

What do Mexican journals publish on seed technology?

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Abstract

Seed research is adapted to the advances obtained and the needs to be met. The objective of this work was to identify the relevant aspects of the information published in Mexican scientific journals related to improving seed quality and production. The information was obtained from 16 Mexican scientific journals from the catalog of the National Council for Science and Technology of Mexico, in its subject area of Biotechnology and Agricultural Sciences. The review period was from January 2010 to July 2021. A total of 149 papers, mostly developed in Mexico, were reviewed. Of 79 papers, their topic focuses on the study of physiological quality. Corn seed was the most studied (27 papers) and in contrast, studies on 50 species were observed with a single paper. The most commonly used keywords were germination (32), *Zea mays* (15), seed(s) (14), and vigor (13). Among the five most cited papers, two focus on public policies and seed market. Although the number of papers on seeds published in Mexico is low, a wide collaboration between authors is observed. It is necessary to strengthen other areas of research to solve problems such as seed sanitary quality and conservation.

Keywords: biotechnology and agricultural sciences, corn, germination and vigor, seed production, seed quality.

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Seed research is adapted to the advances obtained and the needs to be solved. The treatment of seeds against pests and diseases is an example of the above, where progress was made from using arsenic to the use of biological controls approved by the Environmental Protection Agency (Sharma *et al.*, 2015). If it is a crop, rice is an example, since now, it is necessary to find alternatives that give vigor to seeds in direct sowing, due to the scarcity of water and the cost of labor that make it difficult to continue with the method of manual transplantation of seedlings (Farooq *et al.*, 2009).

In legislation and policies, the advances obtained in seed issues demand greater intellectual protection in the world (Domínguez-García, 2021). Therefore, examining the published literature will allow knowing the advances in research and the needs to be solved in terms of seeds. The results of seed research are preferably disseminated in scientific papers. Among the specialized journals are the Journal of Seed Science, which, in volume 43, published 20 papers and a scientific note, the objectives focused on the improvement and understanding of the physical and physiological quality of seeds of different species.

The Seed Science and Technology journal, which, in its volume 43(3), covered topics of basic biology, production, testing, ecology, conservation and biodiversity in seeds (Baalbaki, 2021). Although in Mexico, there are 16 scientific journals indexed in the Index of Mexican Journals of Scientific and Technological Research of the Classification System of Mexican Journals of Science and Technology (CRMICYT, for its acronym in Spanish) of the National Council for Science and Technology (CONACYT, for its acronym in Spanish) in area IV, which corresponds to Biotechnology and Agricultural Sciences, none specializes in seeds; however, that is where a portion of Mexican researchers who work on seeds publishes their results.

The seed sector in Mexico has undergone changes that directly or indirectly modify the themes of seed production within the national territory. Before 1991, areas related to the seed sector were the responsibility of public institutions; with the approval of the Seed Law in that year, the private sector begins to participate in seed research, production, and commercialization (Espinosa-Calderón *et al.*, 2014). In 2011, the Mas Agro program began, which promoted the growth and competitiveness of national seed companies (Donnet *et al.*, 2020). With all the changes in the seed sector, no document that compiles the research on seed published in Mexico was found.

The objective of the work was to identify the focuses of the studies, the species studied, number of citations received and the collaboration between authors of the information published in Mexican scientific journals focused on improving the quality and production of seeds. Collecting and systematizing this information will allow knowing the advances in research and identifying the priority lines of research that Mexico requires in the field of seeds.

Source of information

The information was obtained from 16 Mexican scientific journals of the catalog of the classification system of Mexican journals of science and technology of CONACYT, in its subject area of Biotechnology and Agricultural Sciences (Table 1). The review period was from January 2010 to July 2021. In each issue published online, the paper that has a direct relationship with the genetic, physical, physiological, and sanitary quality of the seeds, without excluding any species,

was sought. To do this, the search keyword was seed(s). The study variables were authors, institutions of the authors, year of publication, country of origin, keywords, research focus and main use of the species studied.

