ISSN 0798 1015

REVISTA ESPACIOS

HOME Revista ESPACIOS ÍNDICES A LOS AUTORES

Vol. 38 (Nº 04) Año 2017. Pág. 27

Systematic Review (SR) on the productivity of sugarcane cultivation in Brazil

Revisão Bibliográfica Sistemática (RBS) sobre a produtividade do cultivo da cana-de-açúcar no Brasil

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Recibido: 23/07/16 • Aprobado:28/09/2016

Content

ABSTRACT:
The theme of sugarcane cultivation is analyzed in a large number of scientific research in several different areas of the knowledge. However, questions about productivity, especially in recent times, occupy a smaller portion of the research found. Thus, this paper aimed to perform a Systematic Review (SR) about sugarcane cultivation in Brazil, focusing on productivity studies. With scientific rigor, this method allowed to review, systematize and analyze the accumulated scientific literature on the subject of interest. Work results reveal a wide coverage of documents on the theme, promoting a strong scientific base for the development of a systematic review. The sugarcane productivity was the central theme and guided the entire process of papers selection. Among the approaches found on literature review stands out: mechanization of harvesting and planting; genetic improvement of sugarcane; the trajectory of sugarcane cultivation in Brazil; the expansion of agricultural borders; and finally, the impact of flex-fuel technology and incentive for the production of ethanol. This work contributes not only to in-depth study of the theme, but

RESUMO:
A temática do cultivo da cana-de-açúcar é objeto de análise de grande número de pesquisas científicas, nas mais variadas áreas do conhecimento. Entretanto, as questões sobre sua produtividade, especialmente no período mais recente, ocupam uma parcela menor das pesquisas localizadas. Assim, esse trabalho teve como principal objetivo realizar uma Revisão Bibliográfica Sistemática (RBS) sobre o cultivo da cana-de-açúcar no Brasil, com enfoque nos estudos sobre sua produtividade. Com rigor científico, esse método possibilitou revisar, sistematizar e analisar a produção científica acumulada do objeto de interesse. Os resultados do trabalho revelam uma cobertura ampla dos documentos acerca do tema, favorecendo uma base científica sólida para elaboração da revisão bibliográfica sistemática. A produtividade da cana-de-açúcar foi o tema central e norteou todo o processo de seleção dos artigos. Dentre as abordagens encontradas na revisão de literatura destacam-se: a mecanização da colheita e do plantio; o melhoramento genético da cana; a trajetória da cultura canavieira no Brasil; a expansão da fronteira agrícola; e, por fim, o impacto da tecnologia

also with the proposition of using SR methodology for studies related to Agricultural Sciences.
Keywords: Mechanization, Ethanol, Research Methods, Database

flex-fuel e o incentivo à produção do etanol. Concluí-se que esse trabalho contribui não só com o estudo aprofundado do objeto de análise, mas também com a proposição da utilização da metodologia de RBS para estudos relacionados às Ciências Agrárias.
Palavras-Chave: Mecanização, Etanol, Metodologia de Pesquisa, Base de Dados

1. Introduction

The theme of sugarcane cultivation is analyzed in a large number of scientific research in various areas of knowledge. Currently, questions on crop productivity occupy a smaller portion of the localized research. However, they deserve to be checked and their results reflected, so that this study can achieve the expected goals.

This paper has as main objective to perform a Systematic Review (SR) about sugarcane cultivation in Brazil, focusing on productivity studies.

From the hypothesis that there are gaps in knowledge construction related to the study of sugarcane productivity is justified the scientific efforts of this research, especially when considering the recent analysis period.

In this context, the present study is based on the pursuit of knowledge generated under different approaches which surround the main objective of the paper. Scientific researches related to the following approaches are objects of analysis: mechanization of harvesting and cultivation; genetic improvement and varieties of sugarcane; the trajectory of sugarcane cultivation in Brazil; the expansion of agricultural borders; the impact of flex-fuel technology and incentive factors to the growth of sugarcane industry.

