

A Scientometric Analysis of Embrapa's Brazil Web of Science Articles from 1977 to 2006

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Abstract

This article studies, using the technique of bibliometrical analysis, Brazilian Agricultural Research Corporation - Embrapa's research centers participation in the journals that were indexed in the Web of Science (WOS) database, from 1977 to 2006. First we analyze the performance of the research centers, followed by the journals which published these articles and finally the partnerships with the institutions that had carried out this scientific work with Embrapa. The results indicated that Embrapa is among the top ten Brazilian institutions to lead in the volume of scientific articles published in indexed WOS journals. They also indicate the relevance of the adoption of a goals and results system by an institution of Sc,T&I and the need to select strategies to establish partnerships, select journals in accordance with the institutional stated mission and standardize their authors affiliations, in order to facilitate the identification and improve their scores.

Index Terms

Scientometry, bibliometrical analysis, agricultural research, scientific production, science in Brazil.

Introduction

Bibliometrical analysis of structured texts is becoming an important tool for organizations. It is an instrument for the creation of profiles of the areas of interest, for mapping relationships, topics and teams, for analyzing tendencies and developing innovative indicators (Penteado Filho, 2007; Penteado et al., 2003).

With bibliometrical analysis of structured texts (Porter and Cunningham, 2005) the word, could represent, amongst many other things a concept or theme, an individual or an organization, or even a group of themes, individuals or organizations. The basic assumptions of the analysis model states that if two words appear together in the same document they might be connected. If the same words appear together in many documents there is a relation between them (Porter, 2006). It involves one-dimensional statistics (how much and what do the values/words mean, bi-dimensional statistics (when and how to evaluate the relationship between two values/words), multi-dimensional statistics (how and when to measure the relationship between various variables/words) and probabilistic statistics (to detect emerging or atypical patterns of behaviors, or even how these values/words behave) (Lafouge et al., 2003; Le Coadic, 2003; Callon et al., 1993).

Spinak (1998) presents scientometry as "an instrument of the science of sociology" (p.143) and cites some applications for these mathematical and statistical techniques:

- *To identify the journals of the nucleus of each discipline;*
- *To estimate the coverage of secondary journals;*
- *To adapt policies for the rejection of publications;*
- *To identify the users of the different disciplines;*

- *To evaluate the usefulness of the services of selective information;*
- *To forecast tendencies in the publication of subjects and themes;*
- *To elaborate norms for standardization;*
- *To elaborate the process for the indication, classification and generation of automatic resumes;*
- *To identify the tendencies and growth of knowledge in the different disciplines;*
- *To study the dispersion and obsolescence of the scientific literature;*
- *To forecast the productivity of publishers, individual authors, organizations and countries, among others. (p.143).*

For Gregolin et al. (2005), scientometry, which is denominated as "the science of all sciences" (p.5), it seeks to develop,

methodologies for the construction and analysis of indicators, based on interdisciplinary [...] including the study of physical, natural and social sciences, with the objective to understand its structure, progression and connections, so as to establish relationships of the sciences with technological, economic and social development. It is based on bibliometrical indicators constructed from published documents in specialized channels and involves innumerable parameters, such as the quality of publications, co-authors, citations, co-occurrence of words and others [...] applied as an indirect measure of the scientific research activity and contribute to the understanding of the objectives of research, the structures of the scientific community, its social, political and economical impact (p.5).

Among others authors, Gregolin et al. (2005), Lafouge et al. (2003), Spinak (1998) and Callon et al. (1993) described three types of indicators for the analysis of scientific production: indicators of production, indicators of citation and indicators of connectivity.

The indicators of production/activity ranges from the "total sum of the number of publications by type of document (books, articles, scientific publications and reports), by institution, area of knowledge, country" (Gregolin et al., 2005, p.7). These are quantitative indicators. They do not include, for example, the quality of publications.

The indicators of citation/impact are the number of citations received for a specific article. They denote the impact of the authors or articles and its influence or visibility. These indicators are based on the theory developed by Garfield (1955, 1964) affirming that the impact of the scientific article may be measured directly by the number of times it was cited after its publication. Garfield and his associates also developed specific databases to allow authors, affiliations and citations counts. They are the Science Citations Index Expanded (SCI-EXPANDED), Social Science Citation Index (SSCI) and Arts & Humanities Citation Index (A&HCI), today databases of Thomson Scientific, under the denomination of Web of Science (WOS).

As for the indicators of connectivity/relation, these are related to the co-occurrence of the authors, the co-citations of words, knowledge mapping and networks of relationships and collaboration between authors, institutions and countries. The number of co-occurrences in the publications are calculated thus, "the efforts for scientific collaboration" are measured (Gregolin et al., 2005, p.7) and "the national, international or regional co-operation in the different areas of knowledge " (Gregolin et al., 2005, p.7) identified and mapped.

