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Collaboration strategies and corresponding authorship in Agronomy research of Brazilian academic and non-academic institutions

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Abstract: Agricultural Sciences have become one of Brazil's most efficient and sustainable research areas, where most publications benefit from scientific collaboration. The present study analyzes the influence of the designation as the corresponding author to researchers linked to Brazilian institutions on the impact of co-authored articles in the category Agronomy from the Web of Science for five-year periods from 2005 to 2019. We have observed a noticeable growth in the number of documents in collaboration between the five-year periods. However, international partnership in the area still needs to be improved, although it is higher in non-academic institutions. The study verified that the documents published by Brazilian authors with international colleagues present a higher normalized citation impact in all types of institutions and five-year periods than documents with national collaboration. The total number of articles, their normalized citation impact, and the percentage of documents as the corresponding author of academic institutions presented less variation than non-academic institutions. For Brazilian academic institutions, assuming the role of the corresponding author of co-authored articles in Agronomy has little influence on citation impact. As for non-academic institutions, we found an association between the corresponding authorship position within the scope of international collaboration and the higher impact of their scientific production. We point out some potential implications and briefly describe the limitations and future research.

Keywords: Citation impact; Scientific collaboration; Corresponding author; Agronomy.

Mathematical Subject Classification: 62P25

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Introduction

Agricultural Sciences as a research field is one of the eight major areas in the Table of Knowledge Areas of the Conselho Nacional de Desenvolvimento Científico e Tecnológico (National Council for Scientific and Technological Development - CNPq) in Brazil. It encompasses the following subareas: Agronomy, Forest Resources and Forest Engineering, Agricultural Engineering, Animal Science, Veterinary Medicine, Fisheries and Fisheries Engineering, and Food Science and Technology (Conselho Nacional, 2022).

Over the last decades, Agronomy has become one of Brazil's most efficient and sustainable research fields. Its strength stems from the liveliness of a research system composed of the Empresa Brasileira de Pesquisa Agropecuária (Brazilian Agricultural Research Corporation - Embrapa), state institutions, universities, and, more recently, private institutions with international standards in scientific publications (Salles Filho & Bin, 2014). Between 2000 and 2011, its scientific production has grown more rapidly than the global Brazilian national output in the Web of Science (WoS) database (Vargas, Vanz & Stumpf, 2015). Essential for Brazil's economic growth, research in Agricultural Sciences has been the focus of investments and one of the most productive areas of national science (Glänzel, Leta & Thijs, 2006; Adams & King, 2009; Cross, Thomson & Sinclair, 2017).

Agronomy, a subject encompassing 10 out of 123 Brazilian journals indexed in the WoS in 2021, is one of the areas with more presence of Brazilian institutions and researchers. Cañas-Guerrero et al. (2013) used WoS data from 1997 to 2011, identifying a notable growth in research in emerging countries, including Brazil. In this period, Brazil's performance was

outstanding, showing an increase of almost 30 times in production. Three of the nine most cited Brazilian authors in 2018 are from Agricultural Sciences (Martinez & Sá, 2020). They also observed that these authors published many articles with five or more authors, with a pattern of international mobility from the early stages of their careers. Furthermore, almost all the articles that qualified these authors as highly cited resulted from scientific cooperation involving researchers from different countries (two to five), showing that they were part of significant national or international research networks.

In the context of collaborative research, co-authorship roles in the bylines of publications have been used in research assessment to credit authors for their contributions (Bu et al., 2020). Depending on the research field, these positions (namely first, middle, and last authors) have significance, while in other areas (e.g., economics and mathematics), authors are ordered alphabetically (Wohlrabe & Bornmann, 2022). Another figure in the byline of publications is the corresponding author, which has been used in several approaches to bibliometric analysis (Wouters et al., 2015; Chinchilla et al., 2023). The corresponding author is usually responsible for the research project, grouping the co-authors, and preparing the manuscript.

The International Committee of Medical Journal Editors issued several recommendations to corresponding authors to ensure credibility and responsibility for the data presented in a scientific article, namely, "[...] to respond to critiques of the work and cooperate with any requests from the journal for data or additional information should questions about the paper arise after publication" (ICMJE, c2021, online document). At the individual level, identifying someone as the corresponding author increases the perceived contribution of this author by the reviewers (Wren et al., 2007) —and confers seniority rather than a particular set of responsibilities (Willems & Plume, 2021). At the international level, some authors have used the influence of the corresponding author as a proxy for scientific leadership (González-Alcaide & Gorráiz, 2018). Although research groups are organized around different structures when they collaborate with other external colleagues, they delegate the responsibility and authority to a researcher who acts as the primary contributor (corresponding author), and by extension, to their affiliated country and institutions. In this global scenario, international partnerships benefit the scholarly impact of research; however, most countries have a higher citation impact

when they do not play a leading role in international publications (Chinchilla-Rodríguez et al., 2019).

The CNPq recently launched a program fostering national and international cooperation networks to improve researchers' scientific quality and mobility. This framework provides an excellent opportunity to analyze the role of leadership at the national and international levels to know how distinct types of institutions increase or decrease national capacities under the condition of corresponding authors.

Objectives

This paper analyzes the relationship between the corresponding author and collaboration strategies in Agronomy published by Brazilian institutions between 2005 and 2019. We want to elucidate whether the scholarly impact can be associated with the role of the corresponding author for Brazilian institutions in national and international collaborative publications.

We want to understand better how the models of scientific communications and the mission of academic and non-academic institutions impact their scientific performance, how the activities performed by their researchers affect their propensity to publish, and whether the scientific impact has the same importance for both types of institutions. We hope that this information can help design scientific agendas.

Related works

The context of Brazilian research in Agronomy

The agricultural sector accounts for almost 30% of the Brazilian Gross Domestic Product (GDP), ensuring the country's leadership in producing commodities such as coffee, corn, sugar, meat, soy, and oranges. Further, it engages almost 21% of the labor force and 47% of Brazilian exports (CEPEA, 2023). Besides increasing the productivity and competitiveness of the agricultural sector, the generation of scientific knowledge and technologies encourages exports, reduces the cost of agricultural products in the internal market, contributes to the growth and convergence of income among Brazilian states, and articulates the preservation and better management of natural resources, which are sources of food, renewable energy and drivers of the economy (Paz; Teodoro & Mendonça, 2000; Parra, 2002; Cruz, 2007; Barreto &

Almeida, 2009). In this context, research focusing on this sector is relevant given the economic and social impact they cause, as they are directed at agricultural production, energy generation, feeding the population, and preserving the environment (Brasil, 2010).

In the timeline of Brazilian science, Agricultural Sciences have gained prominence since the beginning of the 19th century (Vargas, Vanz & Stumpf, 2015). The creation of Horto Real in Rio de Janeiro (1808) paved the way for other initiatives aimed at experimentation and agricultural teaching by implementing higher schools and research institutes in agriculture and veterinary medicine. The Imperial Escola Agrícola da Bahia was established in São Bento das Lages in 1877; the Escola de Medicina Veterinária e Agricultura de Pelotas in 1883; the Estação Agronômica de Campinas, in São Paulo, in 1887. In the 20th century, the Agricultural Sciences inaugurated the national postgraduate course with courses in Phytotechnics and Rural Economics at the Universidade Federal de Viçosa in the 1960s, followed by the constitution of the Empresa Brasileira de Pesquisa Agropecuária (Embrapa), in 1970, which represented a milestone for the scientific and technological development of the country (Capdeville, 1991; Azevedo, 1996).

Unlike countries where research remains organizationally separate from higher education, based on national academies of sciences and research institutes (Lovakov, Chankseliani & Panova, 2022), in Brazil, research is traditionally carried out mainly in public universities (Leta, Glanzel & Thijs, 2006). The first Brazilian university, created in 1920, was the Universidade do Brasil, now Universidade Federal do Rio de Janeiro (UFRJ). The Universidade de São Paulo (USP), the largest Brazilian university, was created in 1934 (Oliven, 2002). There are 2,608 higher education institutions: 2,306 are private, and 302 are public (Brazil, [2019]). Currently, research in Agricultural Sciences is carried out mainly around 224 postgraduate courses maintained by public and private universities and state research institutes, in addition to the 43 units of Embrapa (CAPES, 2021; EMBRAPA, 2022).

Many Brazilian research institutes originated before universities. The first official research institution – Jardim Botânico em Belém do Pará – was founded in 1797 (Schwartzman, 2001). Nevertheless, it was only after the arrival of the Portuguese royal family that technical institutes and more systematic research activities began to emerge in the country. Currently,

there are 102 Institutos Nacionais de Ciência e Tecnologia (National Institutes of Science and Technology) linked to the Ministério da Ciência, Tecnologia e Inovações (Ministry of Science, Technology and Innovation), in addition to many others subordinated to the Brazilian states and other ministries.

More recently, the Programa Institutos Nacionais de Ciência, Tecnologia e Inovação (National Institutes of Science, Technology and Innovation Program - INCTs) was launched by CNPq, to foster sizable long-term research projects in national or international networks of scientific cooperation involving researchers and scholars from the most diverse áreas, which would have a high scientific impact and help the training of established and new researchers. One of the INCTs currently underway operates in the Agricultural Sciences, reinforcing the strategic importance of this area. Among the objectives of the INCTs are the promotion of cutting-edge, high-quality research and internationally competitive standards that enable a productive international interaction with groups of excellence from leading countries, aiming not only at increasing the production of scientific knowledge and the improvement of its quality but also at the mobility of researchers trained or in training. INCTs should thus reach a degree of collaboration that would enhance Brazilian scientific, technological, and innovative research.