Therefore, it is intended to review and systematize the themes already explored through the organization of scientific production already accumulated. In order to solidify this analysis process, the use of a methodological structure which allows scientific rigor to reconstruct the thematic scenario of required search is necessary.

The adoption of SR as a method of organizing and analyzing the state of the art of a theme to be studied is more than just quantify scientific papers produced during a given period of time. The SR can be the opening of a whole field of knowledge already built, and that needs to be covered so that current research does not ignore wthat has already been produced and depart to fill the identified gaps. Thus, it is justified to tread paths already covered.

According to Biolchini et al. (2007), the SR is used to refer to a specific research methodology developed in order to gather and evaluate evidence relating to a particular topic. This method is through a secondary study that depends on the results of preliminary studies to be carried out.

Webster and Watson (2002) state that the SR should ensure that a sufficient number of relevant publications should be reviewed. Also, it can only be considered complete when the researcher does not find more new knowledge and concepts on research topic.

This study was divided into four parts to achieve the expected goal. The first, already presented, reveals the context and justification for guiding this research. Later, it is outlined the methodological structure used. The results and their discussions are presented in the third part. Finally, the final considerations are carried out.

2. Material and methods

This study is based on SR models used in other research areas, such as Biolchini et al. (2007) and Levy and Ellis (2006). These studies describe SR as a process defined by a sequence of steps and activities.

According to Levy and Ellis (2006), to achieve the results using SR three main stages should be defined: input, processing and output. The input stage takes into account the preliminary

information that will be processed, such as: classic articles related to study area, textbooks that form the knowledge of the área and reference articles recommended by experts. The processing stage refers to how the information will be transformed to generate the "outputs" which are the summaries of the results and the report.

The guide for the development of SR (Table 1) is based on Biolchini et al. (2007); Dyba and Dingsoyr (2008) and Levy and Ellis (2006). The characterization of each of the items and respective details to the development of research is presented below.

Table 1: Model for conducting the Systematic Review (SR)

A – Input	B - Processing	C- Output
A.1 - Goals A.2 - Primary sources A.3 - String searches A.4 - Inclusion criteria A.5 - Qualification criteria A.6 - Method and Tools	B.1 - Research conduction B.2 - Selection process of papers B.3 - Final selection of papers	C.1 - Registration and Archive C.2 - Synthesis and Results

Source: Adapted from Biolchini et al. (2007); Dyba and Dingsoyr (2008) and Levy and Ellis (2006).

A. Input

A.1 - Goals*:* the objectives must be aligned to the purpose of the research project. It is important that the objectives are clear and achievable. The definition of the objectives should be carried out rigorously, because they form the basis for the analysis of papers and shall define the criteria for the inclusion of them.

A.2 - Primary sources: can be considered as primary sources papers, journals and databases. These sources are important for defining the keywords, relevant papers and the main authors. A previous literature review (nonsystematic) and/or appointment with experts may contribute to the identification of classic works. It is important to define the inclusion criteria, as the need for indexing databases, timeframe, peer review, among others.

A.3 - String searches: first, the words and terms related to the research theme must be identified. This is possible from preliminary studies of the sources and also by directions from experts and researchers. To build strings you must follow a process of definition, testing and adaptation. It should be understood and test the logical operators in the advanced search or Boolean [5] search in this process. In order to give more importance to the work, it is important to adopt a reference database.

A.4 - Inclusion criteria: starting from the research objectives is defined the criteria for inclusion of papers. The inclusion criteria assume the role of filters, restricting searches and separating the selected materials.

A.5 - Qualification criteria: are used to evaluate the importance of papers which have been approved after application of filters. In this analysis several factors can be considered, such as: research method used, number of citations, journal impact factor in which the paper was published, among others.

A.6 - Method and Tools: this step involves the systematization of research method and the definition of tools to be used in the process. It must be defined: the research steps, research filters, execution sequence, the adopted databases, the storage form of the selected material, among others. The working method should contribute to learning process through the search refinement and realization of cross-searches from the references cited in the articles found.

B. Processing

B.1 - Research conduction: this process involves the steps of search by periodical, cross-search and the search for database. Search strings must be used. At this stage there is a large collection of documents of interest.

