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Mapping Scientific Production in Agriculture 4.0 in Brazil Indexed to Google Scholar

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ABSTRACT: Agriculture has been a sustaining sector of Brazil's economy for many years. Not unlike other sectors, agribusiness has been heavily impacted by unprecedented technological advances, a fact that gave rise to the so-called Agriculture 4.0. The objective of this study is to map academic productions on the theme Agriculture 4.0 indexed in the Google Scholar base in the period between 2015 and April 2021. To achieve the expected objective, bibliometrics was used as a technique for measuring publications. The results show an increase in the number of publications over the researched period, in addition to the predominance of male authors in the publications. More than a third of the publications are of single authorship and the predominant means of dissemination are the annals of scientific events (47.37%), followed by magazines and periodicals.

KEYWORDS: Agriculture 4.0, Brazilian Agriculture, Intellectual Mapping, Scientific Production, Bibliometrics.

I. INTRODUCTION

From the moment that man took up residence, he started to produce for his survival, looking for tools that would facilitate the work and speed up production. The climax of this process took place with the Industrial Revolution, with the use of the new driving force that provided for the intensification of the use of machinery in all stages of production. The evolutions were not restricted to machine mechanization; Information and Communication Technology (ICT) also represented a significant technological transformation, influencing agribusiness through the digitization of agriculture, in order to connect technologies, helping in decision-making and rural management (Massruhá, Leite and Moura, 2014).

Although there are challenges in the application of Agriculture 4.0 in Brazilian territory, there is a lot of expectation with the results that can be obtained: increase in productivity indices, increased yield in the use of inputs, reduction of labor and operations costs (Carraro, Godinho Filho and Oliveira, 2019), improving the quality of work and the safety of workers and reducing impacts on the environment. Precision agriculture, agricultural automation and robotics, big data techniques and the Internet of Things are tools that encompass and facilitate the development of Agriculture 4.0.

Major global challenges such as climate change, finite resources, the need to ensure food in quantity and quality for future generations, demographic changes, among others, exert increasing pressure on the agricultural sector, requiring a more critical and cohesive posture with these demands. In this sense, there is a more general understanding that Agriculture 4.0 can be a great ally in the face of these challenges.

This study aims to map academic productions on the theme Agriculture 4.0 in the Google Scholar database from 2015 to April 2021. In addition to this introduction, this article is structured with a literature review section where contextualization is made about the history of production rural, agriculture 4.0 and its challenges, methods, impacts, potentials and projections; a section where the adopted methodology is explained; followed by the presentation of data and discussion and, finally, the conclusion.

II. LITERATURE REVIEW

2.1 History of rural production

In the 16th century, Brazilian agriculture began in the Northeast region, with the adoption of Hereditary Captaincies, in which the activity of monocultures, slave labor and large estates prevailed, with emphasis on the cultivation of sugar cane (Mattos, Innocentinni and Banellini, 2012).

Over time, the rural worker added to the management tools that facilitated and accelerated production. Until the 18th century, the use of oxen and horses as the traction force of wooden plows and manual handling was predominant, which greatly compromised productivity. The great evolution came from the Industrial Revolution, in the 18th century, which contributed to the creation of technologies applied to rural work. Huge steam-

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powered vehicles were used, which could increase the agility in carrying out tasks, and this process of inserting machines in agriculture became known as field mechanization (NETO, 2020).

According to Neto (2020), at the turn of the 20th century, with the introduction of the combustion engine, the most drastic changes occurred, combined with advances in research on pesticides and fertilizers. The new tractors now powered by gasoline were then responsible for towing and refuelling seeders, harvesters, sprayers, among other machines, which increased production to a level never seen before. Thus, the use of machinery and mechanization came to accompany rural work in all stages of production, from preparing the soil for cultivation to maintaining the crop and harvesting.

Extrapolating the study of machine mechanization, the researches advanced to the field of Information and Communication Technology (ICT). The evolution of ICT in Agriculture is presented in 3 phases (Table 1).