Given the importance of Agricultural Sciences for Brazil, studies focusing on analyzing the scientific production in that area have been taking place for years. Robredo, Chastinet, and Ponce (1974) established an essential list of journals in Agricultural Sciences. Nocetti (1977) created a directory of current Brazilian journals in Agricultural sciences. Velho (1986) investigated the age distribution of citations in a broad sample of articles published by researchers in Agricultural Sciences from four important Brazilian universities. A further study (Velho, 1990) revealed that scientists in this area choose research topics they consider directly relevant to Brazilian agriculture. Lyra and Guimarães (2007) compared Brazilian and the world's scientific production in Agricultural Sciences from 1981 to 2006. Penteado Filho and Ávila (2009) verified the participation of Embrapa research centers in the journals indexed in the WoS database from 1977 to 2006, indicating the institution's role. Puerta, Lopes de Faria, and Penteado Filho (2012) analyzed research activity in nanotechnology and agribusiness to develop scientific indicators. Vargas, Vanz & Stumpf (2015) identified the articles indexed in the WoS category Agricultural Sciences from 2000 to 2011. Costa, Matias, and Rodrigues

(2017) revealed that the INCTs in Agricultural Sciences delivered a significant scientific, technical, and technological production between 2013 and 2015. Oliveira, Rodrigues, and Matias (2017) studied the characteristics of Brazilian journals published in Agricultural Sciences and indexed in Scopus and the WoS. Irizaga and Vanz (2021) analyzed the scientific output in Agricultural Sciences by the Brazilian federative unit in Scopus and compared it to the map of Brazil's agricultural products. Vanz et al (2022) identified that for Agronomy in period from 2015 to 2019, the corresponding author has little influence on the impact of academic institutions' papers, however, for non-academic institutions, the role of corresponding author in the scope of international collaboration is highly related to the impact of scientific output.

Brazil occupied the second position at the international level among the most productive countries in Agronomy (7.1% of the global scientific effort) behind the USA (22.3%). Most of the Brazilian publications involved national authors, as it had the lowest percentage of articles with international collaborations (12.9%) among the 30 most productive countries (Cañas-Guerrero, 2013). This pattern is also present in the most productive countries, reinforcing that scientific capacities are inversely related to the proportion of international collaborations (Chinchilla et al., 2018). Besides, investigations have repeatedly revealed that the scholarly impact of publications is higher when it involves international collaboration (Royal Society, 2011; Adams & Gurney, 2018). In line with this result, new regional networks have reinforced emerging economies' competence and scientific capacity, changing the global balance of research activity (Lundberg, 2011). Latin America has an emerging research network focused on Brazil, which doubled its collaboration with Argentina, Chile, and Mexico in the early 2000s (Adams, 2012). In this scenario, although some areas such as the Humanities, Social Sciences, and Agricultural Sciences cope with problems inherent to a country, international collaboration may broaden the generated knowledge, whose main concepts are universal, and thus contribute to global science (McManus et al., 2020).

The role of the corresponding author in the bylines of publications

Several studies have used the corresponding author in the byline of publications as a proxy for scientific leadership (González-Alcaide et al., 2017) to analyze the scholarly impact of institutions and their dependencies on international collaboration (Chinchilla-Rodriguez et al.,

2016a), combining with specialization in countries in several research fields (Chinchilla-Rodríguez et al., 2016b). The analysis of the leadership role of an institution or a country in international scientific collaborations allows a deeper understanding of the dependencies/asymmetries of the scientific system (Zou & Leydesdorff, 2006; Bordons et al., 2014; Chinchilla-Rodríguez et al., 2016). Moya Anegón et al. (2013) observed that, except in the case of the USA, a tendency to decrease the scientific impact achieved by countries is associated with the assumption of their researchers (and institutions) of the role of the corresponding author in scientific publications.

On the other hand, there are differences in the scholarly impact between national and international collaboration depending on whether the institution assumes the role of the corresponding author (Grácio et al., 2020). Besides, stemming from the assumption that different types of scientific structures can influence the relationships and models of scientific communication (Saisana et al., 2011), the analysis of distinct categories of institutions – academic and non-academic–might bring more insights into patterns of communications and collaboration strategies. In academic institutions, specifically universities, professors conduct research in teaching activities, train new researchers and engage in advisory duties at undergraduate and graduate levels. Student supervision is a substantial part of the teaching activity but expands the possibility of new research projects, particularly within doctoral courses. The German model, which favors research and defends the idea of inseparability between teaching, research, and training, inspired the consolidation of Brazilian universities. However, they also received influence from the North American model, characterized by a strong connection with the community (Souza et al., 2013). Such historical influences explain the robust research vocation assumed by universities since their emergence in Brazil.

Outputs derived from research activities developed for universities and institutes reflect these institutions' different missions and objectives. Research institutes are concerned about interacting with the market and community through innovation activities and patenting ideas and products. They disseminate their scientific outputs through short and less scientific publications, making the article's technical language more popular and accessible in a newsletter format. Brazilian universities are keener on using the traditional scientific communication model based on published articles between peers (researchers and scientists).

Materials and Methods

The first step in collecting data was to set up a threshold on institutional size to get meaningful statistical results, namely, free of outliers due to scarcity of data. We thus proceeded by identifying the ten most productive academic (universities) and non-academic (governmental agencies, research institutes, and corporate companies) Brazilian institutions in terms of the total number of documents (article, review, and proceedings paper) for the three consecutive five-year periods of the analyzed term. These institutions have a diachronically consolidated presence on the international scene for the period under study. We then passed the collection of papers as a dataset to InCites, the customized, web-based research evaluation tool associated with the Web of Science, which has been extensively used to evaluate citation patterns (Hu et al., 2018; Pislyakov, 2022), countries, regions, and institutions (Hu et al., 2020; Wang & Rousseau, 2021) and research groups (Győrffy et al., 2018). We collect data indexed in the category Agronomy on selected institutions from 2005-2009, 2010-2014, and 2015-2019. On August 2021, we retrieved data on the following indicators:

DocG = Total number of documents indexed;
Doc = Total number of documents in collaboration by category, international and national;
%Doc/DocG = Ratio Doc/DocG;
CNCI = Category Normalized Citation Impact
%DAC = Percentage of documents as the corresponding author.

We used an Excel spreadsheet to store data according to the type of scientific collaboration (national or international) and institution (academic or non-academic). We computed some descriptive statistics (arithmetic mean and coefficient of variation, which measures the relative dispersion of the data around the mean. Range of variation: $CV \leq 15\%$ (low dispersion); $15 < CV \leq 30\%$ (moderate dispersion); $CV > 30\%$ (high dispersion) (Jobson, 1991), and plotted them in comparative graphs. Data did not satisfy the ANOVA test prerequisite, namely the data's normality and homoscedasticity (see Tables 1 and 2). Hence, to evaluate whether there is a significant difference between the trends observed in the three five-year periods for the indicators (Doc, %Doc/DocG, CNCI, and %DAC), we applied the non-parametric Kruskal-Wallis test (based on rank analysis) for academic and non-academic institutions, and the type of collaboration (international and national).

When statistically significant differences appeared (p-values less than 0.05), we applied Dunn's post hoc test to evaluate, on a two-by-two basis, the differences between the three five-year periods. We used the Kruskal-Wallis test to identify the specific periods where the statistically significant difference occurred. Subsequently, we evaluated the correlations between %DAC and the other indicators (Doc, %Doc/DocG, and CNCI) through Spearman's rank correlation coefficient.

In the last stage of data collection, we recovered from the WoS the scientific production of academic and non-academic institutions to examine co-authorship with private institutions, major collaborating countries, and the language of publications.

Results and Discussion

Academic institutions

Table 1 shows that the scientific outputs of the most productive academic Brazilian institutions in Agronomy had significant growth (59%) from the first to the second period, remaining stable during the following 10-year period. This finding aligns with the results of Cañas-Guerrrero (2013) for the period 1997-2011.

We observed a considerable variation in the volume of documents published by the universities, especially in the first five years (coefficient of variation = 75.3), with Universidade Federal de Lavras (UFLA) and Universidade Estadual Paulista Julio de Mesquita Filho (UNESP) standing out with 706 and 443 documents, respectively. Despite the significant variation, the number of documents and the proportion of international collaborative publications is closer among all the universities (coefficient of variation of 59.5). Over the last two periods, document differences decreased among universities, whereas variation in international collaboration increased. USP reaches the highest percentage of international collaboration (21.73%) in the second period, a pattern that several other universities follow in the third period. Universidade Federal de Viçosa (UFV) and Universidade Federal de Santa Maria (UFSM) stand out in the first period by being corresponding authors in more than 60% of the documents in international collaboration.

Some universities more frequently assume the leading position in international collaboration. That is the case of the Universidade Federal de Viçosa (UFV), the Universidade Federal de Lavras (UFLA), the Universidade Federal de Santa Maria (UFSM), and the Universidade Federal do Paraná (UFPR).

Table 1. Basis statistics for academic institutions. Evolution over three periods: 2005-2009; 2010-2014; 2015-2019