B.2 - Selection process of papers: at this step is performed the reading and analysis of the results obtained from adopted filters (inclusion criteria). Selected papers are separated for further refining.

B.3 - Final selection of papers: from the application of qualification criteria the resulting papers are selected. These latter will go through further analysis in order to support the final report.

C. Output

C.1 - Registration and Archive: the selected items must incorporate a repositor. The process of cataloging and archival of this material is essential to facilitate the processing, sharing and analysis of data.

C.2 - Synthesis and Results: finally, the synthesis of the studied bibliography should be developed through a report, which may take the form of a section of literature review. Issues such as the evolution of concepts, authors, number of papers, among others, become important indications to identify the state of the art concerning the theme.

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3. Results and discussions

3.1. Input - papers of interest collection

The process of collection and selection of research papers occurred based on the adoption of three databases and a virtual library, respectively, the Scientific Electronic Library Online (SciELO), the Scopus, the Web of Science and CAPES Periodical Portal. From the previous experience of the authors is assumed that such databases are the most representative for the research themes adopted.

SciELO, although considered as a database, alsos call itself as na electronic library. This base covers 344 scientific journals exclusively Brazilians. This base is divided into eight fields of knowledge: Agricultural Sciences, Biological Sciences, Health Sciences, Exact and Earth Sciences, Applied Social Sciences, Engineering, Linguistics, Literature and Arts (SciELO, 2015).

With the status of biggest world's scientific literature database, Scopus contains abstracts, citations and full texts, indexing more than 22,000 titles published in more than 5,000 international publishers. Of these, 20,000 titles are peer reviewed. In 2014, this base gathered over 400 Brazilian papers (SCOPUS, 2014).

Regarded as one of the major world reference database, Web of Science provides access to 20,606 multidisciplinary journals with over 12,000 high impact journals worldwide. The base also includes open access scientific journals, as well as other types of documents (WEB OF SCIENCE, 2015). Currently the Web of Science includes 114 Brazilian journals (Rodrigues, Quartiero and Neubert, 2015).

Unlike the three above mentioned databases, the Capes Periodical Portal is a virtual library which has more than 37,000 titles wtith full texts, integrating 126 reference databases and 11 bases dedicated exclusively to patents. Also includes books, encyclopedias, technical norms, audiovisual content and statistics (CAPES, 2015).

3.2. Processing - selection, cataloging and analysis of selected papers

The criteria and assumptions adopted in the search and selection process of papers, according

to the research theme, are presented in Table 2.

Table 2: Criteria and assumptions adopted in the search and selection process of papers.

Criteria	Assumptions
Databases and virtual library	SciELO, SCOPUS, *Web of Science* and Capes Periodical Portal
Date of collection	Search dates performed in this research are presented to fix the time of collection, as it is considered the possibility of moving contents in databases from time to time.
Filter 1	To start the search process, the "sugarcane" keyword was chosen, which is the main information source of research subject. The adoption of the word in English was intended to cover the largest possible number of documents. It is considered that the papers published in Portuguese are also included in this process, as they are obtained from the registered abstracts.
Filter 2	In performing an advanced search (Boolean) were defined keywords to achieve the greatest possible number of documents related to the research theme. The boolean search employed in this filter used the following criteria sequence: "sugarcane" OR "cana-de-açúcar" AND "Brazil" The adoption of the word "Brazil" was used as a way to geographically restrict the collection of papers.
Filter 3	This filter was different in each database, depending on the diversity of search engines characteristics. However, it can be considered the predominance of the following criteria: time frame collection (2000-2015); selection of only journal papers and, finally, the restriction to the following thematic areas of interest: Agricultural Sciences, Applied Social Sciences and Exact and Earth Sciences.
Filter 4	For the selection of papers of interest, in this first stage of selection, careful readings were performed in relation to the title, the abstract and keywords.

Source: Prepared by the authors.

The process sequence, the description of the criteria and the results of each step are briefly presented in Table 3. Through the deployment of the four mentioned filtering criteria were obtained 159 journal papers, divided into: 39 articles from Capes Periodical Portal, 39 from SciELO, 42 from Scopus and 39 from Web of Science.