Table 1. Number of papers reviewed in each Mexican scientific journal.

| ID | Journal | Number of papers from 2010 to 2021 |
|----|---|------------------------------------|
| 1 | Agricultura Sociedad y Desarrollo | 4 |
| 2 | Agro Productividad | 16 |
| 3 | Agrociencia | 9 |
| 4 | Bio Ciencias | 8 |
| 5 | Biotecnia | 1 |
| 6 | Ecosistemas y Recursos Agropecuarios | 4 |
| 7 | Ingeniería Agrícola y Biosistemas | 1 |
| 8 | Polibotánica | 8 |
| 9 | Revista Mexicana de Ciencias Agrícolas | 29 |
| 10 | Revista Chapingo Serie Horticultura | 5 |
| 11 | Revista Chapingo Serie Ciencias Forestales y del Ambiente | 5 |
| 12 | Revista Chapingo Serie Zonas Áridas | 2 |
| 13 | Revista Fitotecnia Mexicana | 35 |
| 14 | Revista Mexicana de Ciencias Forestales | 10 |
| 15 | Revista Mexicana de Fitopatología | 3 |
| 16 | Tropical and Subtropical Agroecosystems | 9 |
| | Total | 149 |

According to Popinigis (1985), the quality of seeds is a sum of their genetic, physical, physiological, and sanitary attributes. However, seed research covers other topics, therefore, the variable, focus of the research had the following categories: I) genetic quality; II) physical quality; III) physiological quality; IV) sanitary quality; V) conservation and diversity; VI) standardization of seed testing; and VII) public policies and seed market.

The classification of the papers was carried out using the title, keyword, and objectives and when these were not sufficiently determinative, the response variables were used. The variable of use of the species studied was obtained within the paper or in other related sources. The variables of year of publication and country of origin were interpreted using frequency tables. For the research focus and use of the studied species, they were analyzed based on stacked bar graphs, where the total of each bar corresponded to the research focus and the segments corresponded to the use of the studied species.

With the authors and keywords, an analysis of collaborative networks was made using the *bibliometrix* package (Aria and Cuccurullo, 2017) of the R v4.1 software (R Core Team, 2021). In addition, the use of this library allowed the creation of charts based on network analysis.

Finally, a map of the location of the most important institutions in seed works in Mexico was made. For this, it was necessary to use the libraries ggplot2 (Wickhan, 2016) and sf (Pebesma, 2018) also of R.

Google Scholar is a valid tool for extracting bibliometric indicators and a platform that increases the visibility of institutional repositories (Cabezas-Clavijo and Delgado López, 2013; Corchuelo-Rodríguez *et al.*, 2021). Therefore, this platform was used to obtain the number of citations of each reviewed paper. Although a thorough review was carried out to avoid papers with double reference and general errors.

One hundred forty-nine papers related to the topic of seeds were identified in the 16 Mexican journals of the National Catalog of Sciences and Technology of Mexico. The results of the studies were mostly done in Mexico, with 139 papers, followed by Brazil with 3 and seven other countries with one paper each (Table 2). The average number of papers from 2010 to 2020 was 13 (full years).

Table 2. Number of papers on seeds published by year and country of origin.

| Year | Number of papers | Country of origin | Number of papers |
|------|------------------|-------------------|------------------|
| 2010 | 6 | Brazil | 3 |
| 2011 | 13 | Canada | 1 |
| 2012 | 9 | China | 1 |
| 2013 | 9 | Colombia | 1 |
| 2014 | 10 | Cuba | 1 |
| 2015 | 11 | Ecuador | 1 |
| 2016 | 12 | Mexico | 139 |
| 2017 | 15 | Nigeria | 1 |
| 2018 | 29 | Peru | 1 |
| 2019 | 15 | - | - |
| 2020 | 14 | - | - |
| 2021 | 6 | - | - |

The year with the highest number of publications was 2018, in contrast to 2010, where only six papers were published. The relatively low number of published manuscripts can be attributed, among other situations, to the dominance that transnational corporations have over the seed sector, since they have financial resources and infrastructure to carry out research and whose results they are not obliged to disclose (Perelmuter, 2020). Or that seed researchers prefer to publish their results in foreign journals, for fear of not being cited, being victims of antipathy (Cicero-Sabido, 2006).