Scientometric indicators in Embrapa

The Brazilian Agricultural Research Corporation – Embrapa, was founded in 1973. It possesses a series of databases which are used in the various areas of its administration, such as those applied in the area of human resources (SIRH), research projects (INFOSEG), budget and finance (SIAFI), and the performance indicators of the central units and research centers linked to the System of Assessment of Units (SAU), one of the components of the System of Evaluation and Award by Results (SAPRE), implanted in 1996 (Portugal et al., 1999). The indicators data used in the evaluation of the performance of all Embrapa were collected by the System of the Administration of Information of the Annual Work Plan (SISPAT), in the 1996-2006 period. As of 2007, the System of Information and Support to Strategic Decision (SIDE), which attends to SAU, but which is mainly dedicated towards the administration of strategic plans of Embrapa known as PDE (Embrapa Main Plan) and of every research center, the PDU (Unit Main Plan). Actually the corporation has developed, in April 2008, the fifth cycle of the strategic planning with the elaboration of the Vth Embrapa Main Plan (Plano Diretor da Embrapa): 2008-2011-2023.

On evaluating the performance of the research centers, one of the principal indicators which have been used, is the number of article published in the indexed journals. Initially, were merely pure and simple the quantity of articles published without any consideration for journals quality. From 2002, an index was considered based on the Qualis system, which was developed by the Coordination of the Assessment of Personnel of Higher Learning (CAPES), from the Ministry of Education. This system is a list of journals considered references in 45 areas of knowledge with a scope of distribution International, National and Local and quality A, B and C. This article analyses the scientific production of Embrapa research centers viewed from the angle of publication of articles in indexed journals in the Web of Science (WOS) database and also from the extend of the collaboration or co-authorship of the network of Embrapa researchers with national and international partners. Most journals were A quality among the Qualis system.

Methodology

On September 27, 2007, a search was carried out in de WOS database, in the 1973/2007 period, for all records, in every language and all types of documents, with mention of Embrapa in the authors' address.

From this, 5206 records were located. To discard research done before the constitution of the organization the 1974 to 1976 (8 articles) period was not considered. Also were discarded some 366 records from 2007, remaining 4832 articles from a 30 years term.

The Author, Author Affiliation, Country, Publication Year, Publisher, Source e Times Cited fields were standardized and segmented. The Author Affiliation field was divided as follows: Embrapa (type of center and region), Brazil (region), USA/Canada, Europe, Oceania, Africa, Asia, Latin America and UN System. The Publication Year field was divided into 3 decades, 1977 to 1986, 1987 to 1996 to 1997 to 2006, and 6 five-year periods; 1977 to 1981, 1982 to 1986, 1987 to 1991, 1992 to 1996, 1997 to 2001 and 2002 to 2006.

The Source field was divided into Brazilian and foreign journals. The Publisher field was segmented according to geographical regions; Europe, Brazil, USA/Canada, Latin America, Asia, Oceania, Africa. The analysis was centered in the indexed WOS articles produced by Embrapa 37 research centers.

Results

The results are presented in 2 blocks. The first describes the characteristics of the production of the indexed WOS articles: the progression of the year to year production, articles by research center, by language, by national and international journals and its publishers. The

second block approaches the national and international partnerships established for the production of these articles.

In the first two decades analyzed, the average production of all of Embrapa research centers was, 24.7 articles/year and 78.3 articles/year, respectively. In the 1997-2006 period, production grew almost 5 times reaching a production average of articles published in the WOS, from 391.3 articles/year. The mean production in all periods was 161.06 articles/year.

Articles by year

In the first 20 years of Embrapa, the publication of scientific articles did not present a uniform distribution, and only achieved its peak in the 1981-1982 period. It was only in 1992 that the number of 73 articles published in 1981 was overcome. In 1993, this superseded 100 articles/year. From that date, the publication initiative sprinted. In 1997 this reached more than 200 articles/year, in 1999, more than 300 articles/year, in 2003, more than 400 articles/year and in 2006, more than 500 articles/year, which placed Embrapa among the top ten scientific institutions in Brazil.

Therefore, its important to note that as of the early 1990s, through the initiative of the Ministry of Agriculture, Livestock and Supply (MAPA), the demand for an annual production of articles by the research centers began. Embrapa then included in its Annual Report of Activities the scientific production from each of its centers, as well as the generation and transference of technologies. Such a process was structured beginning 1996, when Embrapa created the SAU system and determined annual quantitative goals such as the publication of scientific articles in indexed journals. This process of assessment was adapted to a system of awards for results, which inspired the research centers to increase their production of the items of performance indicators used, particularly, published articles in indexed journals, which is the object of this study. Figure 1 below shows the progression of the production of scientific articles registered in the WOS database from 1977 to 2006.

