technology in dual purpose cattle production units in Sinaloa, México. Rev. Mex. Cienc. Pec. 4(1):31-46.

das Chagas, O. F.; Calle, C. A. and Carvalho, L. L. F. 2012. Peasant innovations and the search for sustainability: the case of Carnaubais territory in Piauí State, Brazil. J. Sustainable Agric. 36(5):523-544.

Dawson, N.; Martin, A. and Sikor, T. 2016. Green revolution in Sub-Saharan Africa: implications of imposed innovation for the wellbeing of rural smallholders. World Development. 78:204-218.

Díaz, J. J.; Rendón, M. R.; Govaerts, B.; Aguilar, Á. J. and Muñoz, R. M. 2016. Innovation diffusion in conservation agriculture: a network approach. Eur. J. Develop. Res. 28(2):314-329.

Dugué, P.; Vall, E.; Lecomte, P.; Klein, H. D. and Rollin, D. 2004. Evolution of relations between agriculture and livestock breeding in Western and Central African savannas. A new framework to improve intervention methods and promote innovation processes. OCL-Oleagineux Corps Gras Lipides. 11(4-5):268-276.

Dutrénit, G.; Rocha, Lackiz, A. and Vera, C. A. O. 2012. Functions of the intermediary organizations for agricultural innovation in Mexico: the Chiapas Produce Foundation. Review of Policy Research. 29(6):693-712.

Falck, Z. J. B.; Traxler, G. and Nelson, R. G. 2000. Surplus distribution from the introduction of a biotechnology innovation. Am. J. Agric. Econ. 82(2):360-369.

Fernandes, J. D. B.; Filho, F. M.; Thiebaut, J. T. L.; Oliveira, E. B. D. and Casali, V. W. D. 1978. The adoption of innovations among market gardeners in Espirito Santo State and its relationship to supervised rural credit. Experientiae. 24(11):289-313.

Fok, M. 2002. Cotton future in Western and Central Africa: the challenge of combining technical and institutional innovations. OCL - Oleagineux Corps Gras Lipides. 9(2-3):115-122.

Frank, B. R. 1997. Adoption of innovations in the North Queensland beef industry. III: implications for extension management. Agric. Systems. 55(3):347-358.

Ghadim, A. K. A.; Pannell, D. J. and Burton, M. P. 2005. Risk, uncertainty, and learning in adoption of a crop innovation. Agric. Econ. 33(1):1-9.

Giller, K. E.; Tittonell, P.; Rufino, M. C.; van Wijk, M. T.; Zingore, S.; Mapfumo, P.; Adjei-Nsiah, S.; Herrero, M.; Chikowo, R.; Corbeels, M.; Rowe, E. C.; Baijukya, F.; Mwijage, A.; Smith, J.; Yeboah, E.; van der Burg, W. J.; Sanogo, O. M.; Misiko, M.; de Ridder, N.; Karanja, S.; Kaizzi, C.; K'Ungu, J.; Mwale, M.; Nwaga, D.; Pacini, C. and Vanlauwe, B. 2011. Communicating complexity: Integrated assessment of trade-offs concerning soil fertility management within African farming systems to support innovation and development. Agric. Systems. 104(2):191-203.

Gladwin, C. H.; Peterson, J. S. and Uttaro, R. 2002. Agroforestry innovations in Africa: can they improve soil fertility on women farmers' fields? Afr. Studies Quarterly. 6:1-2

Gómez, J. S.; Medel, R. R.; Escoto, F. C. and Tirado, Q. L. 2013. Role of change agents in innovation adoption by smallholder sheep farmers. Rev. Mex. Cienc. Pec. 4(3):305-318.

Guerin, L. J. and Guerin, T. F. 1994. Constraints to the adoption of innovations in agricultural research and environmental management: A review. Australian J. Exp. Agric. 34(4):549-571.

Hood, W. W. and Wilson, C. S. 2001. The literature of bibliometrics, scientometrics, and informetrics. Scientometrics. 52(2):291-314.