2005-2009		General	International Collaboration				National Collaboration			
		DocG	Doc	%Doc/DocG	CNCI	%DAC	Doc	%Doc/DocG	CNCI	%DAC
1	Universidade Federal de Lavras (UFLA)	706	18	2.55	0.67	44.44	452	64.02	0.31	35.23
2	Universidade Estadual Paulista (UNESP)	443	38	8.58	0.84	36.00	253	57.11	0.33	38.31
3	Universidade de São Paulo (USP)	322	61	18.94	1.38	48.28	210	65.22	0.50	30.97
4	Universidade Federal de Viçosa (UFV)	317	26	8.20	0.85	69.23	217	68.45	0.37	45.96
5	Universidade Federal de Santa Maria (UFSM)	314	24	7.64	0.89	63.16	134	42.68	0.33	53.91
6	Universidade Federal do Rio Grande do Sul (UFRGS)	159	22	13.84	1.25	36.84	88	55.35	0.36	49.33
7	Universidade Estadual de Maringá (UEM)	106	11	10.38	0.74	28.57	65	61.32	0.47	65.45
8	Universidade Federal de Uberlândia (UFU)	98	1	1.02	0.95	0.00	60	61.22	0.23	41.51
9	Universidade Federal de Pelotas (UFPEL)	96	6	6.25	0.89	50.00	60	62.50	0.32	54.90
10	Universidade Federal Rural de Pernambuco (UFRPE)	90	13	14.44	0.83	50.00	60	66.67	0.23	45.28
Mean		265.10	22.00	9.18	0.93	42.65	159.90	60.45	0.35	46.09
Coefficient of variation (%)		75.3	78.9	59.5	23.8	45.3	79.3	12.3	25.3	22.3
2010-2014		General	International Collaboration				National Collaboration			
		DocG	Doc	%Doc/DocG	CNCI	%DAC	Doc	%Doc/DocG	CNCI	%DAC
1	Universidade Estadual Paulista (UNESP)	742	47	6.33	0.67	44.68	483	65.09	0.29	42.44
2	Universidade Federal de Lavras (UFLA)	628	44	7.01	0.77	36.36	431	68.63	0.39	45.71
3	Universidade de São Paulo (USP)	626	136	21.73	1.34	34.56	392	62.62	0.47	35.20
4	Universidade Federal de Viçosa (UFV)	572	51	8.92	0.96	43.14	391	68.36	0.43	43.22
5	Universidade Federal de Santa Maria (UFSM)	485	29	5.98	0.73	55.17	264	54.43	0.34	64.39
6	Universidade Federal de Uberlândia (UFU)	281	13	4.63	0.85	30.77	182	64.77	0.20	51.65
7	Universidade Federal do Rio Grande do Sul (UFRGS)	264	29	10.98	1.29	44.83	160	60.61	0.51	41.88
8	Universidade Federal de Pelotas (UFPEL)	216	21	9.72	0.67	28.57	150	69.44	0.35	47.33
9	Universidade Federal do Paraná (UFPR)	212	13	6.13	0.65	53.85	162	76.42	0.47	46.30
10	Universidade Federal de Goiás (UFG)	192	15	7.81	0.42	26.67	150	78.13	0.25	41.33
Mean		421.80	39.80	8.92	0.83	39.86	276.50	66.85	0.37	45.95
Coefficient of variation (%)		49.8	92.1	54.8	34.6	25.3	48.3	10.6	27.1%	16.9
2015-2019		General	International Collaboration				National Collaboration			
		DocG	Doc	%Doc/DocG	CNCI	%DAC	Doc	%Doc/DocG	CNCI	%DAC
1	Universidade Estadual Paulista (UNESP)	769	135	17.56	1.16	41.48	476	61.90	0.40	41.81
2	Universidade de São Paulo (USP)	724	207	28.59	1.25	47.34	402	55.52	0.62	34.58
3	Universidade Federal de Viçosa (UFV)	687	99	14.41	1.28	55.56	470	68.41	0.54	46.17
4	Universidade Federal de Lavras (UFLA)	541	78	14.42	0.93	58.97	342	63.22	0.48	46.78
5	Universidade Federal de Santa Maria (UFSM)	460	74	16.09	0.76	55.41	266	57.83	0.36	54.89
6	Universidade Federal do Rio Grande do Sul (UFRGS)	277	62	22.38	0.94	38.71	152	54.87	0.45	57.24
7	Universidade Federal Rural de Pernambuco (UFRPE)	267	49	18.35	0.90	40.82	173	64.79	0.37	51.45
8	Universidade Federal de Uberlândia (UFU)	266	20	7.52	0.85	50.00	174	65.41	0.23	50.00
9	Universidade Federal de Mato Grosso do Sul (UFMS)	248	24	9.68	0.95	25.00	183	73.79	0.40	46.99
10	Universidade Federal do Paraná (UFPR)	246	31	12.60	0.99	51.61	164	66.67	0.51	40.85
Mean		448.50	77.90	16.16	1.00	46.49	280.20	63.24	0.44	47.08
Coefficient of variation (%)		48.2	74.0	37.8	17.2	21.9	46.9	9.4	24.9	14.4

Legend: DocG = Total number of documents indexed by WoS; Doc = Total number of documents in collaboration by category, international and national; %Doc/DocG = Percentage of Doc in relation to DocG; CNCI = Category Normalized Citation Impact; %DAC = Percentage of documents as corresponding author

Seven federal universities highlight among the ten most productive over the whole period Universidade Estadual Paulista (UNESP), Universidade Federal de Lavras (UFLA), Universidade de São Paulo (USP), Universidade Federal Viçosa (UFV), Universidade Federal de Santa Maria (UFSM), Universidade Federal do Rio Grande do Sul (UFRGS) and Universidade Federal de Uberlândia (UFU). These seven universities collaborate with private companies. Monsanto and Syngenta stand out, appearing as partners of six institutions with strong links with the seed sector, as do Dow Quimica (5 universities), Bayer and Pioneer (3), and the Souza Cruz cigarette company, also with three universities. However, several other private companies also appear as partners of these universities in a more specific way.

All these seven universities show collaborations with non-academic institutions, such as EMBRAPA, the most suited partner, followed by Instituto Agronômico de Campinas (IAC) collaborating with USP, UNESP, and UFLA. It is also noteworthy that other government research agencies, e.g., the Empresa de Pesquisa Agropecuária de Minas Gerais (EPAMIG) - whose mission is to do research and experimentation related directly and indirectly to agriculture as the state's main instrument for agricultural research activities (EPAMIG, 2022), appear as a partner of these seven universities, especially with UFLA and UFV. On the other hand, the Agência Paulista de Tecnologia dos Agronegócios (APTA), an agency of the Secretaria de Agricultura e Abastecimento (Secretariat of Agriculture and Supply), intended to coordinate and manage science and technology activities aimed at agribusiness in the state of São Paulo (APTA, 2023), is a primary partner of both USP and UNESP and, less frequently, of the other universities, except for UFSM. USP, UNESP, UFLA, and UFV are the leading academic partners of these seven universities. This intense relationship evidences an intense and fruitful knowledge construction network. This partnership level points to a synergy, albeit fragile concerning private companies, between the University–Industry-Government dimensions within the approximation to the Triple Helix model of Etzkowitz & Leydesdorff (1995, 2000), where each helix (University - Industry - Government) works in partnership and interdependence with the other dimensions through the flow of knowledge (Stal & Fujino, 2005).

Four countries act as main collaborators: the USA, Spain, France, and Germany. Articles with researchers affiliated in the USA appear in the scientific production of all seven

universities, ranging from 2.9% (for UFU) to 11% (for USP). As for Spain, four universities (UFV, UFRGS, USP, UNESP) have more recurrent collaboration, varying between 1% (UFV) and 1.8% (USP). France has more frequent co-authorship with USP and UFRGS, varying between 1.3% (UFRGS) and 3.4% (USP). Among the principal French collaborators, the Center for International Cooperation in Agricultural Research for Sustainable Development (CIRAD), a French organization for agricultural research and international cooperation for the sustainable development of tropical and Mediterranean regions (CIRAD, 2023), stands out. Germany also has more frequent collaboration with USP and UFRGS, with a percentage of co-authored publications ranging from 1.4% (UFRGS) to 1.5% (USP). These results align with those observed by Cañas-Guerrero et al. (2013), in which, for the period with partial overlap with the one analyzed here, most of the Brazilian publications involved only national authors. As for the publication language, English is the most frequent, corresponding to an average of 58% and a coefficient of variation (CV) of 12%. UFLA shows the lowest percentage of publications in English (51%) and USP the highest (76%). Thus, although the maximum participation of partnerships with foreign researchers reaches 11% of scientific production for USP with the USA, these universities favor publication in English, which suggests an initiative to expand dialogue with the international community.

Non-academic institutions

Table 2 shows that the scientific output of the most productive non-academic Brazilian institutions in Agronomy also remained stable during the last ten years (2010-2019), which suggests a sign of a consolidated role in the Brazilian scientific system. However, we observed that among non-academic institutions, the difference in the scientific output is even more remarkable than among academic institutions, with a higher coefficient of variation for the periods: 243.5, 244.2, and 238. Eight non-academic institutions remained among the ten most productive over the period: Empresa Brasileira de Pesquisa Agropecuária (EMBRAPA), Instituto Agronômico de Campinas (IAC), Instituto Nacional de Pesquisas da Amazônia (INPA), Instituto Nacional de Pesquisas Espaciais (INPE), Fundação Oswaldo Cruz (FIOCRUZ), Instituto de Botânica de São Paulo, Fundo de Defesa da Citricultura (Fundecitrus), and Museu Paranaense Emílio Goeldi. Some of these research institutions are older than Brazilian universities. The Instituto Agronômico de Campinas (IAC) was created in 1887, aimed at the development of coffee growing. Together with other institutes, the IAC and the

Instituto de Zootecnia (IZ), which appear among the most productive non-academic institutions in the first and last five-year periods, make up the structure of APTA. Although they do not offer undergraduate courses like universities, the IAC and IZ offer postgraduate courses. Another historical institution - Museu Paraense Emílio Goeldi – was launched in 1866 and is linked to the Ministério da Ciência e Tecnologia e Inovação do Brasil; its activities focus on the scientific study of the natural and socio-cultural systems of the Amazon and the dissemination of knowledge and collections related to the region (Souza, 1995). The history of the Instituto de Botânica is linked to the Jardim Botânico de São Paulo, which began its activities in 1917.

Table 2. Basis statistics for non-academic institutions. Evolution over three periods: 2005-2009; 2010-2014; 2015-2019