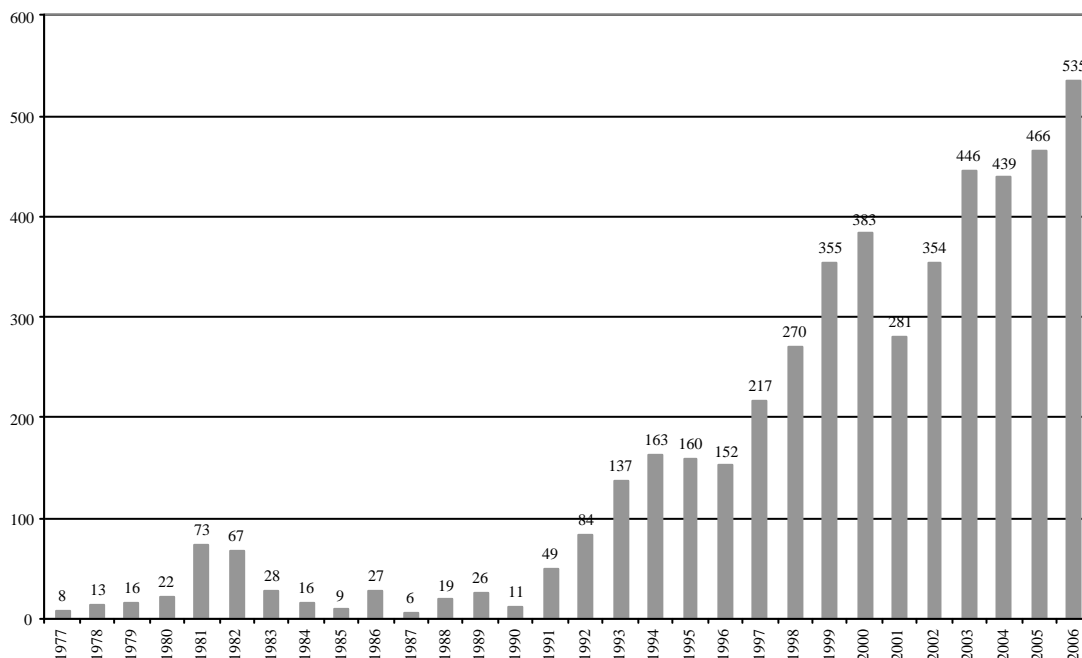


Figure 1. Scientific articles published by Embrapa in Web of Science indexed journals, 1977 to 2006.

Articles by research centers

Figure 2 allows us to analyze the 8 research centers with the most number of articles published in the WOS over the last ten years. Compared to the other centers, there is a differentiated pattern in Embrapa Genetic Resources and Biotechnology in the 1997 to 2006 period. This center registered, from 1999, a spectacular increase in the number of articles published, bypassing the other units, superseding the 40 articles/year average, and almost reaching 80 articles/year. It was only in 2006 that other 2 centers, Embrapa Soya and Embrapa Agrobiology attained the 40 articles/year average. The majority of the 8 centers analyzed published between 10-30 articles/year in the last decade. The other centers are: Dairy Cattle, Cerrados, Rice and Beans, Agricultural Instrumentation and Corn and Sorghum.

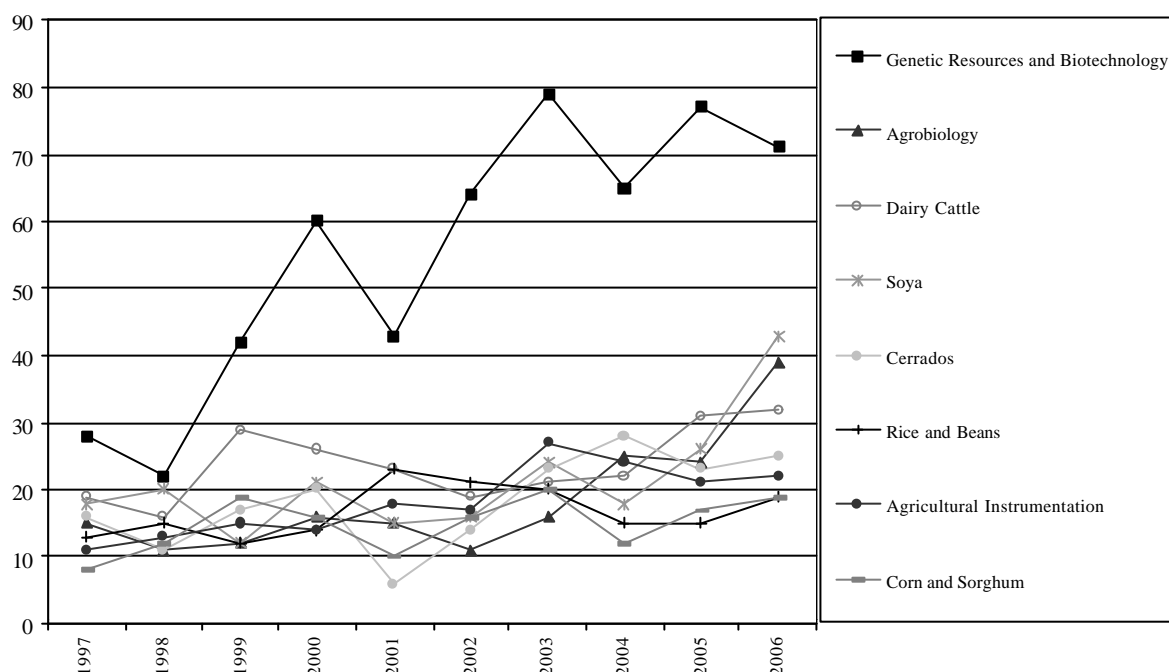


Figure 2. Progression of the production of articles per year by 8 research centers, 1997-2006.