Janssen, S. and van Ittersum, M. K. 2007. Assessing farm innovations and responses to policies: a review of bio-economic farm models. Agric. Systems. 94(3):622-636.

Janssen, W.; Hall, A.; Pehu, E. and Rajalathi, R. 2010. Linking market and knowledge based development: The why and how of agricultural innovation systems. *In:* markets, marketing and developing countries: where we stand and where we are heading. 44-53 pp.

Kan Yeung, A. W.; Goto, T. K. and Leung, W. K. 2017. The changing landscape of neuroscience research, 2006-2015: a bibliometric study. Frontiers in Neuroscience. 11:120-127.

Klerkx, L.; Aarts, N. and Leeuwis, C. 2010. Adaptive management in agricultural innovation systems: The interactions between innovation networks and their environment. Agric. Systems. 103(6):390-400.

Lebel, L.; Garden, P.; Luers, A.; Manuel, N. D. and Giap, D. H. 2016. Knowledge and innovation relationships in the shrimp industry in Thailand and Mexico. Proceedings of the National Academy of Sciences of the United States of America. 113(17):4585-4590.

Leitgeb, F.; Funes, M. F. R.; Kummer, S. and Vogl, C. R. 2011. Contribution of farmers' experiments and innovations to Cuba's agricultural innovation system. Renewable Agriculture and Food Systems. 26(4):354-367.

Li, H.; Zeng, E. Y. and You, J. 2014. Mitigating pesticide pollution in China requires law enforcement, farmer training, and technological innovation. Environ. Toxicol. Chem. 33(5):963-971.

Lu, S. H.; Dong, Y. J.; Yuan, J.; Lee, H. and Padilla, H. 2013. A high-yielding, water-saving innovation combining SRI with plastic cover on no-till raised beds in Sichuan, China. Taiwan Water Conservancy. 61(4):94-109.

Luo, J.; Guo, H. and Jia, F. 2017. Technological innovation in agricultural co-operatives in China: Implications for agro-food innovation policies. Food Policy. 73:19-33.

Meijer, S. S.; Catacutan, D.; Ajayi, O. C.; Sileshi, G. W. and Nieuwenhuis, M. 2015. The role of knowledge, attitudes and perceptions in the uptake of agricultural and agroforestry innovations among smallholder farmers in sub-Saharan Africa. Inter. J. Agric. Sustainab. 13(1):40-54.

Mercer, D. E. 2004. Adoption of agroforestry innovations in the tropics: a review. Agroforestry Systems. 61-62(1-3):311-328.

Morgan, K. y Murdoch, J. 2000. Organic vs. conventional agriculture: knowledge, power and innovation in the food chain. Geoforum. 31(2):159-173.

Musiolik, J.; Markard, J. and Hekkert, M. 2012. Networks and network resources in technological innovation systems: towards a conceptual framework for system building. Technological Forecasting and Social Change. 79(6):1032-1048.

Nhantumbo, N. S.; Zivale, C. O.; Nhantumbo, I. S. and Gomes, A. M. 2016. Making agricultural intervention attractive to farmers in Africa through inclusive innovation systems. World Development Perspectives. 4:19-23.

Novo, A.; Jansen, K. and Slingerland, M. 2015. The novelty of simple and known technologies and the rhythm of farmer-centred innovation in family dairy farming in Brazil. Inter. J. Agric. Sustainability. 13(2):135-149.

Oreszczyn, S.; Lane, A. and Carr, S. 2010. The role of networks of practice and webs of influencers on farmers' engagement with and learning about agricultural innovations. J. Rural Studies. 26(4):404-417.

Padel, S. 2001. Conversion to organic farming: a typical example of the diffusion of an innovation? Sociol. Ruralis. 41(1):40-61.

Peykari, N.; Djalalinia, S.; Kasaeian, A.; Naderimagham, S.; Hasannia, T.; Larijani, B. and Farzadfar, F. 2015. Diabetes research in Middle East countries; a scientometrics study from 1990 to 2012. J. Res. Medical Sci. 20(3):253-262.