Table 1: Evolution of ICT in Agriculture

19885-2000	2000-2015	2015-2030
•Mono-multi user •Desktop software •commercial internet •Central computer •Adaptive search	•Social networks • Mobile apps •Mobile Internet •Cloud computing •Systemic research	•Integrated systems •Big Data/Analytics •Internet of Things •Robotics •Complex search

Source: EMBRAPA (2019)

Neto (2020) informs that, throughout history, agribusiness has appropriated very well the advances provided by technology. Initially called digital agriculture, it signaled a set of technologies that assisted the producer in rural activities, including devices and software to collect and analyse data about the crop and enable better strategic decisions. Technological transformation comes to agribusiness initially through the digitization of agriculture, and is not restricted to certain cultures, products, or regions, and encompasses all locations, in a transversal and interdisciplinary way, with the use of ICTs.

1.2 Agriculture 4.0

According to Vasconcelos (2018), the concept of Agriculture 4.0 is directly linked to the scenario of the Fourth Industrial Revolution, which represents an advance in technologies that transformed the way people live, impacting all sectors of the economy, especially the countryside. Agribusiness is defined as the set of operations in the production chain, from the choice of inputs to marketing, involving agricultural and livestock activities; the use of integrated technologies through software, equipment and systems should optimize agricultural production at all stages (Neto, 2020; Oliveira and De-Carli, 2021).

In the agricultural sector, the advancement of technology involves techniques, mathematical calculations using machine knowledge, image processing with information obtained through sensors installed in the field and the use of digital images. All these processes, together, have the objective of assisting in the activities carried out in the crops, monitoring rainfall and humidity, generating genetic improvement, offering irrigation techniques, in addition to diagnosing the emergence of possible pests (Monteiro, Oliveira and Nakai, 2014).

According to Vasconcelos (2018), the fourth revolution in agriculture involves essential technological innovations in the fields of automation, control and information technology, such as data sharing, genome editing and Artificial Intelligence, used in the procedures that take place in the fields; involves monitoring farms through sensors that are interconnected to the internet (Internet of Things) and result in data that is filtered, stored in a cloud system and subsequently analyzed.

Agriculture 4.0 will be a major contributor to food production and fundamental to global food security, generating a breakthrough in the efficient use of inputs and natural resources, reducing impacts on the environment. Therefore, the role is to ensure that future generations can be fed with quality and safety, involving sustainable production and consumption (Vasconcelos, 2018).

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2.2.1 Challenges of Agricultural Management 4.0

Technology is the basis of Agriculture 4.0, which is one of the biggest challenges faced, as technological standardization is needed to ensure the compatibility of equipment, determining the capacity of farmers to invest in modernization (Bonneau et al., 2017).

Ribeiro, Marinho and Espinosa (2018), point out that the world population is constantly growing, with an estimated increase of 33%, reaching 10 billion people in 2050, which will increase the pressure for food demand. The production made to meet such demand must be reconciled with environmental preservation, with the aggravation of the fact that the world's agricultural lands are becoming increasingly inadequate for production, becoming degraded and possibly infertile in the future (Clercq,Vats and Biel, 2018).

Finally, but not exhaustively, another challenge that is imposed refers to the emission of greenhouse gases (GHG), which reached the highest level in history, according to the Intergovernmental Panel on Climate Change (IPCC), with agriculture being one of the largest producers of GHG, whose emission has doubled in the last 50 years. In view of the highlighted facts, climate change resulting from GHG emissions will result, in the long term, in environmental problems such as reduction of groundwater and soil degradation (Ribeiro, Marinho and Espinosa, 2018).

2.2.2 Methods Adopted in Agriculture 4.0

The search for improvement in the use of natural resources and inputs will make the farm of the future excessively monitored and automated. Sensors dispersed across properties and interconnected to the Internet (Internet of Things) will generate large volume data (Big Data) that will need to be filtered, stored (cloud computing) and analyzed. After data management through computational intelligence techniques, remote commands are generated to tractors and agricultural implements that, equipped with GPS, will carry out operations in the necessary locations, resulting in an optimization of costs, production and environmental impacts (Massruhá, 2015).