The other 29 research centers presented an average production ranging between 0,36 and 6,6 articles/year but, like the first 8, also registered an accentuated growth in the last decade.

Articles by languages

The production of articles in English is an important pre-requisite to enable its publication in an international periodical, in any activity or area of research. Thus, the percentage of articles in English is an indicator of the growth of the publication activity of a research center and also its international exposure. 13 of Embrapa's research centers published more than two-thirds of its articles in English: Genetic Resources and Biotechnology, Soya, Agrobiology, Agricultural Instrumentation, Environment, Horticulture, Eastern Amazon, Food Technology, Pantanal, Forestry, Agriculture Informatics, South Animal Husbandry & Sheep and Satellite Monitoring. Six of them are among the 13 centers which published above Embrapa's average. Eleven of these research centers published a major part of their research in Portuguese. They are: Cattle Southeast, Dairy Cattle, Swine and Poultry, Wheat, Tropical Semi-Arid, Cotton, Goats and Sheep, Coastal Tablelands, Western Region Agriculture, Rondonia and Amapa.

Articles by Journals

Embrapa's and its partners' articles were published in 723 journals, of which 694 are foreign and 29 national. In spite of representing only 4% of the journals, the national journals published practically 50% of the articles. Table 1 shows this synthesis:

Table 1. Embrapa articles published in the WOS according to the journals origins.

ARTICLES PUBLISHED	NUMBER OF JOURNALS	%	NUMBER OF ARTICLES	%
ARTICLES IN NATIONAL JOURNALS	29	4,01	2390	49,46
ARTICLES IN FOREIGN JOURNALS	694	95,99	2442	50,54
TOTAL	723	100	4832	100

There is, in addition, a concentration of articles publication in a limited number of journals and also in Brazilian journals. It was ascertained that, considering only the first 25 from the 723 journals, 14 of which are Brazilians, these published practically 50% of the articles (49,92%). Furthermore, it was also identified that a major part of Embrapa research centers publish practically one-third of its articles in the agricultural Sc&T journal published by the company itself. Those tables are not shown.

Articles by publishers

The European publishers published 36% of the articles while the American and Canadian published 13% of the articles. In the last ten years there has been a significant growth in the publication of articles by European publishers, but this changed in 2006, where there was a 38% increase of publication with Brazilian publishers. The journals from US publishing houses presented a moderate increase while the journals in the other continents have yet to reach a significant figure. Observe the details in Figure 3.

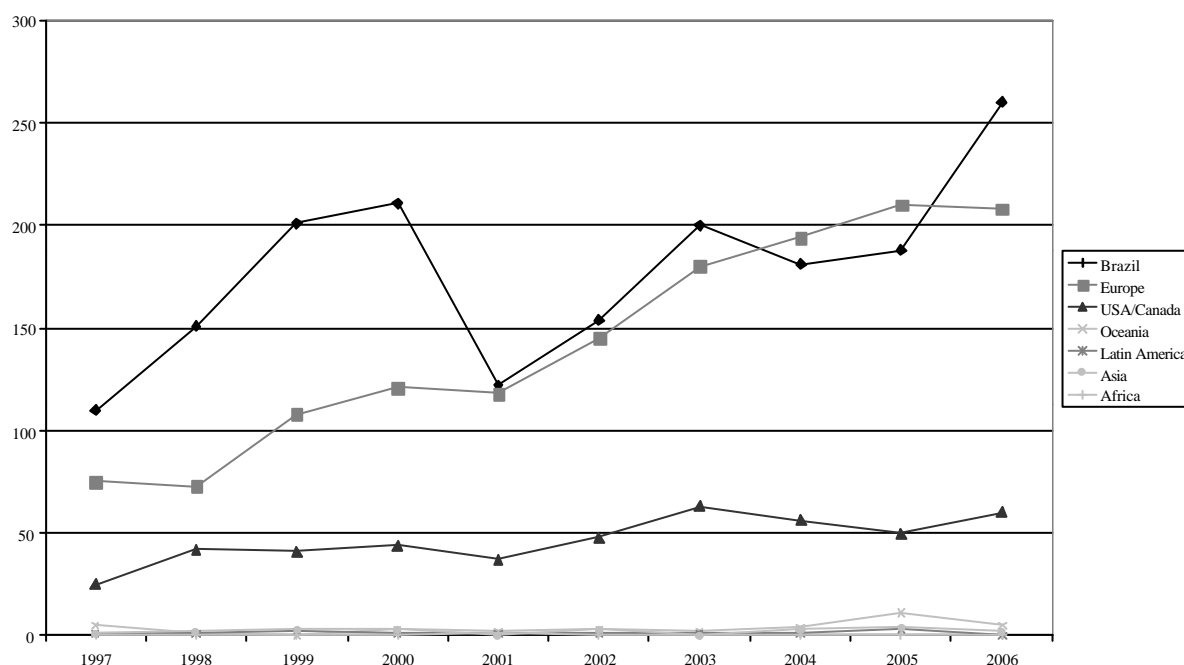


Figure 3. Progression of article publication per year by the publishing houses in the world regions.