After papers selection step was finished in the various databases, the composition of a single database (Cataloging) was performed, enabling the verification of repeated studies. In this process, it was found that 28 of the 159 items appear in more than one database. Thus, after proper exceptions, it reached a final database of 131 selected papers.

Table 3: Results of the filtering process and selection of papers of interest.

DATABASE	Capes Periodical Portal	SciELO	SCOPUS	*Web of Science*

<table>
<tr><td>Date of collection</td><td>08/25/2015 and 08/26/2015</td><td>08/27/2015 and 08/28/2015</td><td>08/29/2015 and 08/30/2015</td><td>08/31/2015 and 09/01/2015</td></tr>
<tr><td>Filter 1 (String searches)</td><td>"sugarcane"</td><td>"sugarcane"</td><td>"sugarcane"</td><td>"sugarcane"</td></tr>
<tr><td>Results 1</td><td>52,331 documents</td><td>1,942 papers</td><td>15,326 documents</td><td>29,911 documents</td></tr>
<tr><td>Filter 2 (Boolean search)</td><td>"sugarcane" OR "cana-de-açúcar" AND "Brazil"</td><td>"sugarcane" OR "cana-de-açúcar" AND "Brazil"</td><td>"sugarcane" OR "cana-de-açúcar" AND "Brazil"</td><td>"sugarcane" OR "cana-de-açúcar" AND "Brazil"</td></tr>
<tr><td>Results 2</td><td>899 documents</td><td>481 papers</td><td>1,700 documentos</td><td>1,011 documents</td></tr>
<tr><td rowspan="4">Filter 3</td><td>- Selection period: 2000-2015</td><td>- Selection period: 2000-2015</td><td>- Selection period: 2000-2015</td><td>- Publication Years: 2000-2015</td></tr>
<tr><td>- Only journal papers</td><td>- Thematic areas: Agricultural Sciences</td><td>- Document Type: Papers</td><td>- Search domain: Science Technology</td></tr>
<tr><td>- Peer-reviewed journals</td><td>- Thematic areas: Applied Social Sciences</td><td rowspan="2">- Subject Area: Agricultural and Biological Science; Management and Account; Economics, Econometrics and Finance</td><td>- Subject Area: Agriculture, Business Economics e Energy Fuels</td></tr>
<tr><td></td><td>- Thematic areas: Exact and Earth Sciences</td><td>- Document Type: Papers</td></tr>
<tr><td>Results 3</td><td>310 papers</td><td>351 papers</td><td>779 papers</td><td>620 papers</td></tr>
<tr><td>Filter 4</td><td>Reading of title, abstract and keywords</td><td>Reading of title, abstract and keywords</td><td>Reading of title, abstract and keywords</td><td>Reading of title, abstract and keywords</td></tr>
<tr><td>Results 4</td><td>39 papers</td><td>39 papers</td><td>42 papers</td><td>39 papers</td></tr>
</table>

Source: Prepared by the authors.

Detailed readings were taken related to the "Introduction" and "Conclusion" sections of the 131 papers cataloged. Thereby, this step promoted the final filter of papers, resulting in 32 articles. In this step, the complete reading of selected papers was performed, enabling viewing the scenario in which is the state of the art concerning the analysis of this research theme.

It was noted that 78% of papers selected were published between 2011-2015, which turns the literature review very actual. In addition, one half of the papers were published in English and

the other half in Portuguese.

From the index SCImago [6], table 4 systematize and shows the indicators "Quartile", "IF" and "h-index" [7] periodicals corresponding to 32 selected papers. Of the total, ten papers were located in Scopus, nine in Capes Periodical Portal, eight in Web of Science and five in SciELO. It is noteworthy that five papers are not in the SCImago, however, they were considered for analysis because they present relevant content for this research.

Table 4: Relevant indexes of representative journals of 32 selected papers.