Focus of the research and use of the species

The use of quality seeds for production is a highly profitable investment for farmers, which justifies the research efforts made to generate them (García-Rodríguez *et al.*, 2018). Of 149 papers reviewed, 124 focus on studying the genetic, physical, physiological, and sanitary quality of seeds,

parameters that determine the capacity and productivity of seeds (Popinigis, 1985). However, physiological quality is the most studied, 79 of the 149 papers reviewed focused on it (Figure 1). The physiological quality considers the integrity of each of the structures and physiological and histochemical processes that provide the seed with high viability rates (Antuna-Grijalva *et al.*, 2003) and for its quantification, germination and seed vigor are used (Pérez *et al.*, 2006).

This justifies that the objectives of 50 papers focus on germination, 14 on histochemistry, eight on morphology and seven on seed deterioration. The focuses, physical and sanitary quality grouped 19 and 18 papers respectively (Figure 1). In physical quality, 10 papers focused on evaluating the effect of seed size on germination and seedling vigor. Other variables studied are weight of 1 000 seeds, volumetric weight, and physical purity, which contribute to determine the totality of the physical quality of the seeds (Moreno, 1996).

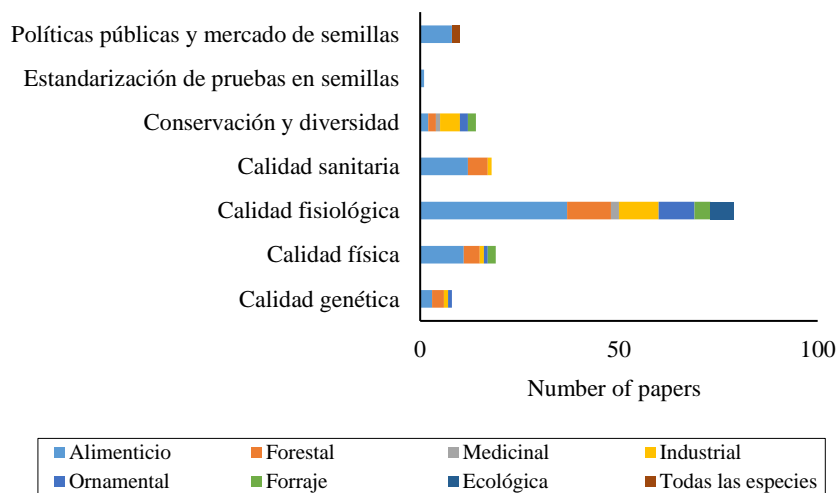


Figure 1. Use of the species studied within the focuses of seed research published in Mexican journals from January 2010 to June 2021.

Regarding sanitary quality, 10 papers aimed to study the effect and control of phytopathogenic fungi and six in pest control, one to viruses and one to bacteria. The number of studies focused on physical and sanitary quality is low compared to those focused on physiological quality. Therefore, we consider that it is necessary to increase research into the physical and sanitary quality of seeds, because in seed production, it is common that phytosanitary quality is not optimal (Navarrete-Maya *et al.*, 2014). Additionally, we recommend expanding knowledge about the importance of physical quality in the physiological aspects of seeds (Fernández-Sosa *et al.*, 2015).

The three focuses with the lowest number of papers were: conservation and diversity (14), public policies and seed market (10), and standardization of seed testing (1). All three focuses are closely related to Mexico’s biological wealth. Although there is a national initiative to study, know and conserve the genetic diversity of Mexico’s native crops and their wild relatives (Mastretta-Yanes *et al.*, 2019), the present review work demonstrates the opposite.

However, to clarify what has been proposed, it will be necessary to review the progress in seed conservation in Mexico. Of the 149 papers reviewed, 74 were studies done on cultivated species. Corn was the most studied species (27 papers), followed by the genus *Capsicum* spp., with 10 papers.