Although Brazilian journals have increased the publication of other languages than Portuguese articles, 71% of the 260 - 2006 articles were written in Portuguese. The other 29% were in English. Such increase in the number of publications by Embrapa in Brazilian journals from 2005 to 2006 was triggered by 9 journals which published 97 articles in 2006. The main one is Pesquisa Agropecuária Brasileira (PAB) with 56 articles, or 58% of those items. It was detected that the rise in articles published in Brazilian journals was also due to the addition of new Brazilian journals since 2003 by Thomson Scientific WOS. These new journals added, in 2006, 49 articles to Embrapa score of 260 articles in Brazilian journals. Foreign journals contributed with 275 articles to Embrapa total score of 535 articles in 2006. This finding punctuates a strong pre-existent flux of scientific articles among Brazilian journals where agricultural research is concerned. Since most of these journals publish eminently in Portuguese, the flux detected concerns mostly Brazilian scientists, Brazilian science and, we must presume, Brazilian interests.

Partnerships by institutions

The indicators for the evaluation of the national and international partnerships gain importance when studied in its entirety; the total number of scientific journals, the number of Brazilian scientific journals, the number of articles published in English and Portuguese, the number of international and national partners (co-authorships) and the number of partnerships in the world by geographical regions.

Figure 4 shows the evolution of publication activity of scientific articles of the 5 principal partners in the last 10 years. All are Brazilian universities. The growth of the relative importance of the University of Sao Paulo (USP) was significant as of 2001. It is also important to note the rising cooperation with University Federal de Viçosa (UFV) and the School of Agriculture Luiz de Queiroz, the ESALQ-USP* from 2003. Other partners' names are in Annex 1.

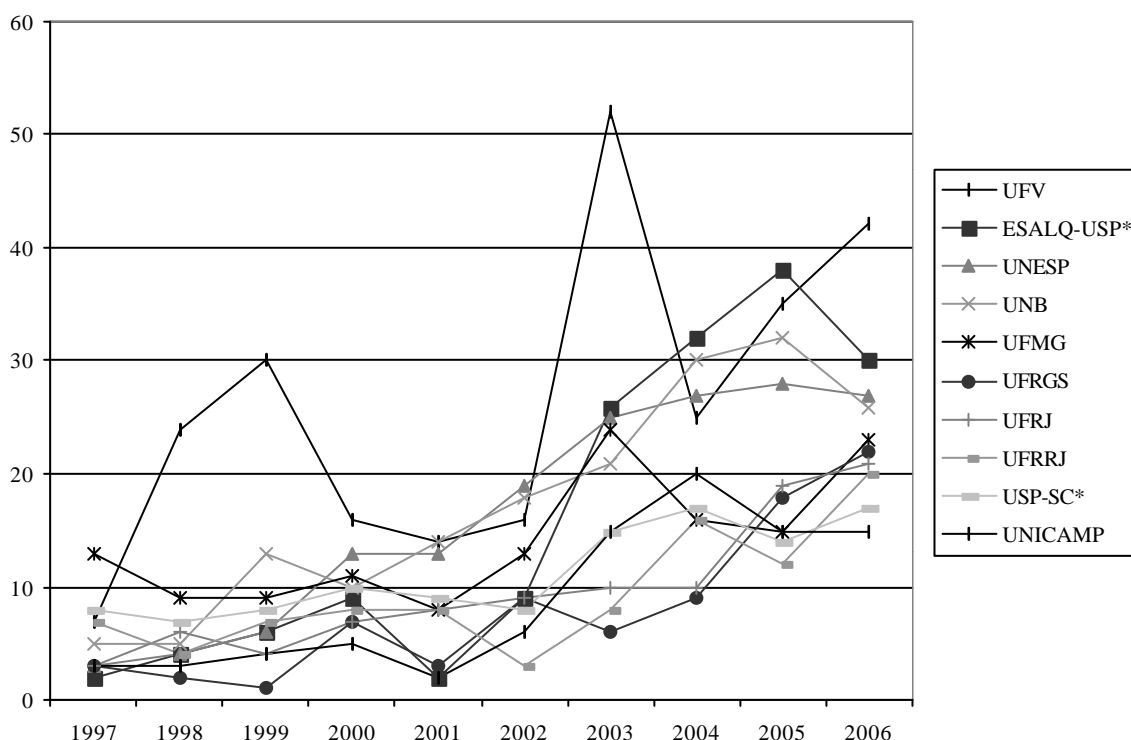


Figure 4. Progression of the 10 main partnerships from 1997 to 2006.