Journals	Number of papers	Quartile	IF	h-index
• Engenharia Agrícola	5	Q2	0.413	15
• Pesquisa Agropecuária Tropical	3	Q2	0.361	6
• Ciência Rural	2	Q2	0.356	21
• Applied Energy	1	Q1	3.149	82
• Ecological (Applications)	1	Q1	2.249	155
• Biotechnology for Biofuels	1	Q1	2.146	37
• PLoS ONE	1	Q1	1.300	153
• Energy Policy	1	Q1	2.077	108
• Land Use Policy	1	Q1	1.316	57
• Agricultural Systems	1	Q1	1.205	67
• Industrial Crops And Products	1	Q1	1.002	67
• Global Change Biology Bioenergy	1	Q1	0.622	151
• Revista Brasileira de Engenharia Agrícola e Ambiental	1	Q2	0.600	19
• Australian Journal of Crop Science	1	Q2	0.424	16
• Crop Breeding and Applied Biotechnology	1	Q2	0.350	11
• Bioscience Journal	1	Q2	0.326	8
• Revista de Ciências Agrárias	1	Q2	0.268	5
• Tropical Plant Biology	1	Q3	0.622	12
• Revista de Economia e Sociologia Rural	1	Q3	0.413	6

• Revista Ceres	1	Q3	0.256	3
• Revista Brasileira de Medicina do Trabalho	1	Q4	0.187	2
• Cepal Review	1	Q4	0.108	5
• Revista Engenharia na Agricultura	1	* N/R	* N/R	* N/R
• Revista Gestão & Conexões	1	* N/R	* N/R	* N/R
• Revista Sociedade & Natureza	1	* N/R	* N/R	* N/R
• Future Studies Research Journal: Trends and Strategy	1	* N/R	* N/R	* N/R
• Cientifica (Jaboticabal)	1	* N/R	* N/R	* N/R

* N/R - Not reported in SCImago
Source: Prepared by the authors based on SCImago index

It is noted that the journals with more selected papers to compose the area of interest of the research were: Engenharia Agrícola (5), Pesquisa Agropecuária Tropical (3) and Ciência Rural (2). From the 22 journals selected by SCImago, 17 (77%) are classified in quartiles Q1 and Q2, which indicates greater visibility. In these journals the Impact Factor (IF) has a range between 0.108 and 3.149 and the h-index there is a range between 2 to 155. The following journals are highlighted with high IF values or h-index: Applied Energy; Ecological (Applications); Biotechnology for Biofuels and Energy Policy.

3.3. Output - Report of Systematic Review

Based on the selected papers, the analysis were grouped into recurring themes (Table 5). It is noteworthy that some authors transited in more than one of the selected approaches.

Table 5: Main approaches found in selected papers.

Approaches	Authors	Databases	Quantity
Mechanization - cultivation and harvesting	Abreu et al. (2009); Capaz, Carvalho and Nogueira (2013); Cassia et al. (2014); Lemos et al. (2014); Ripoli and Ripoli (2010); Santos, Fernandes and Gadanha Junior (2015); Silva et al. (2008); Silva et al. (2015); Voltarelli et al. (2014)	Capes Periodical Portal; SciELO; *Web of Science; Web of Science*; Scopus; Scopus; *Web of Science; Web of Science*; Scopus.	9
Genetic improvement of sugarcane	Arruda (2011); Barbosa et al. (2012); Campos et al. (2014); Carvalho and Furtado (2013)	Capes Periodical Portal; SciELO; Scopus; Scopus.	4
Trajectory of sugarcane cultivation in Brazil	Meurer, Shikida and Vian (2015); Rezende and Richardson (2015); Strachman and Pupin (2011)	Scopus; Scopus; Scopus.	3