2005-2009		General	International Collaboration				National Collaboration			
		DocG	Doc	%Doc/DocG	CNCI	%DAC	Doc	%Doc/DocG	CNCI	%DAC
1	Empresa Brasileira de Pesquisa Agropecuária (EMBRAPA)	625	133	21.28	1.33	37.29	409	65.44	0.49	31.03
2	Instituto Agronômico de Campinas (IAC)	115	12	10.43	0.94	50.00	84	73.04	0.62	43.18
3	Instituto Nacional de Pesquisas da Amazônia (INPA)	16	6	37.50	1.14	0.00	8	50.00	0.25	62.50
4	Instituto Nacional de Pesquisas Espaciais (INPE)	9	3	33.33	1.67	0.00	3	33.33	0.74	50.00
5	Fundação Oswaldo Cruz (Fiocruz)	9	1	11.11	0.12	0.00	7	77.78	0.27	42.86
6	Instituto de Zootecnia - São Paulo (IZ)	7	0	0.00	0.00	0.00	6	85.71	0.43	0.00
7	Fundo de Defesa da Citricultura (Fundecitrus)	6	2	33.33	2.09	100.00	4	66.67	1.33	50.00
8	Instituto de Botânica - São Paulo	6	0	0.00	0.00	0.00	5	83.33	0.19	0.00
9	Petróleo Brasileiro S.A. (Petrobras)	3	0	0.00	0.00	0.00	3	100.00	0.18	0.00
10	Museu Paraense Emilio Goeldi	3	2	66.67	2.78	0.00	0	0.00	0.00	0.00
	Mean	79.90	15.90	21.37	1.01	18.73	52.90	63.53	0.45	27.96
	Coefficient of variation (%)	243.5	259.8	101.0	97.7	181.4	241.2	45.9	84.4	90.5
2010-2014		General	International Collaboration				National Collaboration			
		DocG	Doc	%Doc/DocG	CNCI	%DAC	Doc	%Doc/DocG	CNCI	%DAC
1	Empresa Brasileira de Pesquisa Agropecuária (EMBRAPA)	1243	172	13.84	1.26	38.95	917	73.77	0.54	35.22
2	Instituto Agronômico de Campinas (IAC)	179	21	11.73	0.93	14.29	122	68.16	0.44	31.97
3	Instituto Nacional de Pesquisas da Amazônia (INPA)	53	10	18.87	2.15	20.00	33	62.26	0.34	42.42
4	Instituto Nacional de Pesquisas Espaciais (INPE)	20	11	55.00	1.82	18.18	7	35.00	0.09	57.14
5	Fundaçao Oswaldo Cruz (Fiocruz)	18	0	0.00	0.00	0.00	16	88.89	0.26	25.00
6	Museu Paraense Emilio Goeldi	15	2	13.33	0.64	0.00	11	73.33	0.52	54.55
7	Fundo de Defesa da Citricultura (Fundecitrus)	14	5	35.71	1.33	40.00	8	57.14	1.36	25.00
8	Instituto de Botânica - São Paulo	13	2	15.38	1.64	0.00	8	61.54	0.53	25.00
9	Coord. Aperfeiçoamento de Pessoal de Nível Superior (C	13	0	0.00	0.00	0.00	13	100.00	0.12	61.54
10	Jardim Botânico - Rio de Janeiro	8	0	0.00	0.00	0.00	6	75.00	0.88	16.67
	Mean	157.60	22.30	16.39	0.98	13.14	114.10	69.51	0.51	37.45
	Coefficient of variation (%)	244.2	237.8	105.9	81.5	122.3	249.2	25.5	74.6%	41.9
2015-2019		General	International Collaboration				National Collaboration			
		DocG	Doc	%Doc/DocG	CNCI	%DAC	Doc	%Doc/DocG	CNCI	%DAC
1	Empresa Brasileira de Pesquisa Agropecuária (EMBRAPA)	1300	211	16.23	1.10	33.65	973	74.85	0.50	40.29
2	Instituto Agronômico de Campinas (IAC)	169	32	18.93	0.91	9.38	118	69.82	0.55	33.05
3	Instituto Nacional de Pesquisas da Amazônia (INPA)	78	21	26.92	0.97	42.86	46	58.97	0.33	56.52
4	Coord. Aperfeiçoamento de Pessoal de Nível Superior (Capes)	25	12	48.00	1.67	16.67	13	52.00	0.20	0.00
5	Fundação Oswaldo Cruz (Fiocruz)	24	4	16.67	0.68	0.00	17	70.83	0.35	29.41
6	Instituto Nacional de Pesquisas Espaciais (INPE)	23	12	52.17	2.08	41.67	9	39.13	0.57	33.33
7	Instituto de Botânica - São Paulo	22	0	0.00	0.00	0.00	14	63.64	0.92	50.00
8	Fundo de Defesa da Citricultura (Fundecitrus)	18	5	27.78	2.06	20.00	11	61.11	1.36	63.64
9	Museu Paraense Emilio Goeldi	14	1	7.14	0.00	0.00	10	71.43	0.40	60.00
10	Instituto de Zootecnia - São Paulo (IZ)	10	0	0.00	0.00	0.00	7	70.00	0.20	57.14
	Mean	168.30	29.80	21.38	0.95	16.42	121.80	63.18	0.54	42.34
	Coefficient of variation (%)	238.0	216.4	83.9	85.1	106.9	247.3	17.3	66.6	45.7

Legend: DocG = Total number of documents indexed by WoS; Doc = Total number of documents in collaboration by category, international and national; %Doc/DocG = Percentage of Doc in relation to DocG; CNCI = Category Normalized Citation Impact; %DAC = Percentage of documents as corresponding author

Based on a more detailed analysis of these institutions, five do not collaborate with private companies: FIOCRUZ, INPA, Instituto de Botânica de São Paulo, INPE, and Museu Emilio Goeldi. On the other hand, EMBRAPA, IAC, and Fundecitrus, as well as universities, show little scientific collaboration with private companies. Regarding universities, all of them shared USP as the leading collaborator. UNESP also appears as a significant partner, except INPE, which does not have UNESP among its leading partners.

Regarding their inter-relationships, EMBRAPA appears as the main collaborator except for the Instituto de Botânica de São Paulo and the Museu Emilio Goeldi. Furthermore, there is strong cooperation between EMBRAPA and IAC. On the other hand, institutions such as the Museu Emilio Goeldi, the Instituto de Botânica de São Paulo, and FIOCRUZ have sparse partnerships, with only some of the eight institutions showing a constant presence in the three five-year periods.

This characteristic of non-academic institutions in the context of the Triple-Helix model depends on the institution's mission. EMBRAPA and IAC are government companies focused on generating knowledge and technology for agriculture (EMBRAPA[1]), supplying food to the population and raw materials to the industry (IAC[2]) in order to cooperate for food safety and competitiveness in the national and international market. They form partnerships with scientific institutions, government leaders, society, and the productive sector. Fundecitrus is a private association maintained by citrus growers and juice industries in the State of São Paulo (FUNDECITRUS[3]). Thus, these three non-academic institutions have the Industry Helix established in their organization by their mission.

[1] https://www.embrapa.br/sobre-a-embrapa

[2] https://www.iac.sp.gov.br/areadoinstituto/instituto/instituto.php?pagina=missao

[3] https://www.fundecitrus.com.br/ofundecitrus/quem_somos

On the other hand, since their missions differ, the other five institutions are all public and more focused on social well-being than on delivering products. For example, INPA[4] aims at developing scientific studies of the physical environment and living conditions in the Amazon region to promote human well-being and sustainable socio-economic development. INPE[5] produces science and technology, operating systems, training programs in space and the earth system, knowledge advancement and sustainable development, benefiting Brazil and the world.

The Museu Emilio Goeldi[6] focuses on carrying out research, promoting scientific innovation, training human resources, conserving collections, and communicating knowledge in the natural and human sciences related to the Amazon. The Instituto de Botânica de São Paulo[6] develops botanical research to subsidize the environmental policy of the State of São Paulo, and finally, FIOCRUZ[7] promotes health and social development by generating and disseminating scientific and technological knowledge. It is also worth highlighting the intense international partnership of INPA and INPE since each had a significant participation of 11 countries in their collaboration network, with the USA being the leading partner (25% of INPE and 12.6% of INPA). On the other hand, the Instituto de Botânica de São Paulo did not present significant international cooperation. Over the period, five countries were consistently present as collaborators: the USA (with six institutions), France and Australia (5), and Germany and the Netherlands (3), respectively.

As for the language of publication, English stands out (average of 77.8% and a coefficient of variation equal to 11.7%). Fundecitrus and INPE publish mainly in English (97% and 85%, respectively). FIOCRUZ presents the lowest percentage of publications in English (69%). This result shows that non-academic institutions publish more in English than universities, even those with shallow international partnerships, such as the Instituto de Botanica de São Paulo.

[4] https://www.gov.br/inpa/pt-br

[5] https://www.gov.br/inpe/pt-br/acesso-a-informacao/institucional/missao-visao-e-valores

[6] https://www.infraestruturameioambiente.sp.gov.br/instituto-de-botanica/

[7] https://portal.fiocruz.br/fundacao

Some non-academic institutions show greater participation as corresponding authors in national collaborations (INPA, Fundecitrus, Museu Paraense Emilio Goeldi, and INPE) and international collaborations (Fundecitrus and EMBRAPA). In at least two periods, they showed a much higher normalized impact than other non-academic institutions, revealing a similar trend to academic institutions in terms of assuming the corresponding author role. INPA and INPE also increased their participation as the corresponding authorship in international collaboration in the last five years. INPA shows a high percentage (94%) of documents published in international collaboration, especially with the USA, suggesting that the publications' high impact as corresponding authors may be due to the internationally acknowledged record of Brazilian science in these research fields. Non-academic institutions present more international collaboration than universities (Table 1). Meanwhile, many non-academic institutions never assume the role of the corresponding author in international collaborations, resulting in many zero values (Table 2). Even the most productive, such as Embrapa and IAC, show timid participation as the corresponding author. Besides, the importance of international collaboration is evident when comparing CNCI values. The average CNCI for international collaboration is about 1, and 0.50 for national collaboration.

The available literature shows that Brazilian scientific production revolves around academic environments (Leta, Glänzel & Thijs, 2006). We found several universities with approximately the same size of publications (Tables 1 and 2), and one non-academic institution with outstanding outputs, EMBRAPA, that has become an important research institution in Agronomy, with a particular emphasis on research in genetic improvement (Nascimento & Rodrigues, 2015). This institution (created in 1973 by the Ministério Brasileiro da Agricultura, Pecuária e Abastecimento) currently employs 2232 researchers, 2321 analysts, 1319 technicians, and 2195 assistants (Empresa Brasileira de Pesquisa Agropecuária, 2022), which shows a scientific structure equivalent to or higher than some universities highlighted in this study, such as UNESP (2804 faculty members), UFSM (2064), UFU (1128), and UFLA (766), whose main activities include not only research but also teaching in various courses and areas of knowledge.