Partnerships by geographical and local groups

Table 2 shows Embrapa scientific production divided by geographical and local groups per five-year period. The articles generated 8435 partnerships in the form of co-authorships. There were 4663 co-authorships within Embrapa and 3772 with external partners. Also relevant is the partnerships with Brazil, which added to those within Embrapa represent 82% of all co-authorships. This and the fact that the ten main partners over the last ten years are all Brazilian universities are other indicators that agricultural research in Brazil is strongly nationally oriented.

In the last 5 years, Europe bypassed the United States and Canada, as Embrapa major international partner. Partnership with Asia, Oceania e Africa also increased notably. However, the partnerships with the rest of the world (Latin America, Asia, Africa e Oceania) added to 2,96% of all co-authorships. In spite of a growth tendency, this still is a residual figure in Embrapa international partnerships. The cooperation with the United Nations Agricultural Research System (UN SYSTEM) organizations grew within the period although at a lesser rate compared to other segments being studied.

Table 2. Main partners of the published articles by geographical regions in the world, by 5-year periods.

PARTNERS	1977 a 1981	1982 a 1986	1987 a 1991	1992 a 1996	1997 a 2001	2002 a 2006	TOTAL	% TOTAL	% TOTAL 2
BRASIL	40	20	20	120	585	1492	2277	60.37	26.99
USA/CANADA	15	9	16	79	190	298	607	16.09	7.20
EUROPE	8	5	9	56	164	307	549	14.55	6.51
LATIN AMERICA	1	0	0	11	22	68	102	2.70	1.21
UN SYSTEM	3	6	3	14	28	36	90	2.39	1.07
ASIA	4	2	0	7	11	38	62	1.64	0.74
OCEANIA	2	1	1	6	16	33	59	1.56	0.70
AFRICA	1	0	0	3	7	15	26	0.69	0.31
TOTAL	74	43	49	296	1023	2287	3772	100.00	-
EMBRAPA	122	133	102	670	1459	2177	4663	-	55.28
TOTAL 2	196	176	151	966	2482	4464	8435	-	100.00

The following is a study of the partnerships by regions of the world: United States and Canada; Europe, Africa, Latin America, Asia and Oceania. The tables show the number of articles published, in 5-year periods, from 1992 to 2006.

Below are listed Embrapa first six partners in the United States and Canada (Figure 5) and in Europe (Figure 6). It is not by chance, the first partners in the USA/Canada and the first two in Europe are the headquarters of Embrapa Overseas Virtual Laboratory: Agricultural Research Service from the United States Department of Agriculture (USDA-ARS), France's institutions of agricultural international cooperation, the Center of International Cooperation for Agricultural Research and Development (CIRAD), the Institute of Research for Development (IRD/Orstom) and the University of Wageningen (UWAGENINGEN), in the Netherlands. Other partners' names are in Annex 1.

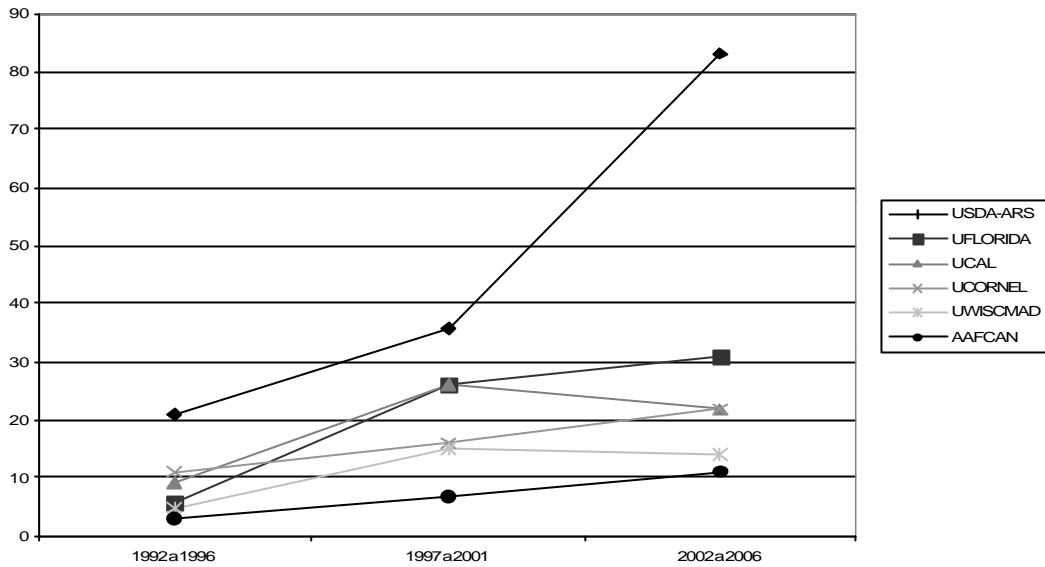


Figure 5. Partners in the USA and Canada 1992-2006.

