Acta Scientiarum

http://www.periodicos.uem.br/ojs/
ISSN on-line: 1807-8621
Doi: 10.4025/actasciagron.v45i1.60016

REVIEW

Genetic improvement of black oats: a scientometric review

Maikely Luana Feliceti[1*], Jean Carlo Possenti[2], Carlos André Bahry[2], Natana Zuanazzi[3], Nédia Ghisi[3], Ilana Niqueli Talino dos Santos[3] and Renan Quisini[3]

[1]Departamento de Agronomia, Universidade Tecnológica Federal do Paraná, Campus Pato Branco, Via do Conhecimento, s/n, km 01, 85503-390, Pato Branco, Paraná, Brazil. [2]Departamento de Ciências Biológicas, Universidade Tecnológica Federal do Paraná, Campus Dois Vizinhos, Dois Vizinhos, Paraná, Brazil. [3]Departamento de Agronomia, Universidade Tecnológica Federal do Paraná, Campus Dois Vizinhos, Dois Vizinhos, Paraná, Brazil. *Author for correspondence. E-mail: maikk_lu@hotmail.com

ABSTRACT. There are few new black oat cultivars in Brazil; therefore a reduced number of cultivars are available for the most varied production regions. Strategies aimed at studying genetic variability, such as mutation induction, of the few cultivars available on the market represent alternatives to increase the variety in this sector. The objective of the present study was to prepare a scientometric analysis of studies of the genetic improvement of black oats (*Avena strigosa* L). The literature review was performed using data from the Web of Science (WoS) from 1945 to 2020. Initially, 859 articles were analyzed, which after refinement, were reduced to 404 for further analysis. This study provides a new method for quantitatively visualizing information regarding the development of this area over time. After searching and refining with the aid of the CiteSpace software (5.6 R4), graphic representations were developed of the scientific journals, authors, countries, subject categories, organizations, and individual publications extracted from the WoS. The results of the analysis indicated a growing trend in the number of publications on the genetic improvement of black oats, as well as the number of citations over the years studied.

Keywords: lineages; genetic variability; mutation induction; analysis; web of science (WoS); *Avena strigosa* Schreb.

Received on July 8, 2021.
Accepted on October 26, 2021.

Introduction

Black oat (*Avena strigosa* Schreb L.) belongs to the family Poaceae and has an annual cycle. This crop is important in the production system (Dias-Filho, 2014), and is a widely cultivated forage plant that produces high levels of dry matter, with a nutritional quality suitable for animals (Cover, Federizzi, & Pacheco, 2011). The main characteristics of black oats are rusticity, adaptability to poorly fertile soils, and vigorous growth, which allow their use as cover plants, as well as for high quality forage that is abundant in the winter period, when pastures in southern Brazil are compromised by low temperatures (Fontaneli et al., 2012).

In addition to these characteristics, black oat crops are widely used in the production of grains for human and animal food, forage in the form of silage and direct grazing, and weeding. With respect to coverage of the soil, the literature reports that this species contributes to improvements in the physical, chemical, and biological properties of soil, promoting the sustainability of the no-tillage system by providing green manure and inhibition of invasive plants, due to its allelopathic effect (Nunes, Melo, Dantas, Aragão, & Nunes, 2011).

The role of black oat has become increasingly important due to its versatility (Milach, Rines, & Phillips, 1997). However, despite the existing cultivated areas, there is little research on the introduction of new cultivars of this plant. Black oat is still a nominally domesticated species that has a limited source of available genetic variability due to the limited number of cultivars released and their similarity to each other (Cruz, 2011).

Strategies aimed at genetic variability, such as mutation induction, of the few cultivars available on the market are possible solutions to the precarious condition of this sector. Some chemical agents can be used to generate point mutations (Coimbra, Carvalho, Oliveira, Silva, & Lorencetti, 2005) and mutagenic agents are important tools in plant breeding, as they can induce genetic changes in a species that result in the creation of genetic variability, which can represent the raw material for the selection of characters of interest or individuals with superior phenotypes (Manova & Gruszka, 2015).