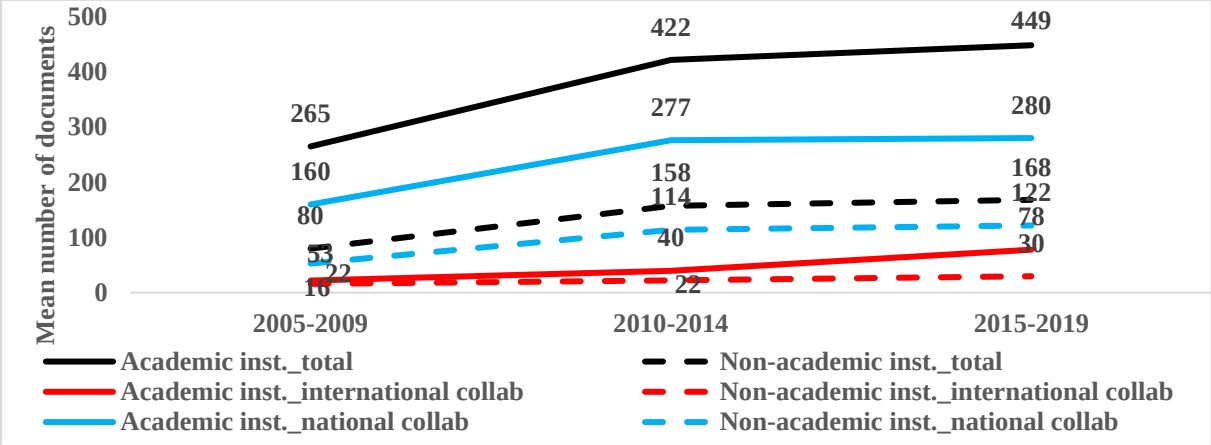
This result represents the behavior of the most productive Brazilian institutions responsible for scientific advances in Agronomy, confirming the results of Cañas-Guerrero et al. (2013),

highlighting EMBRAPA, UFLA, UNESP, UFV, and UFSM as the main responsible for the remarkable growth of Brazilian research in Agronomy from 1997 to 2011.

Correlation analysis between academic and non-academic institutions

Figures 1, 2, 3, and 4 present a diachronic account of the following indicators trends: total number of documents, % docs in national collaboration, % docs in international collaboration, % docs as the corresponding author, and Category Normalized Citation Impact.

Figure 1. Average number of documents published by type of institution and scientific collaboration.



The mean values of the total number of documents (DocG) in the three five-year periods (Figure 1) initially show that academic institutions presented, on average, more than twice as many documents as non-academic institutions. However, it is noteworthy that EMBRAPA stands up as an outlier among non-academic institutions (Table 2). Its performance matches that of the most productive academic institution in the first five-year period, UFLA, while surpassing (by far) the performance of UNESP over the last two five-year periods. This fact caused a high dispersion rate (coefficient of variation) for the documents published by non-academic and collaborative institutions (international and national). IAC has also contributed to this dispersion, although to a lesser extent.

Figure 1 shows a significant growth in the Brazilian institutions contributing to the Web of Science Agronomy category. Between the first and second periods, the mean average of documents published by academic institutions increased by 59% (from 265 to 422). For non-

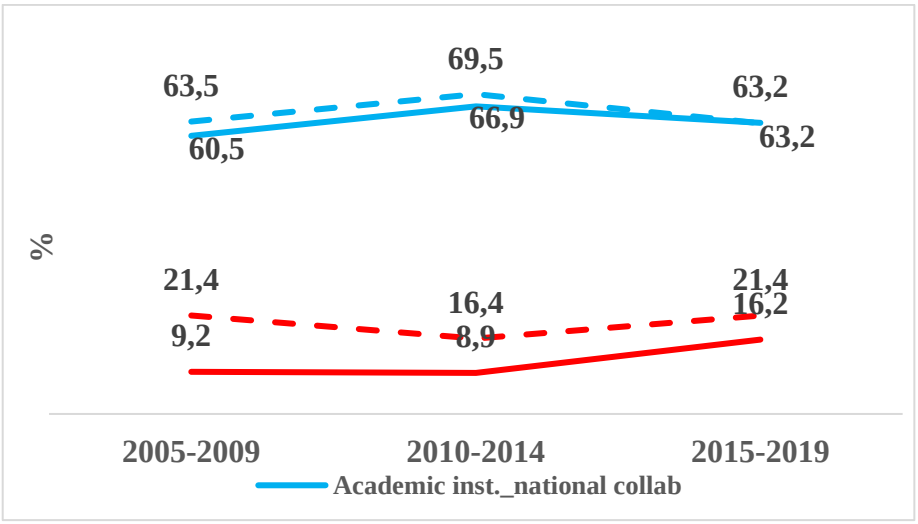
academic institutions, outputs grew by 98% (from 80 to 158 documents). It is worth highlighting, as a baseline, that Brazilian researchers' participation in the area's total scientific output grew 39% from the first to the second period and remained stable afterward. Among academic institutions, this growth mainly derives from the increase in international collaboration (82%, 22 out of 40 documents) and national collaboration (73%, 160 versus 277 documents). For non-academic institutions, the growth is most associated with national collaboration (115%, 53 versus 114 documents), and international collaboration (38%, 16 versus 22 documents).

Although further research is required to have a statement, this growth corresponds to the period that marks the highest entry of Brazilian journals into the WoS, strongly characterized by the indexation of Agricultural Sciences journals (Vargas, Vanz & Stumpf, 2014). It is also in line with previous studies showing that Brazil was the second major country in Agronomy research from 1997 to 2011 and that articles concentrated in some national journals (Cañas-Guerrero et al., 2013). McManus, Baeta Neves & Maranhão (2020) mentioned that national journals in the agricultural sciences concentrated 24% of the articles published by Brazilian authors, with 80% published in just 10.3% of those journals demonstrating that many Brazilian journals of Agricultural Sciences are among the top 50 journals used as communication vehicles by Brazilian authors. This growth of Agricultural journals in international databases was dated first between 1971 and 1980, showing that the area began to develop from that period onwards, corresponding to 22.4% of national journals indexed in Scopus and 27% of those indexed in WoS; 31.1% of those journals appeared between 1971 and 1980 (Oliveira, Rodrigues & Matias 2017). In the early 2000s, we can link this growth to factors such as the expansion of graduate programs and higher investment in research. Moreover, several low-impact journals published in Portuguese modified their periodicity after being indexed in the WoS (Vargas, Vanz & Stumpf, 2014).

Figure 2 shows the proportion of documents by type of institution and collaboration strategies. Academic and non-academic institutions presented a similar trend in national collaboration (in blue) over the entire period (mean percentages are between 60% and 70% of total production. On the other hand, international collaborations were less present in both academic and non-academic institutions. However, although they present reasonably similar

trends, non-academic institutions show higher mean percentages (with values between 16.4% and 21.4%) than academic institutions (with values between 8.9% and 16.2%). This result evidences that academic institutions are more productive, whereas non-academic institutions tend to engage more in international networks. As for the international collaboration, the outliers correspond to INPE and Fundecitrus in the three five-year periods and to INPA and UFRGS in the first and third five-year periods (Tables 1 and 2).

Figure 2. Mean % of documents in national and international collaboration, by type of institution.



According to the Royal Society (2011), the percentage of Agronomy documents in international collaboration in 2008 was lower than the world average for all the areas (36%). Vanz and Stumpf (2012) showed that 30.3% of all the Brazilian articles indexed in WoS from 2004 to 2006 were in international collaboration, for only 24% of the articles in the agricultural sciences. Cañas-Guerrero et al. (2013) also pointed out that Brazil had a low percentage (12.9%) of articles with international collaborations in the period from 1997 to 2011 (partially overlapping the period analyzed in this study). The authors evidenced that the other four most productive countries in Agronomy (the USA, India, Japan, and Canada) also showed a trend towards low international collaboration. However, given the lower citation rates per article, the dissemination of Brazilian publications was barely noticeable. As for the relative dispersion of the percentage of documents in collaboration (Tables 1 and 2), we observed a sharp dispersion drop over the period, especially for non-academic institutions. Furthermore, academic and non-

academic institutions show less dispersed values in national collaborations; however, academic institutions present much more homogeneous percentages in the three five-year periods, close to their group's average.

Figure 3. Average normalized citation impact by type of institution and scientific collaboration.

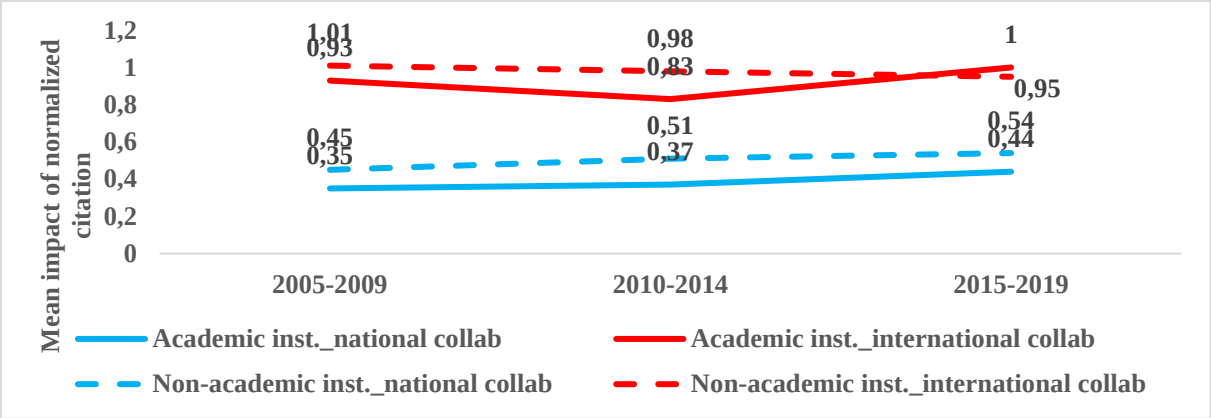


Figure 3 demonstrates that non-academic institutions presented a normalized citation impact (CNCI) higher than academic institutions for national and international collaboration, except in the last period for international collaboration. The trend seen is a decline over time. Non-academic institutions exceed the world average in the first period, with a downward trend over the years in international collaboration. This trend is consistent with the decrease in international publications, as shown in Figure 2. Even so, the impact of their output is at the world average. At the same time, in national collaboration, their normalized citation is 5% less than the average in the first period, with a significant decrease in the second period (17% less than the world average) and picks up again in the third period. Furthermore, the average citation impact of academic and non-academic institutions in articles on Agronomy involving national collaboration remained below the global mean (1.0). As for publications with international collaboration, their normalized citation impact was very close to or equal to the global mean, remaining stable over the three five-year periods. This trend is more representative of academic institutions, as they presented less dispersion (coefficient of variation in Table 1) around the mean than non-academic institutions. Specifically, for articles with international collaboration, the dispersion of non-academic institutions' normalized citation impact indexes is almost four times greater than that of academic institutions in all five-year periods.