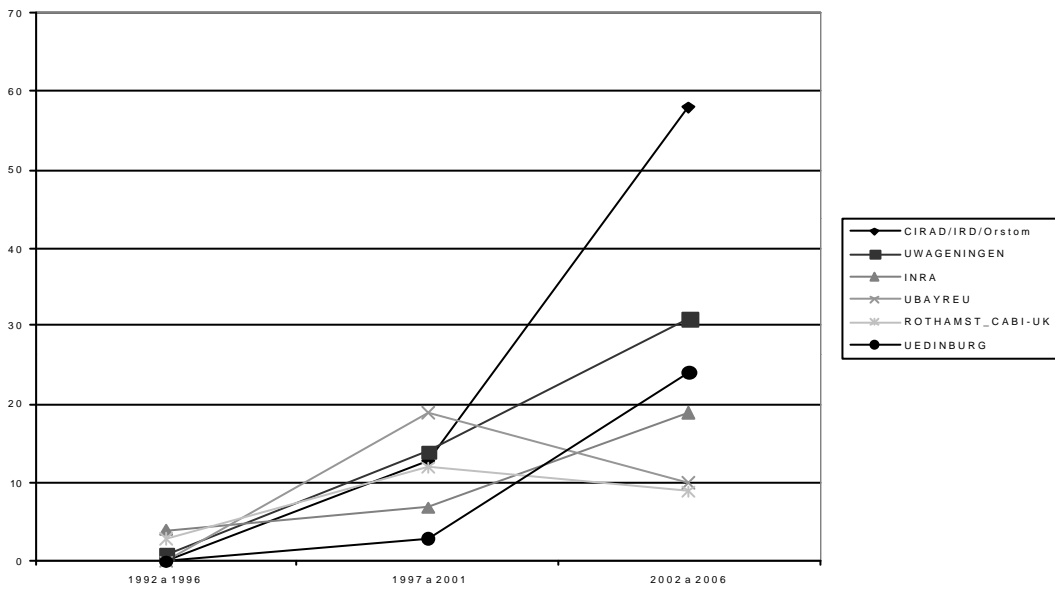


Figure 6. Partners in Europe 1992-2006.

Partnerships with the rest of the world are mainly found in Australia's Commonwealth Science and Industry Research Organization (CSIRO), Argentina's Instituto Nacional de Tecnologia Agropecuaria (INTA), México's Universidad Nacional Autónoma de México (UNAM) and Japan's Japan International Research Center for Agricultural Sciences and National Agricultural Research Center (JIRCAS/NARC). See Figure 7. Other partners' names are in Annex 1.

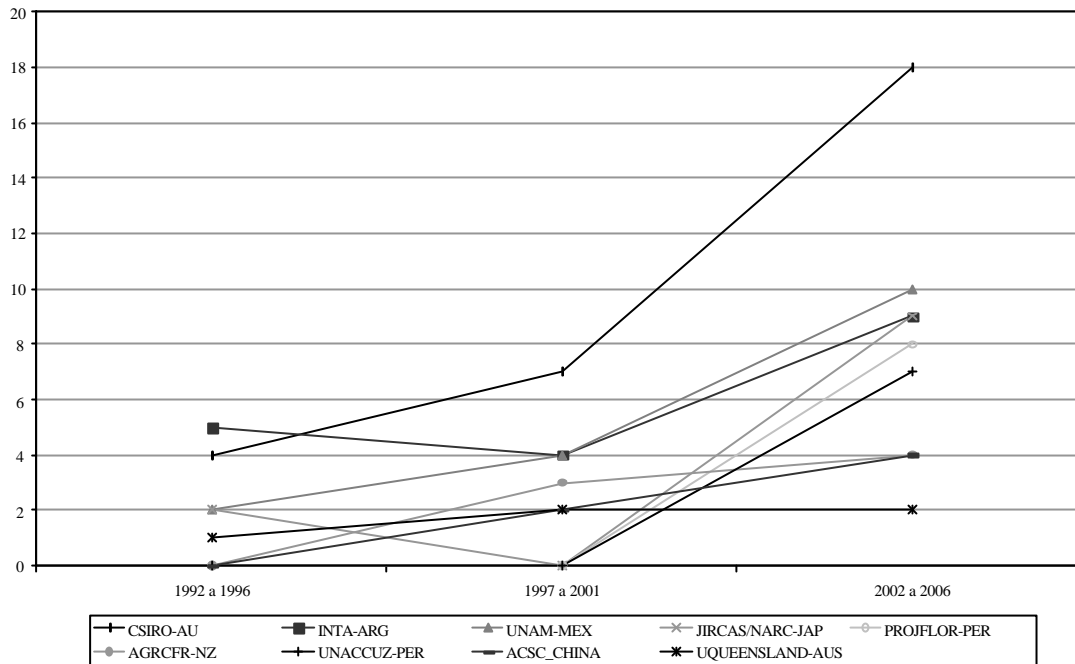


Figure 7. Ten main partnerships in articles published with the rest of the world, 1992-2006.