Pisante, M.; Stagnari, F. and Grant, C. A. 2012. Agricultural innovations for sustainable crop production intensification. Italian J. Agron. 7(4):300-311.

Reinhardt, R. and Gurtner, S. 2015. Differences between early adopters of disruptive and sustaining innovations. J. Business Res. 68(1):137-145.

Reynolds, M. P. and Borlaug, N. E. 2006. Applying innovations and new technologies for international collaborative wheat improvement. J. Agric. Sci. 144(2):95-110.

Rogers, E. M. 1983. Diffusion of innovations. 3th. (Ed.) The Free Press, New York. 367 p.

Roldán, S. E.; Rendón, M. R.; Camacho, V. T. C. and Aguilar, Á. J. 2018. Interaction management in rural innovation processes. Corpoica Cienc. Tecnol. Agropec. 19(1):29-42.

Röling, N. 2009. Pathways for impact: scientists' different perspectives on agricultural innovation. Inter. J. Agric. Sustainability. 7(2):83-94.

Schut, M.; Rodenburg, J.; Klerkx, L.; van Ast, A. and Bastiaans, L. 2014. Systems approaches to innovation in crop protection. A systematic literature review. Crop Protection. 56:98-108.

Shiferaw, B. A.; Okello, J. and Reddy, R. V. 2009. Adoption and adaptation of natural resource management innovations in smallholder agriculture: reflections on key lessons and best practices. Environ. Develop. Sustainability. 11(3):601-619.

Spielman, D. J.; Davis, K.; Negash, M. and Ayele, G. 2011. Rural innovation systems and networks: Findings from a study of Ethiopian smallholders. Agric. Human Values. 28(2):195-212.

Tang, M.; Liao, H.; Wan, Z.; Herrera-Viedma, E. and Rosen, M. 2018. Ten years of sustainability (2009 to 2018): a bibliometric overview. Sustainability. 10(5).

Teeken, B.; Nuijten, E.; Temudo, M. P.; Okry, F.; Mokuwa, A.; Struik, P. C. and Richards, P. 2012. Maintaining or abandoning African rice: lessons for understanding processes of seed innovation. Human Ecol. 40(6):879-892.

Tomekpe, K.; Kwa, M.; Dzomeku, B. M. and Ganry, J. 2011. CARBAP and innovation on the plantain banana in Western and Central Africa. Inter. J. Agric. Sustainability. 9(1):264-273.

Van Der Weide, R. Y.; Bleeker, P. O.; Achten, V. T. J. M.; Lotz, L. A. P.; Fogelberg, F. and Melander, B. 2008. Innovation in mechanical weed control in crop rows. Weed Res. 48(3):215-224.

van Eck, N. J. and Waltman, L. 2010. Software survey: VOSviewer, a computer program for bibliometric mapping. Scientometrics. 84(2):523-538.

Wigboldus, S.; Klerkx, L.; Leeuwis, C.; Schut, M.; Muilerman, S. and Jochemsen, H. 2016. Systemic perspectives on scaling agricultural innovations. A review. Agron. Sustainable Development. 36(3):36-46.

Wu, B. and Pretty, J. 2004. Social connectedness in marginal rural China: the case of farmer innovation circles in Zhidan, north Shaanxi. Agric. Human Values. 21(1):81-92.

Wu, B. and Zhang, L. 2013. Farmer innovation diffusion via network building: A case of winter greenhouse diffusion in China. Agric. Human Values. 30(4): 641-651.

Zapata, C.; Vazquez, B. D. A.; Plaza, U. J. and De Burgos, J. J. 2014. 'The biofuels program': Decreasing rural poverty and environmental deterioration through cooperative land-use innovation. *In*: collaboration for sustainability and innovation: a role for sustainability driven by the global South?: A Cross-Border, Multi-Stakeholder Perspective. 271-292 pp.

Zarazúa, J. A.; Almaguer, V. G. y Rendón, M. R. 2012. Social capital: a network case of innovation around corn in Zamora, Michoacán, Mexico. Cuadernos de Desarrollo Rural. 9(68):105-124.