Behind this surprising result, we acknowledge the performance of some small non-academic institutions. For instance, in the 2005-2009 period, two documents published through international collaboration by Fundecitrus and Museu Paraense Emílio Goeldi reached a normalized impact of 2.78 and 2.09, respectively; on the other hand, in the 2010-2014 period, the values of INPA and INPE were 2.15 and 1.82, respectively. Finally, in the 2015-2019 period, INPE and Fundecitrus values were 2.08 and 2.06, respectively (Table 2). Documents published with international partners achieve a higher normalized impact than those in national collaboration, a trend aligned with other studies reporting the advantage that documents in international collaboration have in citations (Royal Society, 2011; Adams & Gurney, 2018).

Figure 4 reveals that academic and non-academic institutions have greater participation in articles as corresponding authors (%DAC indicator) in national collaboration in the three five-year periods. The non-academic institutions exhibit high dispersion in this indicator's values, with international collaboration even more significant. Meanwhile, academic institutions show similar percentages of documents (low dispersion) within each collaboration category, especially when co-authorship involves national collaboration.

Figure 4. Mean % of documents as corresponding author, by type of institution and collaboration.

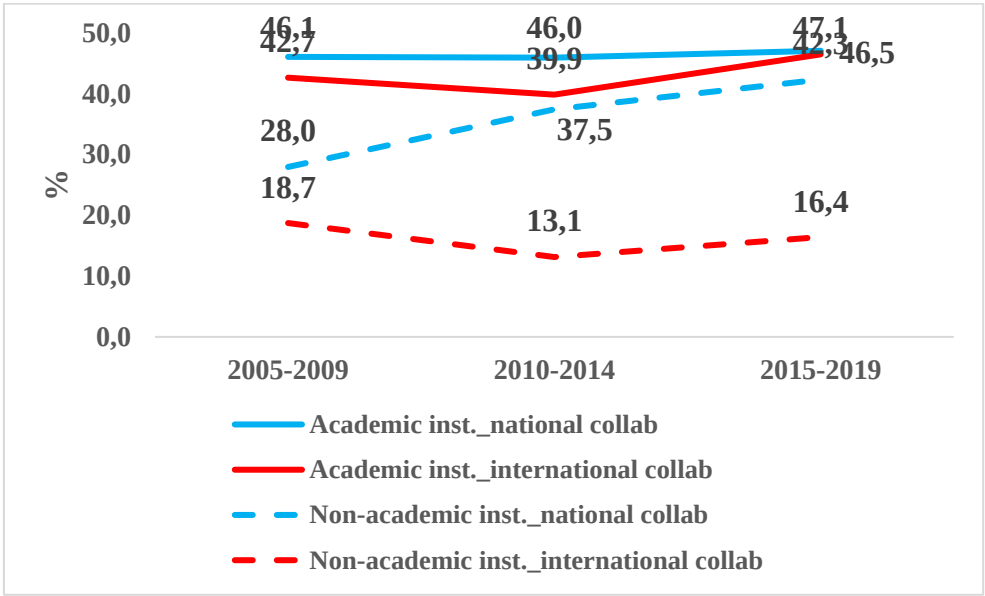


Table 3 presents the results of the Kruskal-Wallis Test, evaluating the significance of the differences in trends observed over the period. Dunn's post hoc test for cases that showed a statistically significant difference ($p < 0.05$) in the Kruskal-Wallis test identified the five-year periods where the notorious difference occurred. Table 3 reveals that there are significant differences between the 2005-2009 and 2015-2019 for publications in national collaboration by non-academic institutions (with a 130% increase in the number of documents from the first to the third five-year period) and for publications in international collaboration by academic institutions (with a 254% increase from the first to the third five-year period). Between the 2010-2014 and 2015-2019 periods, a statistically significant difference appeared in the percentage of documents published in international collaboration by academic institutions, corresponding to a 76% growth from the 2010-2014 period to the following five-year period (2015-2019). On the other hand, the tests did not find sufficient statistical evidence to confirm differences over the period for the number and proportion of documents (Doc and %Doc/DocG). As for the normalized citation impact (CNCI) and the % of documents as corresponding author (%DAC), the Kruskal-Wallis Test did not detect sufficient evidence in support of significant statistical differences over the period for both academic and non-academic institutions in national and international collaboration, which indicates the regularity of the values in these two indicators over the analyzed five-year periods.

Table 3: Kruskall-Wallis nonparametric test to verify the significant difference in Doc, %Doc/DocG, CNCI, and %DAC indicators between the three five-year periods by type of institution and scientific collaboration.

Type of Collaboration	**Type of Institution**	**p-value for Kruskal-Wallis test**			
		Doc	%Doc/DocG	CNCI	%DAC
International	Academic	**0.008**** (1 and 3)	**0.015*** (2 and 3)	0.146	0.366
	Non-academic	0.476	0.765	0.965	0.787
National	Academic	0.061	0.206	0.096	0.826
	Non-academic	**0.028*** (1 and 3)	0.587	0.692	0.402

*; ** = significant difference for the significance level of 0.05 and 0.01, respectively.

(1) = 2005-2009; (2) = 2010-2014; (3) = 2015-2019.

Table 4 presents Spearman's correlation coefficients between the percentage of documents as corresponding author (%DAC) and the other three analyzed indicators (Doc, %Doc/DocG, and CNCI), evaluating the intensity of their association.

Table 4: Spearman's correlation by type of institution and collaboration strategies.

2005-2009								
Type of collaboration	**Type of institution**	**Spearman's Correlation (rho)**	**International collaboration**			**National collaboration**		
			Doc	%Doc/DocG	CNCI	Doc	%Doc/DocG	CNCI
International	Academic	%DAC	0.35	0.10	0.03			
	Non-academic	%DAC	0.54	0.09	0.37			
National	Academic	%DAC				-0.51	-0.30	0.13
	Non-academic	%DAC				0.30	-0.49	**0.63***
2010-2014								
Type of collaboration	**Type of institution**	**Spearman's Correlation (rho)**	**International collaboration**			**National collaboration**		
			Doc	%Doc/DocG	CNCI	Doc	%Doc/DocG	CNCI
International	Academic	%DAC	0.13	-0.28	0.11			
	Non-academic	%DAC	**0.77****	**0.70***	**0.64***			
National	Academic	%DAC				-0.10	-0.10	-0.35
	Non-academic	%DAC				0.24	-0.01	**-0.68***
2015-2019								
Type of collaboration	**Type of institution**	**Spearman's Correlation (rho)**	**International collaboration**			**National collaboration**		
			Doc	%Doc/DocG	CNCI	Doc	%Doc/DocG	CNCI
International	Academic	%DAC	0.30	-0.24	-0.02			
	Non-academic	%DAC	**0.76***	-0.41	**0.82****			
National	Academic	%DAC				-0.53	-0.21	**-0.68***
	Non-academic	%DAC				-0.38	-0.26	0.27

*; ** = significant correlation at significance level of 0.05 and 0.01, respectively.

Regarding the association between the percentage of documents as corresponding author and the percentage of documents in general, Table 4 shows a significant positive correlation between the two indicators in the 2010-2014 period for non-academic institution publications deriving from international collaboration (rho = 0.70; p = 0.0241), corroborating the

correlations described in the previous paragraph. When considering international scientific collaboration, we observed a significant positive correlation between the percentage of documents as corresponding author and the total number of documents published by non-academic institutions in the periods 2010-2014 (rho = 0.77; $p < 0.01$) and 2015-2019 (rho = 0.76; $p = 0.0116$). That correlation indicates that the higher the number of documents published with international collaboration, the greater the participation of these institutions as corresponding authors. On the other hand, we did not find any association between this indicator and the number of publications by non-academic institutions with national scientific collaboration. As for academic institutions, we did not acknowledge, for any collaboration, any correlation between the indicator %DAC and the total number of documents published in any of the five-year periods.

As for the association between the percentage of documents as corresponding author and the impact of citations of the Brazilian institutions with higher productivity, Table 4 provides evidence that non-academic institutions present significant positive correlations in the period 2010-2014 (pho = 0.64; $p = 0.0485$) and 2015-2019 (rho = 0.82; $p = 0.0039$) in international collaboration. It is clear that for this type of institution, the more they assume the role of leadership associated with the corresponding authorship position, the higher the impact of their publications.

These results differ from Chinchilla et al. (2018), reporting the advantage regarding the impact of articles when Brazilian authors do not lead the publications (do not appear as corresponding authors) in the Biomedical Research field. Grácio et al. (2020) reported similar findings for articles indexed by Scopus between 2003 and 2015, showing that articles in international collaboration have a normalized mean impact of 1.48 with corresponding authors not affiliated with a Brazilian institution. When the corresponding author belongs to a Brazilian institution, the mean normalized citation impact decreases to 0.88 (a 60% reduction). Vanz and Docampo (2022) also reported that when a Brazilian university assumes the role of the corresponding author, the influence on research impact decreases for most areas. For all 25 most productive Brazilian universities, collaboration with at least one of the four major English-speaking countries (Australia, Canada, the United Kingdom, and the United States) favored the number of received citations by 57.7%.

Regarding the correlation between %DAC and CNCI for national collaboration, the authors found that non-academic institutions have a significant positive correlation in the 2005-2009 period (rho = 0.63; p = 0.0495) and a negative correlation in the 2010-2014 period (rho = -0.68; p = 0.0301). For the same type of collaboration, academic institutions show a significant negative correlation only in the 2015-2019 period (rho = -0.68; p=0.0302). In these last two situations, the negative correlation indicates a trend for the CNCI to increase when institutions do not assume the role of the corresponding author in this type of collaboration. Therefore, leadership is associated with a higher impact on publications only for non-academic institutions, specifically in the 2005-2009 period.

Conclusion

This research aimed to analyze whether the impact of citation, among other indicators, can be associated with the role of the corresponding author for Brazilian institutions with research in scientific collaboration. We focus on the analysis of Agronomy as a subject area indexed by the WoS in the five-year periods of 2005-2009, 2010-2014, and 2015- 2019. Our ultimate goal is to verify whether this condition aggregates information to describe their scientific performances and modes of scientific communication. We analyzed two types of institutions: academic and non-academic, in two collaboration strategies: national and international.

Our results show that for academic institutions, documents published in international collaboration grew between the first and the last five-year period, as the CNCI and percentage of documents designated as corresponding author (%DAC). On average, Brazilian institutions present a similar normalized citation impact, close to the global mean in the country in the category "Agronomy" only for documents with international collaboration. This behavior is more representative for non-academic institutions, where most universities show a citation impact close to 1.0, and less for academic institutions, given the broad indicator's dispersion among them. We also observed a high dispersion of the percentages of documents as corresponding authors, more significant among non-academic institutions in international collaboration. Furthermore, both types of institutions show higher shares of documents as the corresponding author in national collaboration. We also observed a trend for both types of institutions, the greater the scientific production, the greater the participation as the

corresponding author, especially when the research involves international scientific collaboration.