Scientometrics is the study of quantitative aspects of scientific production, enabling measurement of the number of publications over time and identification of the most studied themes (Santos & Kobashi, 2009). This technique is important for identifying trends and gaps in publications in the area studied.

In addition, this methodology can assist researchers in decision-making. Thus, software has been developed that conducts a bibliographic search that is rapid and efficient, and produces results that are straightforward to view through the use of graphs and figures. In the present study, a scientometric review of publications on the topic of black oat genetic improvement was performed by analyzing the trends and gaps in the research. The CiteSpace program (5.6 R4) was used for interpretation and graphic representation to demonstrate the relationships and dimensions of the researched topics, such as scientific journals, authors, countries, organizations, and individual publications extracted from WoS (Chen, 2014).

Thus, the objective of the current research was to conduct a scientometric review of studies in the area of black oat breeding, with reference to publications from 1945 to 2020.

Material and methods

Initially, a search was conducted using the Clarivate Analytics Web of Science (WoS) database, which presents a precise and comprehensive picture of academic impact (Falagas, Pitsouni, Malietzis, & Pappas, 2008).

Searches were performed using the following keywords in the "topic" field: "Mutagenic agents" AND "genetic improvement," OR "improvement" AND "oats." The total references found were then refined, whereby each of the publications was individually analyzed by perusing the title and abstract to select only works involving oats and genetic improvement, while those covering other areas, such as nutrition and medicine, were excluded. The analyzed publications included the period from 1945 to December 2020.

The following information was collected from the WoS for each publication: i) characteristics and year of publication, ii) countries and authors, iii) journals, iv) analysis by subject categories, and v) keywords. The impact factor was also obtained from the Journal Citation Reports (JCR) of the WoS.

Another survey performed through the WoS platform was the H index, an evaluative parameter of an author or article, using the "Create Citation Report" tool, which relates the number of scientific publications to the number of citations (Clarivate, 2021). After searching the WoS database, the data obtained were exported to a Microsoft Excel spreadsheet for further refinement of the information and creation of graphs.

For the graphical representation, the software CiteSpace (5.6 R4) was chosen, as it shows relationships and dimensions such as scientific journals, authors, countries, organizations, and individual publications extracted from the WoS. Using this software, relationship maps were obtained for centrality and frequency. Centrality involves the observation of a large groups of nodes, with the strongest colors being highlighted in the center of a network component, while frequency indicates how much that citation or term is mentioned in the search (Chen, 2014).

In addition, some data were analyzed in the form of clusters, where similar objects were grouped, and areas related to the studies were identified. The size of the set was the number of grouped objects (Chen, 2014).

Results and discussion

Characteristics and year of publication

Initially, 859 references were found. The results after refinement totaled 404 publications related to the topic under study. Of these works, the predominant language was English, with 377 publications, which is the main language of communication or dissemination in the scientific environment (Bernardo, 2017), in addition to being the language of globalization and the most taught in schools worldwide (Pilhion, 2008).

These publications were classified into seven types of documents: 364 articles, 25 reviews, 17 procedural papers, 3 editorial materials, 1 book review, and 1 correction. The various reports were cited 10,470 times, which generates an average of 25.92 citations per item and an H factor of 49. These data suggest that the line of research on genetic improvement of black oats has a relevant impact factor.

Figure 1 presents the total number of publications and citations per year, indicating a publication peak in 2012. However, since 1992, there has been a significant growth in the number of annual publications. The years 2012 and 2018 had the highest number of publications, with 27 and 24 articles, respectively.