Expansion of agricultural borders	Aguiar and Souza (2014); Carvalho et al. (2011). Ferreira Filho and Horridge (2014); Guimarães, Tureta and Coutinho (2010); Lourenzani and Caldas (2014); Marin and Nassif (2013); Martinelli and Filoso (2008); Petrini and Rocha (2014); Picanço Filho et al. (2012); Rachid et al. (2013); Silva and Miziara (2011)	Capes Periodical Portal; Capes Periodical Portal; Capes Periodical Portal; SciELO; SciELO; Scopus; *Web of Science*; SciELO; Scopus; Scopus; Capes Periodical Portal.	11
Impact of flex-fuel technology and ethanol incentive factors	Chen, Nunes and Xu (2015); Dalchiavon et al. (2014); Furtado, Scandiffio and Cortez (2011); Goldemberg (2008); Santos, Favaro and Parente (2010)	Capes Periodical Portal; Capes Periodical Portal; *Web of Science; Web of Science; Web of Science*.	5

Source: Prepared by the authors.

One of the most discussed issues refers to the **mechanization of cultivation and harvesting**. Nine papers related to this approach were found. Silva et al. (2015) analyze the visible losses during mechanical harvesting, correlating them with the speed of the harvesting machines. The authors discuss the importance of harvest mechanization for the sugarcane sector, since it is less intrusive and has lower operating costs compared to manual harvesting, but they argue that still needs to be improved. Silva et al. (2008) evaluated the losses in mechanical harvesting of sugarcane through quality indicators of harvest process. This issue was also discussed by Santos, Fernandes and Gadanha Júnior (2015).

Carvalho et al. (2011) analyzed the productivity and economic viability of sugarcane. They observed that the soil compaction caused by mechanical harvesting, resulted in decreased productivity. The changes caused by replacement of semi-mechanized system for mechanized system of sugarcane cultivation were studied by Lemos et al. (2014).

Abreu et al. (2009) identify the social impact caused by sugarcane harvest mechanization and point out the determinants factors for the growth of mechanization, such as: legislation, social and political pressure and environmental issues, mainly resulting from problems caused by burnings. The authors also point out the consequences brought by the harvest mechanization: harvest time reduction; the reduction of the hiring of manpower and the need for qualification of workers.

Voltarelli et al. (2014) analyzed the planting and harvesting mechanized through statistical control process tool. They also state that Brazilian sugar and alcohol industry is globally recognized for its investments in new technologies, with emphasis on mechanization. Ripoli and Ripoli (2010) discuss the issue related to the high variation in agricultural sugarcane productivity stating that this is not only due to genetic factors, but rather point that productivity variations can be corrected with the best preparation of soil and adaptation to mechanical planting.

Cassia et al. (2014) point to the growth mechanical harvesting, especially in areas of agricultural expansion of sugarcane, as the states of Mato Grosso do Sul and Goiás. They also address the issue of damage to harvested cane as well as the cane roots, giving the responsibility to baseline cut and sharp deflection of the cane stalks.

Capaz, Carvalho and Nogueira (2013) highlight that global ethanol production is concentrated in two countries, Brazil and United States, which together represent approximately 80%. They claim that the expansion of the global biofuels market is accentuated and reflect concerns about sustainability, especially food safety issues, agricultural commodities, deforestation, monoculture and working conditions. In this context, they describe as a mechanical harvesting

process that seeks to mitigate adverse effects, both environmentally and socially.

Regarding **genetic improvement of sugarcane** approach, Carvalho and Furtado (2013) discuss the challenges posed by climate conditions and changes in industry regulations. Such challenges include overcoming time to launch new varieties on the market; internal infrastructure; transfer of technology to the field; lack of government support and genetic complexity of sugarcane.

Barbosa et al. (2012) trace a historical reconstruction of the foment agencies intended to support for genetic improvement research. The authors contextualize the Inter-University Network for the Development of Sugar and Ethanol Industry (Ridesa); the National Ethanol Program (PROALCOOL); the Central Cooperative to Sugar and Alcohol Production of state of São Paulo (Copersucar) and the Center for Sugarcane Technology (CTC), as well as highlight the importance of Federal University of São Carlos (UFSCar) and the Agricultural Economic Institute (IEA) to the development of research in this area.

Campos et al. (2014) explain the low productivity of Goianian savanna due to the absence of varieties developed to the region, which has a large water deficit. According to the authors, the lack of variety adapted to the reality of the region can be considered as the main factor of variation in productivity.