Ribeiro, Marinho and Espinosa (2018) emphasize that the use of precision agriculture is one of the main tools of Agriculture 4.0, as it enables the guidance of vehicles and specific monitoring and control to the displacement location, improving the accuracy of operations. The use of drones with increasingly advanced sensors and image resources and real-time monitoring, allowed the damage to crops to be reduced; the activities performed by this device are: soil and field analysis, seed planting, crop spraying and monitoring, irrigation and crop health assessment (Oliveira, 2016).

The development of Agriculture 4.0 should help advance new production trends such as hydroponics, algae cultivation, desert and ocean agriculture, vertical and urban farms and progress in sustainable packaging (Ribeiro, Marinho and Espinosa, 2018).

2.2.3 Impacts and Potential of Agriculture 4.0

According to Vasconcelos (2018), the development of Agriculture 4.0 can generate impacts on agro-industries, as, once the monitoring is carried out in a more detailed and precise way, genetic improvements can be made to these plants by conducting the best information collected, in addition to being able to develop its products aimed at the real needs of production, increasing resource efficiency and sustainability. Rural producers also benefit, as technology works as an ally in production optimization, generating cost reduction (Carraro, Godinho Filho and Oliveira, 2019), increased productivity, improved production quality and reduced environmental impact.

The entire value chain also had an impact, due to the demands of consumers, who seek transparency, well-being, experiences and positive social impact, requiring producers to take a stand on the origin and composition of food, as essential procedures in reducing of the social and environmental impacts (Vasconcelos, 2018).

Brazilian agribusiness has great representation in the Gross Domestic Product (GDP), with high volumes of investments, generating development and job creation. With technological evolution, Agriculture 4.0 can make important contributions to the world's food security and Brazil, whose potential to offer agricultural products throughout the year and with the necessary evolutions is notorious, is a protagonist in the food security area of future generations (Villafuerte et al., 2018).

As stated by Vasconcelos (2018), Brazil has a large share of exports of agricultural products, and should present growth above the global average in the supply of food in the coming years. Given the current scenario, marked by the increase in the use of new technologies, Brazil is privileged to position itself in the agricultural sector in view of the ease of adaptation to changes and the development of technological activities

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aimed at tropical agriculture. The extension of the Brazilian territory and, consequently, the diversities presented, allow Brazil to adapt to different types of technological advances.

2.2.4 Agriculture Projections 4.0

The new era of Agriculture 4.0, inserted in the context of the Fourth Industrial Revolution, comes from a necessary transition to master the great global challenges, ensuring food for the next generations, in a scenario of climate change and growing limitation of natural resources. Thus, technological advances can be a resource to remedy such adversities (Vasconcelos, 2018).

Vasconcelos (2018) postulates that artificial intelligence is a great ally to contain the impacts of pests and diseases in the field, which represent a major problem in agriculture. Likewise, Agriculture 4.0 tends to be a differential in the development of predictive models of diseases, identifying them in the crop, with a high probability of being remedied at an early stage, thus avoiding major losses in the harvest.

III. METHODOLOGY

With a descriptive-exploratory character, the bibliometric method was used for data analysis. The theoretical basis was built from bibliographic research as a required part of all scientific work, with a view to structuring the theoretical platform of the study (Martins and Theóphilo, 2016). Macias-Chapula (1998, p. 134) understands bibliometrics as "the study of the quantitative aspects of the production, dissemination and use of registered information". For Jalal et al. (2009) bibliometric research involves methods that apply a relevance to the properties of documents, describing the publication patterns of a research field through quantitative and statistical analyses. In short, it proposes to assist in the knowledge of a particular area of research, measuring its growth according to the chosen variations (Oliveira, Pereira and Gaspar, 2014).