Despite the significance of black oats in the agricultural scenario, there is little published research and work by breeders on this species, which is apparent from the small number of cultivars available on the market. Black oats are a species of great importance in agricultural systems because of their strong potential for exploitation by management systems in the production unit (Hartwig et al., 2006). Authors such as Fontanelli and Piovezan (1991) stated that the high production of dry matter from black oats relates to a strong potential for the production of forage in the form of winter pasture, or conserved in the form of silage and hay.

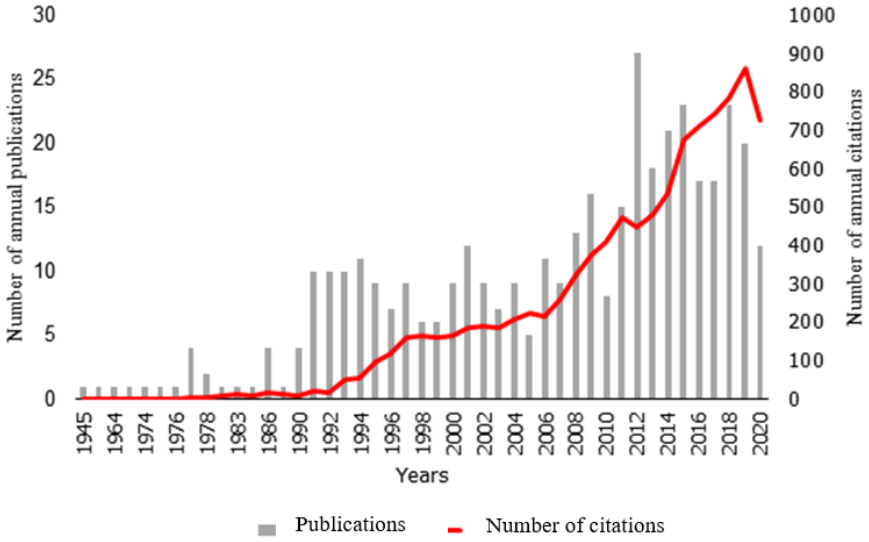

Figure 1. Publications vs. number of citations between 1945 and 2020.

Countries and authors

Analysis by country based on the publication authors is essential to understand the distribution of nations with the highest rates of publication on the species. Thus, in Figure 2, the font size is proportional to the volume of publications, while the thickness of the connecting lines between countries demonstrates the intensity of cooperation. The thicker the connecting line, the more frequently the two countries cooperate, for example, Australia and India have a high degree of collaboration (Figure 2).

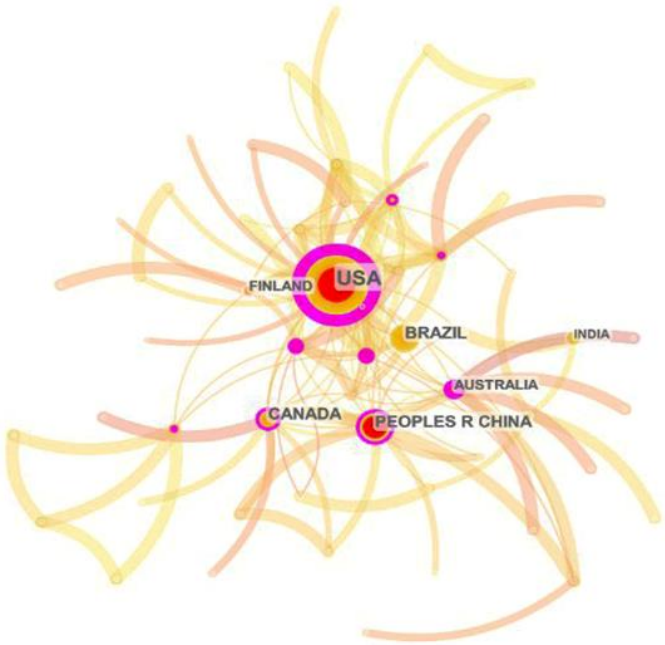

Figure 2. Countries with the highest publication rates.