Arruda (2011) discusses the prospects for the Brazilian sugar and alcohol industry, from the genetic improvement and breeding new varieties produced by CTC and by Institute of Sugar and Alcohol (IAA). The author points out as the main challenge the creation of high yielding varieties for areas of new agricultural borders.

As regards the **trajectory of sugarcane cultivation in Brazil**, Rezende and Richardson (2015) bring an analysis of the economic viability of sugar and ethanol production in Brazil, at the prospect of future prices. In a recent historical context they point out the main difficulties that Brazil has been facing and attribute the low prices of sugar and ethanol to the negative results obtained in 2007/08 and 2008/09 harvest periods. They also say that the global financial crisis of 2008 reduced the availability of credit, influencing investments in new varieties.

According to Strachman and Pupin (2011), this situation caused also a strong reduction in the renewal rate of sugarcane plantations generating productivity decrease over the years. It is observed that politics of gasoline price control established by the government did not encourage ethanol consumption.

Meurer, Shikida and Vian (2015) trace a characterization of the sugarcane industry in Brazil's Midwest and contextualize within the national development history of this sector. Campos et al. (2014) discuss historical context of sugarcane in Brazil, including world market characterization.

The **expansion of agricultural borders** of sugarcane was another widely discussed topic in selected items. Silva and Miziara (2011) trace the progress of this sector in the state of Goiás as new agricultural border. The authors used this state as a basis for delimiting the model of expansion of sugarcane and the assessment of soil use between 2002 and 2009. The authors Picanço Filho et al. (2012) deal with sugarcane policy network and its power resources occurred in the state of Goiás.

Guimarães, Turetta and Coutinho (2010) discussed the expansion of the agricultural borders of sugarcane in the state of Mato Grosso do Sul. The authors attribute the expansion in the state to lower land prices than in other regions, as well as its proximity to countries that integrate Mercosul and the state of São Paulo, placing it in a geographically strategic position. Martinelli and Filoso (2008) indicate the climatic and topographic conditions of the Midwest as a success for the expansion of agricultural borders. Petrini and Rocha (2014) report that the great expansion of sugarcane is due to the incorporation of new planting areas in detriment of the conversion of cropland and rangeland, and not in terms of improved productivity.

Starting from the establishment of Agroecology Zoning of Sugarcane, conducted in 2009, Marin

and Nassif (2013) affirm that Brazil had the availability of more than 66,000 hectares of land suitable for the expansion of sugarcane cultivation. The Midwest stands out as the region that had the highest percentage of land suitable for the realization of sugarcane expansion, with 45% of the total estimated.

Meurer, Shikida and Vian (2015) argue, through satellite mapping carried out in the Central-South region, that the expansion of sugarcane area should occur mainly in the states of Mato Grosso do Sul, Goiás and Minas Gerais. Rachid et al. (2013) talk about the expansion of production of sugarcane in savanna due to the bioethanol production. The authors point out that in the last five years the cultivated areas in the states of Mato Grosso do Sul and Goiás increased more than 300%. Petrini and Rocha (2014) also attribute the expansion of sugarcane in the Midwest to the growing demand for biofuel.

Aguiar and Souza (2014) use the shift-share model to analyze the impacts of expansion in eight major producing states. Among them, the states of Mato Grosso do Sul and Goiás present the advancement of sugarcane to replace agricultural areas previously used for the production of soybeans, corn, beans, rice and pastures.

Lourenzani and Caldas (2014) discussed the changes in land use caused by the expansion of sugarcane cultivation in the period between 2003 and 2012, in the Midwest of São Paulo. Ferreira Filho and Horridge (2014) also deal with the implications of expansion of ethanol on changes of land use.

The study of Carvalho et al. (2011) address the growth of this sector in Mato Grosso do Sul through the analysis of productivity and economic viability of sugarcane due to soil preparation.