Among non-academic institutions, we verified the gain in citation impact when their researchers assume a leadership role (as corresponding authors) in international collaboration. Although less significant among academic institutions, the higher the proportion of publications as the corresponding authors, the smaller the citation impact of collaborative publications tends to be, which opens new research questions about the patterns of communications and thematic covered by these institutions.

Implications

Even though our results refer to the group of the most productive institutions, they have overall implications. They expand the knowledge of scientific communications models of successful institutions in terms of insertion and recognition of Brazilian research in the Agronomy field. This finding might contribute to research management guidelines according to the different types of institutions. They are also relevant for contextualizing leadership's role in the Brazilian scientific ecosystem and opening more research questions.

Overall national partnerships get less impact when they act as corresponding authors. However, there is a tradeoff: they are essential as they are usually more tailored to national interests and increase national cohesiveness and scientific capacity. On the other hand, international partnership usually increases visibility, although most academic Brazilian institutions benefit from international partnerships when they are not leading research. In any case, they should keep consolidating international networks to increase the knowledge base and resources available for local development. For further research, it would be interesting to study whether international collaborations are taking advantage of national and regional networks in Brazil.

Our findings show genuine research capacities in some non-academic institutions, which might significantly impact their collaboration strategies at the national and international levels. It would be interesting to analyze their communication practices further to understand how they might improve their impact locally and globally (e.g., venues and language of

publication, local vs. global topics of research related to the territorial interest of publications, and their focus when Brazilian researchers act or not as the corresponding authors).

Finally, this analysis is helpful as an input to reflect on CNPq objectives that can become specific goals and as a basis for public policies. It could inform the institutional policy on the search for a balance between the anchoring of institutional synergies and territorial cohesion while promoting changes by exploring mechanisms that encourage international associations, such as strategic alliances, collaboration agreements, and mobility programs. On the other hand, they can serve as a basis for analyzing communication practices at the institutional level that help improve their visibility at the national and international levels.

Limitations and further research

This study is not exempt from limitations that will be coped with in further research using complementary approaches. First, we will expand the study to the entire universe of Brazilian institutions. Second, using CNCI globally may represent a limitation, given that we did not evaluate specific CNCIs, such as those where the institution signs as the corresponding author. In future studies, we will use the CNCI in detail, evaluating the effect of domestic and international collaborations (Potter, Szomszor & Adams, 2020). Third, we will compare the impact difference by document category, taking into account that the proceedings are of little relevance in Agronomy. Fourth, we plan to conduct a qualitative analysis (through surveys and semi-structured interviews) from the perspective of Brazilian authors to understand their perceptions about the meaning of the role of the corresponding author in national and international collaborations. Other limitations intrinsic to bibliometrics analyses are also highlighted, like for example the use of commercial databases. Further studies can be developed using other data sources in order to know and be able to interpret different results derived from different coverage, indexation policies, etc.

REFERENCES

Adams, J., & King, C. (2009). *Global research report Brazil:* research and collaboration in the new geography of science. Leeds: Thomson Reuters.

Adams, J. (2012). The rise of research networks. *Nature*, 490, 12 Oct, 335-336.

Adams, J. & Gurney, K. A. (2018). Bilateral and Multilateral Coauthorship and Citation Impact: Patterns in UK and US International Collaboration. *Front. Res. Metr. Anal*., 23 March. https://www.frontiersin.org/articles/10.3389/frma.2018.00012/full

Azevedo, J.L. (1996). Pesquisa Agropecuária. In: Schwartzman, Simon. *Ciência e tecnologia no Brasil:* a capacitação brasileira para a pesquisa científica e tecnológica. Rio de Janeiro: Fundação Getúlio Vargas, p. 287-320.

Barreto, R.C.S & Almeida, E. (2009). A contribuição da pesquisa para a convergência da renda agropecuária no Brasil. *Revista de Economia e Sociologia Rural*, 47 (3), 719-737. https://doi.org/10.1590/S0103-20032009000300009

Bhandari, M., Guyatt, G.H., Kulkarni, A.V., Devereaux, P.J., Leece, P., Bajammal, S., Heels-Ansdell, D., Busse, J.W. (2014). Perceptions of authors' contributions are influenced by both byline order and desthe ignation of corresponding author. *Journal of Clinical Epidemiology*, 67, 1049-1054. https://www.sciencedirect.com/science/article/pii/S0895435614001267

Bordons, M., et al. (2014). The influence of R&D intensity of countries on the impact of international collaborative research: evidence from Spain. *Scientometrics*, 102 (2), 1385-1400. https://link.springer.com/article/10.1007/s11192-014-1491-4

BRASIL. Ministério da Educação. Instituto Nacional de Estudos e Pesquisas Educacionais Anísio Teixeira. [2019]. *Censo da Educação Superior*: notas estatísticas 2019. https://download.inep.gov.br/educacao_superior/censo_superior/documentos/2020/Notas_Estatisticas_Censo_da_Educacao_Superior_2019.pdf.

Bu, Y., Wang, B., Chinchilla-Rodríguez, Z., Sugimoto, C. R., Huang Y., & Huang W. (2020). Considering author sequence in all-author co-citation analysis. *Information Processing & Management*, 57 (6); 102300 https://doi.org/10.1016/j.ipm.2020.102300

Cañas-Guerrero, Ignacio et al. (2013). Bibliometric analysis of research activity in the "Agronomy" category from the WoS, 1997–2011. *European Journal of Agronomy*, 50, 19-28. https://www.sciencedirect.com/science/article/pii/S116103011300066X

Capdeville, G. (1991). *O ensino superior agrícola no Brasil.* Viçosa: UFV, Imprensa Universitária.

CEPEA, Centro de Estudos Avançados em Economia Aplicada. Available at < http://www.cepea.esalq.usp.br/ >. Acess on 18th April 2023.

Chinchilla-Rodríguez, Z., Sugimoto, C.R, Lariviére, V. (2019). Follow the leader: On the relationship between leadership and scholarly impact in international collaboration. *PLoS ONE*, 14 (6), e0218309. https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0218309

Chinchilla-Rodríguez, Z., Ocaña-Rosa, K., & Vargas-Quesada, B. (2016). How to Combine Research Guarantor and Collaboration Patterns to Measure Scientific Performance of Countries in Scientific Fields: Nanoscience and Nanotechnology as a Case Study. *Frontiers in Research Metrics and Analytics*, 1:2. https://doi.org/10.3389/frma.2016.00002

Chinchilla-Rodríguez, Z., Zacca-González, G., Vargas-Quesada, B., Moya-Anegón, F. (2016). Benchmarking scientific performance by decomposing leadership of Cuban and Latin American institutions in Public Health. *Scientometrics*, 106 (3), 1239–1264. https://doi.org/10.1007/s11192-015-1831-z

Chinchilla-Rodríguez, Z., Larivière, V., Costas, R., Robinson-García, N., Sugimoto, C.R. (2018). Building ties across countries: International collaboration, field specialization, and global leadership. 23th International Conference on Science and Technology Indicators, STI2018. Leiden, The Netherlands, 12-14 September 2018, *STI 2018 Conference Proceedings*, 1509-1518. https://digital.csic.es/handle/10261/170064

Conselho Nacional de Desenvolvimento Científico e Tecnológico. (2022) *Tabela de áreas do conhecimento*. Brasília: CNPq. Available at: http://www.lattes.cnpq.br/documents/11871/24930/TabeladeAreasdoConhecimento.pdf/d192ff6b-3e0a-4074-a74d-c280521bd5f7

Costa, H., Matias, M. & Rodrigues, R.S. (2017). Institutos Nacionais de Ciência e Tecnologia da área de Ciências Agrárias: estudo da publicação científica, técnica e tecnológica (2013-2015). *Biblios*, 68, 1-20. http://dx.doi.org/10.5195/biblios.2017.390

Cross, D., Thomson, S., Sinclair, A. (2017). *Research in Brazil*: a report for Capes by Clarivate Analytics. [S.l]: Clarivate Analytics.

Cruz, Carlos H. Brito. (2007). Ciência e Tecnologia no Brasil. *Revista USP*, 73, 58-90.

Empresa Brasileira de Pesquisa Agropecuária (2022). Transparency Portal Access to Information. https://www.embrapa.br/en/web/portal/accesstoinformation

Etzkowitz, H.& Leydesdorff, L. (1995). The Triple Helix—university–industry–government relations: A laboratory for knowledge-based economic development. *EASST Review*, 14, 14–19.

Etzkowitz, H.& Leydesdorff, L. (2000). The dynamics of innovation: From national systems and 'Mode 2' to a Triple Helix of university–industry–government relations. *Research Policy*, 29(2), 109–123.

Glänzel, W., Leta, J., Thjis, B. (2006). Science in Brazil. Part 1: A macro-level comparative study. *Scientometrics*, 67 (1), 67-86. https://akjournals.com/view/journals/11192/67/1/article-p67.xml

González-Alcaide, G., & Gorraiz, J. (2018). Assessment of Researchers Through Bibliometric Indicators: The Area of Information and Library Science in Spain as a Case Study (2001–2015). Frontiers Research Metrics & Analytics, 3. https://doi.org/10.3389/frma.2018.00015

González-Alcaide, G., et al. (2017). Dominance and leadership in research activities: Collaboration between countries of differing human development is reflected through authorship order and designation as corresponding authors in scientific publications. *PLoS ONE*, 12 (8), e0182513. https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0182513

Grácio, M.C.C., et al. (2020). Does corresponding authorship influence scientific impact in collaboration: Brazilian institutions as a case of study. *Scientometrics*, 125, 1349–1369. https://doi.org/10.1007/s11192-020-03655-7

Győrffy, Balázs et al. (2018). Factors influencing the scientific performance of Momentum grant holders: an evaluation of the first 117 research groups *Scientometrics*. 2018; 117(1): 409–426. https://doi.org/10.1007/s11192-018-2852-1Hu, Z., Tian, W., Guo, J. et al. (2020). Mapping research collaborations in different countries and regions: 1980–2019. Scientometrics 124, 729–745. https://doi.org/10.1007/s11192-020-03484-8

Hu, Z. et al. (2018). Four pitfalls in normalizing citation indicators: An investigation of ESI's selection of highly cited papers. *Journal of Informetrics* 12 (4), 1133-1145. https://doi.org/10.1016/j.joi.2018.09.006

International Committee of Medical Journal Editors (ICMJE). c2021. *Defining the Role of Authors and Contributors.* ICMJE. http://www.icmje.org/recommendations/browse/roles-and-responsibilities/defining-the-role-of-authors-and-contributors.html.