Countries with larger circles had the greater contribution to the item under study. Thus, larger circles indicate greater weights for those countries based on the number of publications in the period studied. The countries highlighted in yellow refer to the most recent publications. The countries with the greatest impact in this study area were from different geographic regions, and Figure 2 indicates that the United States publishes the majority of documents on this subject, followed by China, Canada, and Brazil. The inner part of the circles in red represents the citation number and the centrality is represented in purple, so there is are more citations in the United States, followed by China, as well as greater centrality in the same countries. In Brazil, there is no representation of the circles of citation and centrality.

Black oats in Brazil have shown a strong increase in cultivated areas, mainly with the arrival of direct sowing and crop rotation, and with the adoption of agricultural systems. Thus, any method that expands the genetic reservoir of the culture is fundamentally important for the improvement of the species (Vieira, Goulart, Viglioni, & Fernandes, 1995), to allow for coverage in different regions and countries.

Figure 3 presents the list of countries and authors, showing that similar to the number of publications, the largest number of authors is from the United States.

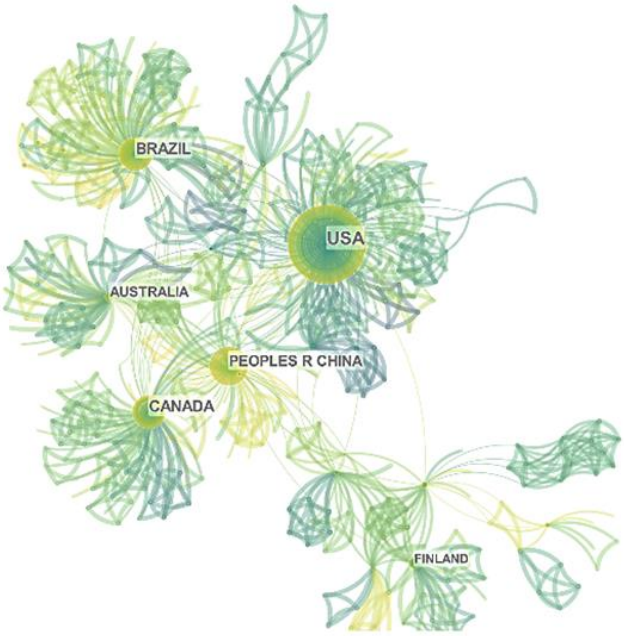

Figure 3. List of countries and authors with the highest publication rates.

Scientometrics is a branch of information science that seeks to study quantitative aspects of science and scientific production through its own indicators. This analysis is widely used to evaluate the quality of journals, institutions, and researchers. Researchers can analyze the progress, trends, and challenges of various research fields (Ye, 2018), as well as the relationship between countries and authors with the highest rates of publication, as shown in Figure 3.

Figure 4 shows the network of authorship of the works, providing an overview of the authors with the highest number of publications.

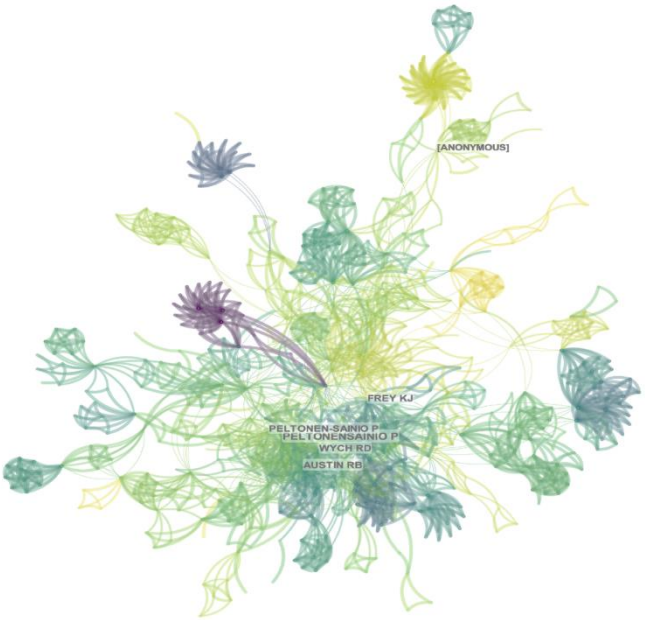

Figure 4. Authors with the highest publication rates.