The keywords "Agriculture 4.0" and "Agro 4.0" were used as descriptors contained in the title of the document and indexed in the Google Scholar (Google Academic) database, in the period from 2015 to 2021 (until the month of April), in the language Portuguese. After the first search, a set of 227 records were obtained, which were downloaded for further analysis. After the analysis in the second stage, 208 documents that did not meet the pre-established criteria for the research were excluded. The reasons for excluding these documents varied from the impossibility of downloading (3), registration in duplicate in the foreign language (2) (Adriaanse and Rensleigh, 2013) and containing the keyword in other fields of the document other than the title (203). Once this step was completed, the set of documents consisted of 19 (nineteen) records.

Google Scholar was chosen due to its breadth of indexing, comprising articles, annals of scientific events, e-books, TCCs, dissertations, theses, among other documents, enabling greater search reach (Meho and Yang, 2007; Martín-Martín et al., 2018, Peress, 2019), in addition to the fact that it constitutes a scientific database of increasing relevance (Prins et al., 2016; Zientek et al., 2018), being considered the first search device used by the majority scientists when carrying out a bibliographic research (Mugnaini and Strehl, 2008; Delgado López-Cózar et al., 2019), equating to the traditional Web of Science (Mingers andLipitaks, 2010).

Several national studies have used these electronic resources to develop research with bibliometric indicators, namely those by Mugnaini and Strehl (2008), Souza, Ensslin and Ensslin (2012), Aragão, Oliveira and Lima (2014), Soares and Casa Nova (2016, 2017), Soares and Lima Filho (2017).

The characteristics found and analyzed in the documents downloaded from the academic base were:

1. Year of publication;
2. Authors/Quantity/Sex;
3. Number of authors per article;
4. Forms of publication.

These are considered the basic characteristics components of a bibliometric research, in agreement with Soares et al. (2018) for which the most widespread indicators in bibliometric research are based on the quantification of articles (number of documents published in a given period of time), number of journals/periodicals, number of authors, number of authorships, number of institutions or number of quotes.

IV. DATA PRESENTATION

4.1 Year of Publication

The first foundation analyzed was the distribution of publications over the period analyzed. The total set of documents analyzed are distributed over 5 years, with the year 2021 being considered until the month of April.Table 2 presents these data more carefully.

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Table 2: Publications by year between 2017 and April 2021 and percentage of participation.

Year	Records	%
2017	2	10.53
2018	3	15.79
2019	7	36.84
2020	6	31.58
2021 (until April)	1	5.26
Total	19	100.00

It is possible to observe that publications on the subject are recent, and in a visible process of growth, a characteristic analogous to technological development itself. There is a quantitative leap of just over 130% from 2018 to 2019, with a small retraction in the following year (2020). No publications were found in the period between 2015 and 2016.

4.2 Authors/No. of Publications/Gender

From the set of analyzed records (19), 55 authors were identified, 72.72% male and 27.28% female, an expressive difference of 45.44% between the two. Table 3 shows the authors by year, divided between males and females.

Table 3: Participation by sex in publications in the period analyzed.

Year	Male		Feminine	
	Nº Authors	% Of 55	Nº Authors	% Of 55
2017	5	9.09	2	3.64
2018	6	10.91	-	-
2019	11	19.99	9	16.36
2020	16	29.09	2	3.64
2021	2	3.64	2	3.64
Total	**40**	**72.72**	**15**	**27.28**

There is a marked predominance of males in publications, in addition to constant growth over the years surveyed. The year 2018 stands out, with no female authors. In the year 2019 there is an approximation of the percentages, returning to the disparity in the following year (2020). The year 2021 surveyed until the month of April, there was parity in the number of publications, with the participation of two (2) male authors and two (2) female authors.

4.3 Number of Authors per Publication

As for the number of authors and co-authors per publication, the survey indicates a predominance of one (1) author per article, representing approximately 37% of the total publications in the period. The second place is occupied by publications with four (4) authors, accounting for just over 26% of the total documents, followed by publications with five (5) authors (15.79%). Publications with three (3) authors and six (6) authors maintained equal representation in the number of publications in the period, with 5.26% each. Table 4 systematizes this information for better visualization of the measured results.

Table 4: Number of authors per publication in the period surveyed.