Discussion

The highest merit of this pioneer study was the definitive induction of Embrapa as one of the leading institutions in Brazil in terms of scientific production. The majority of rankings realized to date in the country only concerned scientific production by Brazilian universities in the WOS, or dealt with Embrapa only partially (Gregolin et al., 2005; Leta, J. and Cruz, C.H.B., 2003). With the results obtained here, one can compare the production of scientific articles by Embrapa, in the 1977-2006 period with other national institutions of S&T. The publication in 2006 of more than 500 articles in WOS indexed journals Embrapa amongst the 10 greatest Brazilian institutions of Sc,T&I in articles production.

This paper also shows that with the analysis of the articles production from year to year, as of 1990, when a system of supervision and award for results started to operate, the number of published articles grew significantly, even contrasting with the development of the production registered in the previous years. As of 1996, when Embrapa established the SAU system, with annual quantitative goals for diverse items, amongst which are scientific articles in indexed journals, the company's article output changed for good. The significant and sustained increase in the production of articles in indexed journals in the Web of Science, verified from 1997 to 2006 contrast with the performance of the previous periods and it coincides with the SAU adoption.

In addition the study allows us to observe the progression of the partnerships between Embrapa and other national and foreign institutions and focus on the main partnerships in Brazil and in the world. It is more concentrated in few partners than expected or presumed. Still is to register the growth of cooperation with Europe in the last 5 years including taking the traditional second place of the co-operation with the United States and Canada. The evidence that co-authorships within Embrapa and with Brazil count for 82% of all articles is linked to the fact that in Brazil, Agricultural Research is a main national scientific area. This is clearly shown by the publication numbers: Although only 29 (4% of the total number of journals), the Brazilian journals publish 49,46% of the articles. Foreign journals represent 96% of all journals but 50,54% of all articles.

The parallel fluxes of articles written in Portuguese published in Brazilian journals and written in English published in foreign journals express the different missions and main publics of Embrapa research centers. Some centers are dedicated to frontier areas of knowledge and to a more international public such as Genetic Resources and Biotechnology, Agrobiology, Environment and Instrumentation. They publish mostly in English and in foreign journals. Others such as Dairy Cattle, Swine and Poultry, Rondonia and Amapa, are focused on national, regional or even state levels and their main public - considering who their research will benefit first - is more Brazilian oriented. So they publish mostly in Portuguese and in Brazilian journals.

This paper demanded an enormous effort for the standardization of data, as it is a norm in bibliometric studies. As an example, the 634 published by Embrapa Genetic Resources and Biotechnology research center, have 533 different forms for denominating this unit. For that, a pre-standardization initiative of authors' basic information, for instance, their affiliations, by their own scientific and technological institutions such as Embrapa and others that practice scientific activities and publish indexed articles in international databases, would be most welcomed. This would have facilitated the localization of these articles and its counts and recovery by third parties, which means attaining bigger chances of better scores and rankings.

Conclusion

Two main conclusions are advanced. First, the data suggests that the flux of articles in Portuguese published in Brazilian journals is pre-existent and greater than shown in WOS. It indicates that WOS based indicators can be a weak measure of the state of the art in a nationally oriented area of science, for countries like Brazil, that are less represented in the database. More research is needed and will be carried on this subject. Second, institutions that establish policies of Superior Education and of Science, Technology and Innovation should consider the counter effect on national development that WOS based indicators can have on these nationally oriented research areas. Researchers would then be encouraged to dislocate their flux of articles to other languages and journals where their research could be ignored, whenever published. This is a condensed version of Volume 1 of two studies reuniting these and other findings together with a throughout analysis of Embrapa WOS articles that will be published in Portuguese by Embrapa "Texto para Discussão" series later this year.

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Annex 1: Names of other institutions cited

AAFCAN	Agriculture and Agri-Food Canada
ACSC_CHINA	Academy of Sciences of China
AGRCFR-NZ	Agricultural Research New Zealand
INRA	Institut National de Recherche Agricole - France
PROJFLOR-PER	Projeto Flora Peru
ROTHAMST_CAB-UK	Rothamstead Research Institute /Commonwealth Agricultural Bureaux - UK
UBAYREU	University of Bayreuth - Germany
UCAL	State Universities of California - USA
UCORNELL	University of Cornell - USA
UEDINBURG	University of Edimburg - UK
UFLOIDA	University of Florida - USA
UFMG	University Federal of Minas Gerais - Brazil
UFRGS	University Federal of Rio Grande do Sul - Brazil
UFRJ	University Federal of Rio de Janeiro - Brazil
UFRRJ	University Federal Rural of Rio de Janeiro - Brazil
UNACCUZ-PER	University National of San Antonio Abad, Cusco - Peru
UNB	University of Brasília - Brazil
UNESP	University Estadual Paulista - Brazil
UNICAMP	University of Campinas - Brazil
UQUEENSLAND-AUS	University of Queensland - Australia
USP-SC	University of São Paulo - São Carlos - Brazil
UWISCMAD	University of Wisconsin-Madison - USA