It appears that among the study representatives, Professor Pirjo Peltonen-Sainio, from the Institute of Natural Resources Finland, appeared most frequently in the image, publishing several works on winter cereals, including black oats. The second most published author on this subject was RD Wych, who works with hybrid plants, and is based in the United States, the country that produces the highest number of publications in this study area.

Journals

Table 1 presents the 15 main journals found in this study, which are also represented in Figure 5 in relation to the frequency of publications regarding the topic studied. The highest ranked magazine by citation count was the Journal of Agronomy and Crop Science, with 184 records, considered the best source for scientists to develop and disseminate works on the subject studied, followed by the Euphytica, Theoretical and Applied Genetics, and the Agronomy Journal, respectively.

The Journal of Agronomy and Crop Science covers several publications on the researched topic. One of the studies published in the magazine presented the theme of chromosomal and genomic relationships between the diploid species *Avena strigosa* and *A. eriantha*, and the tetraploid *A. maroccana*, and was written by Legget (1998). Another study, published by Chandra, Bhatt, and Misra (1998), focused on the "Effect of water stress on the biochemical and physiological characteristics of oat genotypes". These works demonstrate the credibility of the periodical that ranked first in the table of the top 15 magazines (Table 1).

Table 1. The top 15 journals in terms of frequency and impact factor (JCR) in 2020.

Journal name	Frequency	Impact factor
Journal of Agronomy and Crop Science	184	3.057
Euphytica	116	1.620
Theoretical and Applied Genetics	98	0.773
Agronomy Journal	94	1.860
Field Crops Research	70	4.190
Canadian Journal of Plant Science	65	1.425
Australian Journal of Agricultural Research	62	--
Journal of Plant Physiology	61	2.960
Proceedings of the National Academy of Sciences of The United States of America	53	--
Journal of the Science of Food and Agriculture	52	2.614
Journal of Plant Breeding and Genetics	52	1.662
Journal of Experimental Botany	47	5.090
Journal of Cereal Science	47	2.660
Genome Research	47	11.093
Journal of Agricultural and Food Chemistry	40	3.610

The diversity of areas in which plant breeding can be found was notable, including journals in the areas of agronomy, genomes, genetics, field crops, and botany. Figure 5 shows the scale of the journals in relation to the frequency of publication according to the classification of the top 15.

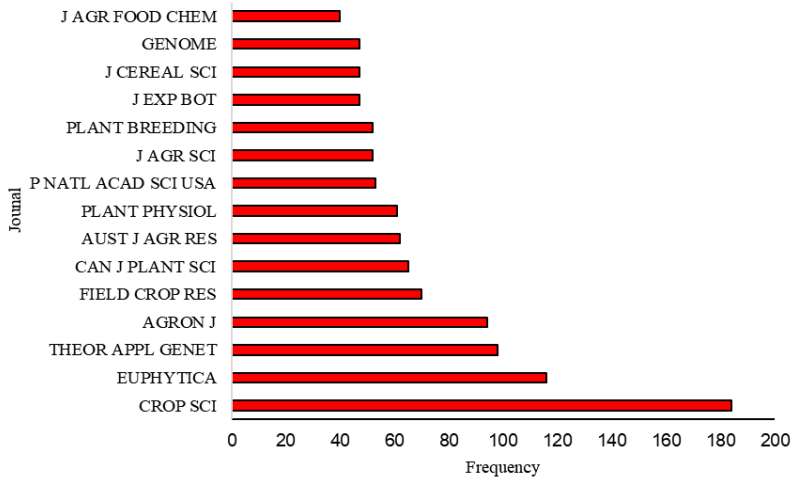

Figure 5. Scale of the journals in relation to the frequency of publication.