These results can be attributed to the fact that, in Mexico, chili and corn are very important crops, since they are a source of income for many families and are part of the national culture and identity (Mancilla-Villa *et al.*, 2020). Of the total papers reviewed, 25 focused on forest species (Figure 1). Mexican forestry researchers probably prefer to publish their results in international journals. However, if the papers published in national journals are a sample of studies focused on forest seeds, the number of papers is low.

This contrasts with their importance as a source of germplasm, their use in the mass production of plants (Sáenz *et al.*, 2011) and the territorial area of the country that is approximately 65% (Zamora, 2016). On the other hand, the number of forestry researchers in Mexico is low compared to the researchers dedicated to the agricultural area, this in turn could explain the low production in this area. Therefore, it is necessary to try to increase the number of forestry researchers in Mexico whose field of study includes forest germplasm.

Together, species for industrial, ornamental, fodder, ecological and medicinal use accumulated 48 papers (Figure 1). In addition to the above, 50 species only had a single paper. It is possible that due to the lack of funding and the importance given to the plant species studied, many of these studies did not have continuity, at least with regard to the study of their seeds. This trend is maintained in other areas of knowledge of the plant species of Mexico, according to Mastretta-Yanes *et al.* (2019), information on this regard is scarce or does not even exist.

Keywords

Keywords are of vital importance in the indexing and retrieval of information (Gonzalez and Mattar, 2012), so the time spent to choose them properly is important. The total keywords were 475, the minimum and maximum words were 2 and 9 respectively, with an average of 4.5 words per paper. The most commonly used keywords in the reviewed papers were germination (38), *Zea mays* (18), vigor (15), seed(s) (13) and viability (9), which have a close relationship (Figure 2). The keywords correspond to the focus and the most studied species, germination, and corn, respectively.

Using keywords incorrectly makes the document inaccessible in a literature search (González and Mattar, 2012). In this sense, one of the possible causes why 85% of the papers reviewed have less than 10 citations is because the authors did not make correct use of the keywords. For example, repeat the name of the species studied in the title of the manuscript and in the keywords.

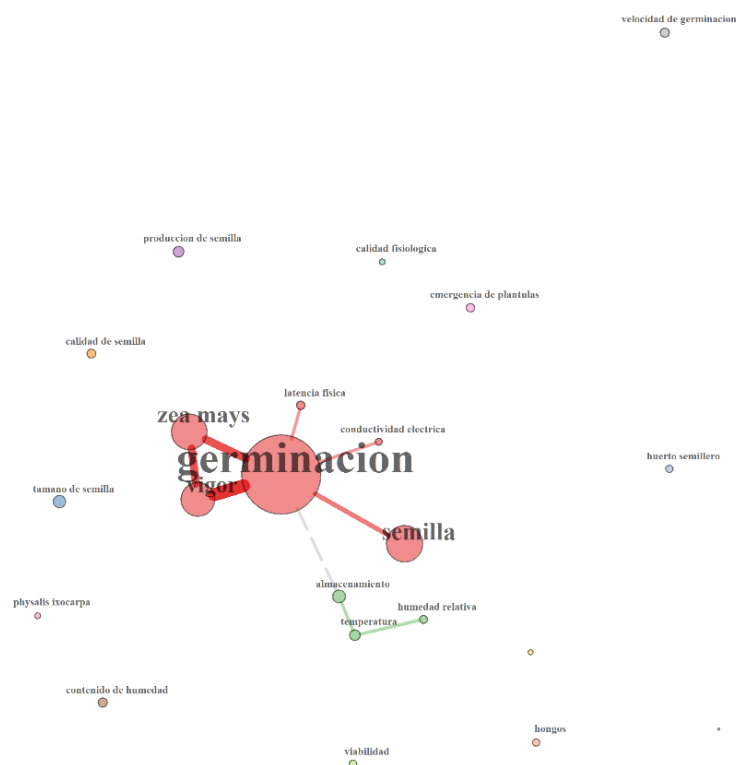


Figure 2. Keywords most used in the 149 papers reviewed.