Authors	Records	% Of 19
1 Author	7	36.84
2 Authors	2	10.53
3 Authors	1	5.26
4 Authors	5	26.32
5 Authors	3	15.79
6 Authors	1	5.26
Total	19	100.00

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Generally, what is observed as an implicating factor in the number of authors/co-authors per published article, in most cases, is linked to the publication fee (Fee Publication) charged by journals for the publication of studies, causing an increase in the participation of co-authors in publications as a way of diluting the cost, which is now shared by more individuals. However, this is a practice more commonly practiced by international journals/periodicals that publish the works in a much shorter time compared to national journals/periodicals that do not practice Fee Publication for the publication of articles. It should also be noted that this modality where the author(s) pays for the publication has been showing increasing acceptance over the years, leveraged, above all, by the high response time of journals/periodicals that do not charge a fee. and rely on volunteer reviewers/reviewers for peer review work.

4.4 Types of Publication

The number of academic-scientific events has grown in the country, following an international trend in the modalities of disseminating research, thematic studies, among other categories. Notwithstanding the specificities between the fields of science, it is commonly accepted that a work originating from a scientific research is submitted to an event in the area of study or related area, undergoing an initial process of peer review and evaluation. Afterwards, when accepted for oral presentation, the work can be scrutinized by the participants interested in that work, which can often mean an opportunity to improve the text presented here.

In this process, it is expected that the full text, the result of scientific research, is published in the annals of the scientific event in question, giving publicity to the material. In due time, the research can be updated, adjusted and reconfigured for subsequent submission to a journal/periodical whose editorial line is in line with the proposal of the work. Notably, in this new stage, the article will be submitted again to other reviewers who will evaluate the possibility of publication, especially regarding the quality and contribution of the work to the advancement of science.

Possibly, at a later time, the text may be published as an organized book chapter, either in physical format or in digital format (e-book) with ISBN duly registered, ensuring the consolidation of the work and an even broader dissemination of the scientific study. Table 5 shows the types in which the scientific documents studied in this research were published.

Table 5: Types of publication of works in the period researched.

Types Publication	Records	% Of 19
Papers/Journals	6	31.58
Proceedings	9	47.37
Monographs (CCP)	3	15.79
Book/e-Book	1	
Total	19	

The publication in annals of scientific events comprised almost half of the publications (47.37%), followed by articles published in magazines/periodicals, with 31.58% of the total publications.

The monographies as Course Completion Paper (TCC) occupies third place in this ranking, with approximately 16% of publications. Although it is common, it is possible that not all higher education institutions require, for the purposes of graduation completion, the preparation of a monograph, since the Ministry of Education (MEC) makes it optional for the Higher Education Institution (HEI) to include or not this requirement in its Pedagogical Project Course (PPC). Furthermore, it may happen that not all HEI have a digital repository with open access for indexing the work.

V. CONCLUSION

The advancement of technology is a reality in all market segments, with variations in the intensity of impacts perceived. Agribusiness has been one of these sectors, whose impact has been quite significant, given the changes required, especially in reducing production costs, increasing competitiveness, improving scale, increasing quality, optimizing processes, with consequent gain in efficiency and productivity. In addition, the use of new planting techniques, cultural treatments, harvesting, production and processing, calculations, platforms and programs, among others, make up a framework that aims to optimize agricultural

production, and direct and positive effects on the country's food security and of the world.

Interest in the subject is on the rise, as can be seen by the growing number of publications over the period established in the research. This research intended to carry out the mapping of intellectual productions on the theme Agriculture 4.0 in Brazil, in the period between the years 2015 to 2021 (month of April), indexed in the Google Scholar database (Google Scholar).

The work has some limitations that are evidenced in the time frame, which is considered short. In addition, the fact of requiring that the key descriptors appear only in the title of the documents greatly reduced the scope of the works, since, from what was observed, many documents were no longer included in the formation of the analysis set by the fact that they only appear in the keywords.

On the other hand, the exposed limitations constitute an opportunity to undertake new studies with proposals to overcome these obstacles and consequent contribution to the field of study. It is expected that this work can contribute to the development of new proposals for studies in this area, given its strategic importance for the field, for the economy, for the country and for the world.

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