Using this methodology, it is possible to study the quantitative aspects of scientific production to enable measurements of the number of published documents in a given period of time, as well as analyze the areas of study and main trends to identify the institutions that presented the greatest scientific production (Razera, 2016).

The history of genetic improvement depends on the variability expressed in the segregating populations. In addition to presenting desirable characteristics, for the success of the hybridization, the parent plants need to demonstrate good coupling ability (Milach et al., 1997; Barros, 2013).

The most commonly cited publications are shown in Table 2, which also shows the values of the year and total citation counts for each article, as well as the author and year of the document.

Table 2. Top 10 highly cited publications.

Title	Authors	Year of publication	Citations per year
Saturated molecular map of the rice genome based on an interspecific backcross population	Causse, Fulton, Cho, Ahn, Chunwongse, Wu, Xiao, Yu, Ronald, Harrington, Second, Mccouch, and Tanksley	1994	23.52
Why whole grains are protective: biological mechanisms	Slavin	2003	20.67
Barley for food: Characteristics, improvement, and renewed interest	Baik and Ullrich	2008	23.31
Measurement of (1-]3),(1-]4)-beta-d-glucan in barley and oats - a streamlined enzymatic procedure	Mccleary and Codd	1991	10
Review of prospects for germplasm improvement for waterlogging tolerance in wheat, barley and oats	Setter and Waters	2002	16.33
Crops that stay green	Thomas and Smart	1993	9.32
Effect of polyamines on stabilization of Molecular-complexes in thylakoid membranes of osmotically stressed oat leaves	Besford, Richardson, Campos, and Tiburcio,	1993	7.71
Implant success and safety of left atrial appendage closure with the WATCHMAN device: peri-procedural outcomes from the EWOLUTION registry	Boersma, Schmidt, Betts, Sievert, Tamburino, Teiger, Pokushalov, Kische, Schmitz, Stein, and Bergmann	2016	37.2
Grain yield of rice cultivars and lines developed in the Philippines since 1966	Peng, Laza, Visperas, Sanico, Cassman, and Khush	2000	7.81
Net primary production of US Midwest croplands from agricultural harvest yield data	Prince, Haskett, Steininger, Strand, and Wright	2001	7.95

Analysis by subject categories

The research areas of these studies varied and ranged from multidisciplinary agriculture to genetics and molecular biology (Figure 6). These categories are of great relevance to the study of genetic improvement. The subjects in the field of genetics refer to knowledge of the principles of gene and chromosomal segregation, the degree of kinship between individuals, the identification and expression of genes that allow the choice of the most efficient breeding methods, and the type of cultivar to be marketed. Molecular biology includes the study of DNA, RNA, and proteins that allow the identification, building, and transfer of genes to different organisms (Borém & Miranda, 2013).

According to Chen (2014), frequency represents the visibility of a category, while centrality shows the influence of the subject category. A high centrality intermediation node is usually one that connects two or more large groups of nodes with the intermediate node itself; hence, the term intermediate. CiteSpace software highlights nodes with a high centrality of intertwining with purple rings.