Five papers were found regarding the **impact of flex-fluel technology and ethanol incentive**. Santos, Favaro and Parente (2010) trace an ethanol chronology summarizing it in four periods. The first is referred to as moderate expansion (1975 to 1979). The second is called the accelerated expansion that occupies the period from 1980 to 1985. The third (1986-1995) occurs during the downswing and crisis. Finally, the period "after 2003" when ethanol returns to be encouraged as a result of the flex-fuel engine technology.

Dalchiavon et al. (2014) discuss the socio-economic importance of the culture of sugarcane in Brazil, as being the main raw material for the production of ethanol used by motor vehicles. They affirm that knowledge of sugarcane productivity can be achieved by their technology and production components, using statistical techniques that allow to estimate it.

Goldemberg (2008) evaluates the technological characteristics of ethanol as fuel. The author also discusses the future perspectives for ethanol in Brazil and discusses the possibilities of expanding production of ethanol through sugarcane. He still features questions about the relationship between ethanol and engines, evaluating it as superior to gasoline by presenting lower pressure and, consequently, lower pollutant emissions, besides presenting a lower risk of flammability.

Lourenzani and Caldas (2014) contextualize the development of flex-fuel technology as being responsible for encouraging the demand of ethanol and, as a result, opened a new phase of expansion of the sugarcane cultivation in Brazil.

Chen, Nunes and Xu (2015) argue that the production of biofuels has received support from governments around the world for various reasons, among which are highlighted: the search for increased energy security; concern about accelerated climate change and promoting rural development. In Brazil, the same authors also describe the National Ethanol Program (PROALCOOL) established in 1975 as the main government support. However, in 1990 government reduced subsidies to ethanol and starts an industry deregulation process, although it kept the mixture of ethanol in the gasoline. Such policies, together with the commercial success of flex-fuel vehicles, contributed to the development of the ethanol industry in the country.

According to Furtado, Scandiffio and Cortez (2011) ethanol has attracted attention around the

world for two main reasons. First, it is a viable alternative to fossil fuels for lightweight vehicles like those of flex-fuel engines. Second, ethanol is a renewable energy source and reduces the impact of greenhouse gas emissions. The authors also say that the success of Brazil with sugarcane can not be understood only as result of an advantage derived from natural resources. Above all, it is the result of a virtuous trajectory of technological learning strongly based on innovation.

4. Conclusions

With scientific rigor proposed by the SR methodology used in this research it was possible a wide coverage of the documents concerning the theme under analysis. Thus, providing a scientific basis for the contributions submitted.

The sugarcane productivity was the central theme of this research and guided the entire process of papers selection. Among the approaches found on literature review stands out: mechanization of harvesting and planting; genetic improvement of sugarcane; the trajectory of sugarcane cultivation in Brazil; the expansion of agricultural borders; and finally, the impact of flex-fuel technology and incentive for the production of ethanol.

The methodology applied allowed to verify the degree of visibility and relevance of selected scientific production by means of indicators (Quartile, Impact Factor and h-index). In this context it is possible to highlight the systematic literature review quality on productivity of sugarcane cultivation in Brazil.

Finally, it is concluded that this study contributes not only to the in-depth study of the object of analysis, but also with the proposition of using the SR methodology for studies related to Agricultural Sciences.

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5. The Boolean model is based on set theory. Documents are retrieved from the conditions specified by the user, who can also use Boolean operators ‘or’, ‘and’ and ‘not’ to establish specific relationships with occurrence of keywords (Souza, 2006, p.166).

6. The SCImago index evaluates the journals from the amount of citations received in the last three years. This index takes into account the origin of the citations (if comes from leading journals or median) and the logic of self-citations to each subarea. Thus, it is considered that the SCImago content is more qualitative and contextual that the impact factor (SCImago, 2015).

7. Quartile is a division into four portions and distributed in a position table (Rank in Category) that gives the position occupied by the journal in each category in which is included based on the Factor impact (FI) that is measured by means of the citations that papers received. As most quoted is the periodical, greater is the importance to the área. The h-index quantifies the production based on the most cited papers, i.e., the number of papers with citations greater than or equal to this number (SCImago, 2015).

Revista ESPACIOS. ISSN 0798 1015
Vol. 38 (Nº 04) Año 2017

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