Impact of papers

According to Google Scholar, among the five papers with the highest number of citations reviewed in this work, there are two papers on corn with a focus on public policies and seed market (Table 3). The two papers give argument to works in corn with different focuses. Probably because public policies and the mechanisms for their implementation influence every aspect of the competitiveness of Mexico’s agricultural sector (Ávila-Foucat, 2017).

Table 3. Papers related to seeds with the most citations published in Mexico from 2010 to 2021.

| Title | Authors and year | Number of citations in Google Scholar |
|---|--|---------------------------------------|
| Seed quality evolution of <i>Capsicum annuum</i> L. through different fruit development stages | Ayala-Villegas <i>et al.</i> (2010). | 28 |
| Influence of the electromagnetic field in maize seed vigor | Domínguez-Pacheco <i>et al.</i> (2010) | 31 |
| The corn (<i>Zea mays</i> L.) improved seed market in México: An analysis of the commercial balance by state | García-Salazar <i>et al.</i> (2014) | 36 |
| Water pre-hydration as priming for <i>Moringa oleifera</i> Lam. seeds under salt stress | Dos Santos <i>et al.</i> (2011) | 39 |
| Perspectives of the maize seed industry development in Mexico | Luna-Mena <i>et al.</i> (2012) | 94 |

To ensure their establishment, plants developed strategies that regulate their germination (Nonogaki, 2019). Knowing these aspects contributes to improving the physiological quality of the seeds. Therefore, it is not surprising that among the five most cited papers, it is sought to know the maximum germination in different conditions.

For a paper to be cited, it is necessary that one knows how good the work is or send it to a journal with visibility and importance in the scientific community (Romero, 2010). In this regard, the publication of papers in Mexico has increased, but not the quality indicators (López-Leyva *et al.*, 2018). That is why, of 149 papers, 45 have never been cited, 24 have only been cited once and 59 have been cited between 2 and 10 times.

Author networks

The total of authors and coauthors was 543, with an average of 3.6 authors per paper, Ayala-Garay, Córdova-Téllez and López-Upton from the College of Postgraduates and Covarrubias-Prieto from the Technological Institute of Roque stand out (Figure 3). The number of papers and researchers on seeds in Mexico is low, but with extensive collaboration between authors (Figure 3). This is consistent with Rodríguez-Miramontes *et al.* (2017), who pointed out that after 2011, the collaborative activities between researchers in Mexico are continuously growing.

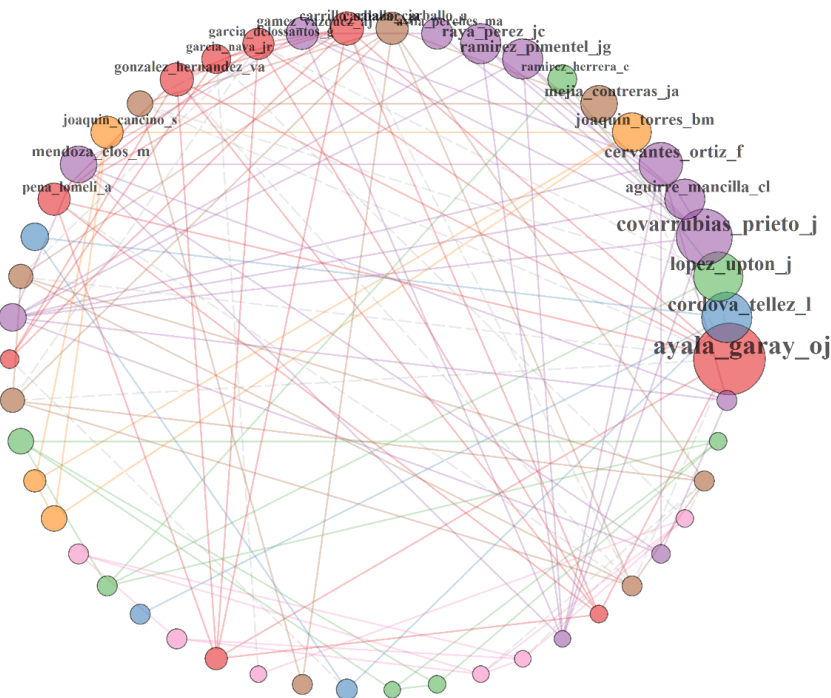


Figure 3. Networks of collaboration between the 50 authors with the highest number of seed papers published in Mexico from 2010 to June 2021. Where the size of the circles is proportional to the number of publications and similar colors indicate close collaboration between authors.