Irizaga, K.R.F. & Vanz, S.A.S. (2021). A produção científica por unidade federativa brasileira em ciências agrárias na SCOPUS: uma análise bibliométrica. *AtoZ: novas práticas em informação e conhecimento*, 10 (1) 1-14. http://dx.doi.org/10.5380/atoz.v10i1.76894

Jobson, J.D. (1991). Multiple Linear Regression. In: *Applied Multivariate Data Analysis*.

https://doi.org/10.1007/978-1-4612-0955-3_4

Leta, J., Glänzel, W., Thijs, B. (2006). Science in Brazil. Part 2: sectoral and institutional research profiles. *Scientometrics*, 67(1), 87-105. https://doi.org/10.1007/s11192-006-0051-y

Lovakov, A., Chankseliani, M., Panova, A. (2022). Universities vs. Research institutes? Overcoming the Soviet legacy of higher education and research. Scientometrics, p. 6293-6313. https://doi.org/10.1007/s11192-022-04527-y

Lyra, T.M.P. & Guimarães, J.A. (2007). Produção científica brasileira em comparação com o desempenho mundial em ciências agrárias. *Planejamento e Políticas Públicas*, 3, 141-162, http://www.ipea.gov.br/ppp/index.php/PPP/article/view/39

Lundberg, H. (2011). Challenges, Complexities, and Advantages of Regional Strategic Networks. In: Johanson, M., Lundberg, H. (eds) *Network Strategies for Regional Growth*. Palgrave Macmillan, London. https://doi.org/10.1057/9780230299146_12

Martinez, M., Sá, C. (2020). Highly cited in the south: International collaboration and research recognition among Brazil's highly cited researchers. *Journal of Studies in International Education*. https://doi. org/10.1177/1028315319888890.

Martins, G.A. (2010). *Estatística geral e aplicada*. 3. ed., São Paulo: Atlas.

McManus, C., Baeta Neves, A.A., Maranhão, A.Q. (2020). Brazilian publication profiles: where and how Brazilian authors publish. *Anais Academia Brasileira de Ciências*, 92 (2). https://www.scielo.br/j/aabc/a/tMdTJkXy6VTchzGwDjqq9fF/abstract/?lang=en

Moya Anegón, F. et al. (2013). The research guarantors of scientific papers and the output counting: a promising new approach. *Scientometrics*, 97, 421–434. https://link.springer.com/article/10.1007/s11192-013-1046-0

Nocetti, M. A. (1977). Análise bibliométrica dos perfis das publicações periódicas e seriadas brasileiras correntes em ciências agrícolas e afins. *Revista de Biblioteconomia e Documentação*, 5 (1), 567–575.

Oliveira, A.B., Rodrigues, R.S., & Matias, M. (2017). Periódicos científicos das Ciências Agrárias: análise dos títulos brasileiros indexados na Web of Science e Scopus. *Perspectivas em Ciência da Informação* 22(2), 3-28. https://www.scielo.br/j/pci/a/8JcxSCVNPnQdNyK4p3tKG5v/abstract/?lang=pt

Oliven, A.C. (2002). Histórico da Educação Superior no Brasil. In: SOARES, Susana Arrosa Soares (org.). *A Educação Superior no Brasil*. Brasília: CAPES, p. 31-42.

Paz, V.P.S., Teodoro, R.E.F. & Mendonça, F.C. (2000). Comunicado Técnico: recursos hídricos, agricultura irrigada e meio ambiente. *Revista Brasileira de Engenharia Agrícola e Ambiental*, 4 (3), 465-473.

Parra, J.R.P. et al. (2002). Área de Ciências Agrárias: importância da agricultura para o Brasil. *Revista Parcerias Estratégicas***,** 4 (14), 11-32.

Penteado Filho, R.C.; Avila, A.F.D. (2009). Embrapa Brasil: análise bibliométrica dos artigos na *Web of Science* (1977-2006). **Texto para discussão**, 36, doc. não paginado.

Pislyakov, Vladimir (2022). On some properties of medians, percentiles, baselines, and thresholds in empirical bibliometric analysis. *Journal of Informetrics* 16 (4), 101322. https://doi.org/10.1016/j.joi.2022.101322Potter, Ross W.K., Szomszor, Martin & Adams, Jonathan (2020). Interpreting CNCIs on a country-scale: The effect of domestic and international collaboration type. *Journal of Informetrics*, 14 (4). https://doi.org/10.1016/j.joi.2020.101075

Puerta, A.A.; Lopes de Faria, L.I.; Penteado Filho, R.C. (2012). Desenvolvimento científico em nanotecnologia para o agronegócio: indicadores bibliométricos de produção científica a partir da *Web of Science* (2001-2010). *Em Questão*, 18 (3), 145-160.

Robredo, J., Chastinet, Y. S., & Ponce, C.A. (1974). Metodologia para a elaboração da lista básica dos periódicos nacionais em ciências agrícolas e estudo da dispersão da literatura agrícola brasileira. *Revista de Biblioteconomia de Brasília*, 2(2), 119–142. https://periodicos.unb.br/index.php/rbbsb/article/view/28637

Royal Society. (2011). *Knowledge, networks and nations: global scientific collaboration in the 21st century*. London: Elsevier. https://royalsociety.org/~/media/Royal_Society_Content/policy/publications/2011/4294976134.pdf

Saisana, M., d'Hombres, B., Saltelli, A. (2011). Richety numbers: Volatility of university rankings and policy implications. *Research Policy*, 40 (1), 165-177. https://www.sciencedirect.com/science/article/pii/S0048733310001812

Salles Filho, S., Bin, A. (2014). Reflexões sobre os rumas da pesquisa agrícola. In: Buainain, A.M. et al (eds.) *O mundo rural no Brasil do século 21*: a formação de um novo padrão agrário e agrícola. Brasília: Embrapa. https://repositorio.iica.int/handle/11324/20109

Stal, E., Fujino, A. (2005). As relações universidade-empresa no Brasil sob a ótica da Lei de Inovação. *Revista de Administração e Inovação*, 2 (1), 5-19.

Souza, J. G. (1995). Evolução histórica da Universidade brasileira: abordagens preliminares. *Revista da Faculdade de Educação – PUCCAMP*, 1 (1), 42-48.

Souza et al. (2013). Concepções de universidade no brasil: uma análise a partir da missão das universidades públicas federais brasileiras e dos modelos de universidade. Revista GUAL, 6 (4), 216-233.

Schwartzman, Simon. (2001). *Um Espaço para a Ciência*: a formação da comunidade científica no Brasil. Brasilia: MCT.

Vanz, S.A.S., Stumpf, I.R.C. (2012). Scientific Output Indicators and Scientific Collaboration Network Mapping in Brazil. *Collnet Journal of Scientometrics and Information Management*, 6 (2).

https://www.tandfonline.com/doi/abs/10.1080/09737766.2012.10700942

Vanz, S. A. S., Docampo, D. (2022). The Influence of International Scientific Collaboration with English-speaking Countries on the Research Performance of Brazilian Academic Institutions. *Journal of Scientometric Research* 11(3), 1-8.

Vanz, S. A. S., et al (2022). O impacto da produção científica brasileira em "Agronomy": a influência do autor correspondente (2015 a 2019). *Anais do Encontro Brasileiro de Bibliometria e Cientometria* (8: Maceió, AL).

Vargas, R.A., Vanz, S.A.S., Stump, I.RC. (2014). The role of National journals on the rise in Brazilian Agricultural Science Publications in Web of Science. *Journal of Scientometric Research*, 3 (1). http://jscires.org/sites/default/files/JSciRes_2014_3_1_28_143698.pdf

Vargas, R.A., Vanz, S.A.S., Stumpf, I.R.C. (2015). Brazilian agricultural research in the Web of Science: a bibliometric study of scientific output and collaboration (2000-2011). *Em Questão*, 21 (3), 296-318. https://dialnet.unirioja.es/servlet/articulo?codigo=6142010

Velho, L. M. L. S. (1986). A contemporaneidade da pesquisa brasileira como reflexo da distribuição da idade das citações. *Ciência da Informação*, 15 (1), 3-9.

Velho, L. M. L. S. (1990). Sources of influence on problem choice in Brazilian university agricultural science. *Social Studies of Science*, 20 (3), 503-517.

Wang, Zhii & Rousseau, Ronald (2021). COVID-19, the Yule-Simpson paradox and research evaluation. *Scientometrics* 126, 3501–3511. https://doi.org/10.1007/s11192-020-03830-w

Willems, L. & Plume, A. (2021). Great Power or Great Responsibility: What Is the Meaning of 'Corresponding Authorship' in Modern Research? *International Center for the Study of Research Paper*, 8, http://dx.doi.org/10.2139/ssrn.3835300

Wohlrabe, K., & Bornmann, L. (2022). Alphabetized co-authorship in economics reconsidered. *Scientometrics* 127, 2173–2193. https://doi.org/10.1007/s11192-022-04322-9

Wouters, P. et al. (2015). *The Metric Tide:* Literature Review. HEFCE. (Supplementary Report I to the Independent Review of the Role of Metrics in Research Assessment and Management). https://re.ukri.org/documents/hefce-documents/metric-tide-lit-review-1/.

Wren, J.D., Kozak, K.Z, Johnson, K.R., Deakyne, S.J., Schilling, L.M., Dellavalle, R.P. (2007). The write position: a survey of perceived contributions to papers based on byline position and number of authors. *EMBO reports*, 8(11), 989-991. https://www.embopress.org/doi/full/10.1038/sj.embor.7401095

Zhou, P., & Leydesdorff, L. (2006). The emergence of China as a leading nation in science. *Research Policy*, 35(1), 83-104. https://www.sciencedirect.com/science/article/pii/S0048733305001794