The papers with research results in Mexico (139) were prepared by national researchers attached to Mexican institutions. According to Corrales-Reyes (2017), collaborating with international researchers increases the number of citations of papers, an option that national seed researchers

should consider. In addition, this type of collaboration will eventually allow access to resources that may not exist in Mexico. Among the Mexican institutions to which the authors are attached and that stand out by quantity, three have postgraduate programs related to biotechnology and agricultural sciences (Table 4).

Table 4. Institutions that stand out for the number of papers on seeds published from 2010 to June 2021.

| Institution | Number of papers |
|--|------------------|
| College of Postgraduates-Montecillo Campus | 39 |
| Chapingo Autonomous University | 23 |
| INIFAP- Valle de México Experimental Field | 15 |
| Technological Institute of Roque | 11 |
| INIFAP-Bajío Experimental Field | 8 |

INIFAP= National Institute of Forestry, Agricultural and Livestock Research.

These institutions are where research centers such as INIFAP send their staff to be trained. In this regard, the Experimental Fields of Valle de México and Bajío are the INIFAP affiliation sites that published the highest number of seed papers from 2010 to June 2021.

From 2010 to June 2021, of the 32 states of the Mexican Republic, 27 have institutions that participated in the publication of a paper referring to seeds (Figure 4). By state, the personnel attached to institutions located within the State of Mexico stand out with 101 papers, followed by Veracruz with 16 papers. In the period of review, in the northern states and part of western Mexico, published research on seeds is limited, probably because in these states are the large seed companies, which fulfill the function of researching and solving the problems in terms of seeds of species of commercial interest.

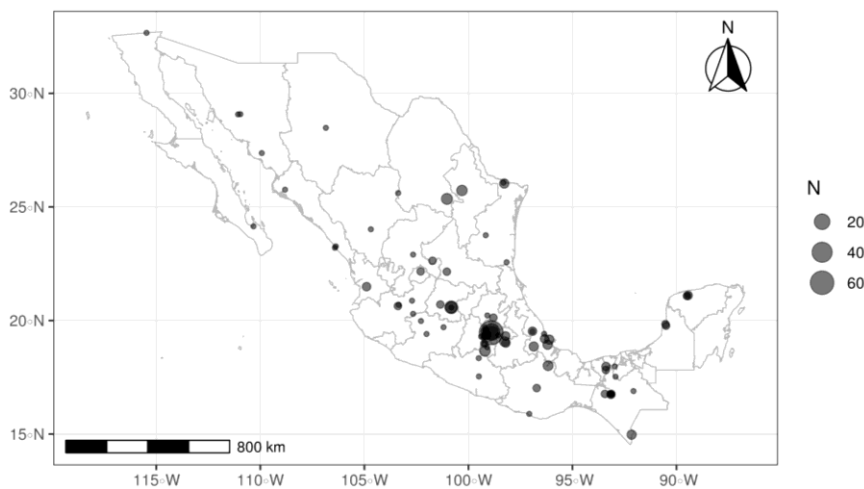


Figure 4. Geographical location of the institutions of affiliation of the researchers that published papers related to seeds in Mexico from 2010 to June 2021 and number of papers per institution. Where the size of the circles is proportional to the number of papers.

Conclusions

The information published on seeds in Mexico focuses on the physiological quality of crops of dietary importance. However, it is necessary to strengthen other research areas to solve problems such as sanitary quality and seed conservation. The number of papers is low, as is their impact, to reverse this situation it is necessary to improve the quality of publications and properly use keywords.

There is collaboration between authors; however, the institutions with postgraduate degrees are the ones that published the highest number of papers in the study period. This research considers that its contribution represents a fundamental tool that allows knowing the current state of seed research in Mexico, which will allow defining the direction and priority areas for the science of seeds for agricultural use and forest germplasm at the national level.

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