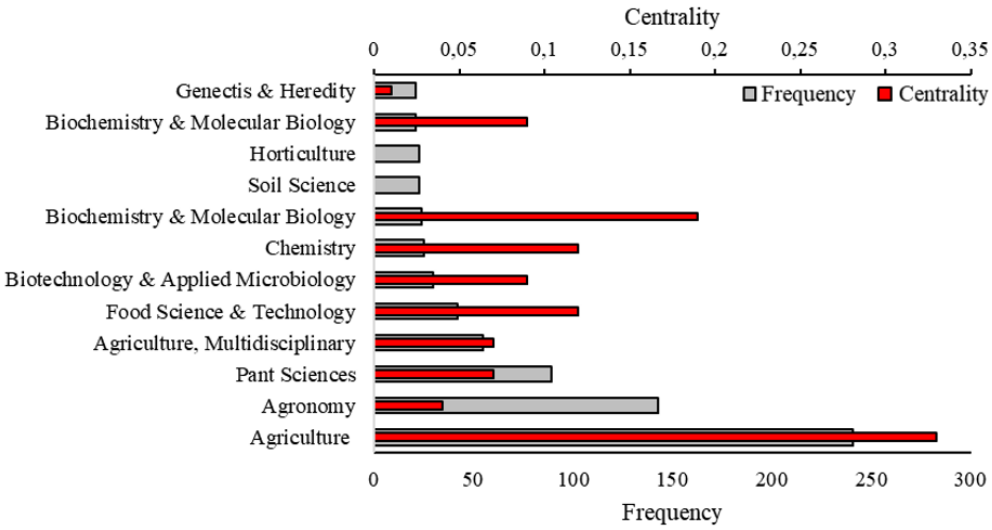

Figure 6. Analysis by subject categories.

In Figure 7, the co-occurrence network is shown, where the nodes are a subject category, and the lines that connect the nodes show the co-occurrence of two categories within the subject.

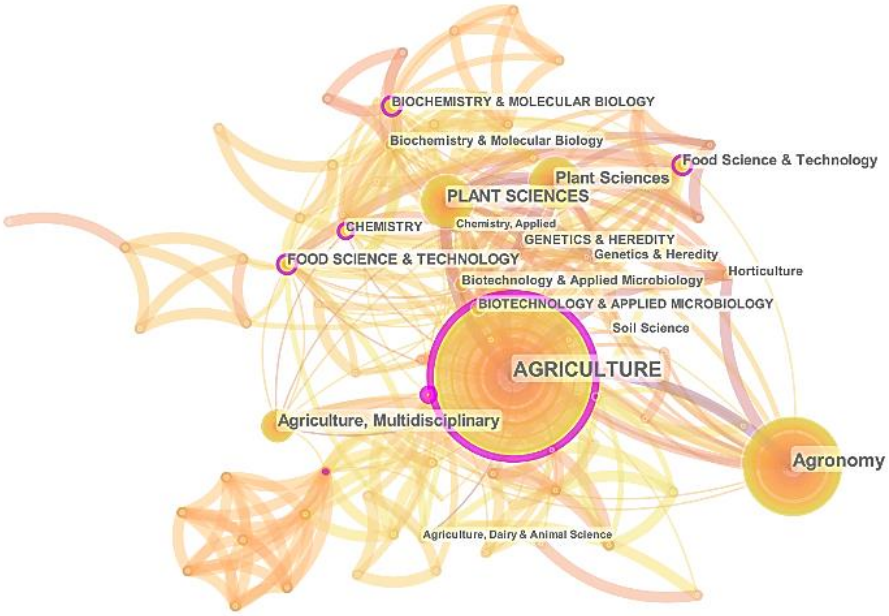

Figure 7. Network organized by subject category.

Based on the highlighted categories of the study, it is noted that the main categories are agriculture and agronomy. These two categories are represented by high centrality nodes, as well as connections with the other categories.

Key words

Figure 8 presents the top 15 keywords and the frequency with which they appear in the studies. The keywords that appear in the journals most often are oats, wheat, barley, and breeding.

Figure 9 presents the network visualization map, with the main keywords and the citation point for each word, where the color represents the time of citation; green represents first quotes and blue denotes the most recent quotes. The words oat, barley, wheat, and cereal are dominant as they are strongly linked to the subject under study.

The keywords are highly relevant when searching for articles, as they indicate topics of importance in the study. On this map, it is possible to analyze the interconnection between keywords, that is, the formation of a connection network. Closer and thicker keywords indicate stronger connections (Chen, 2014).

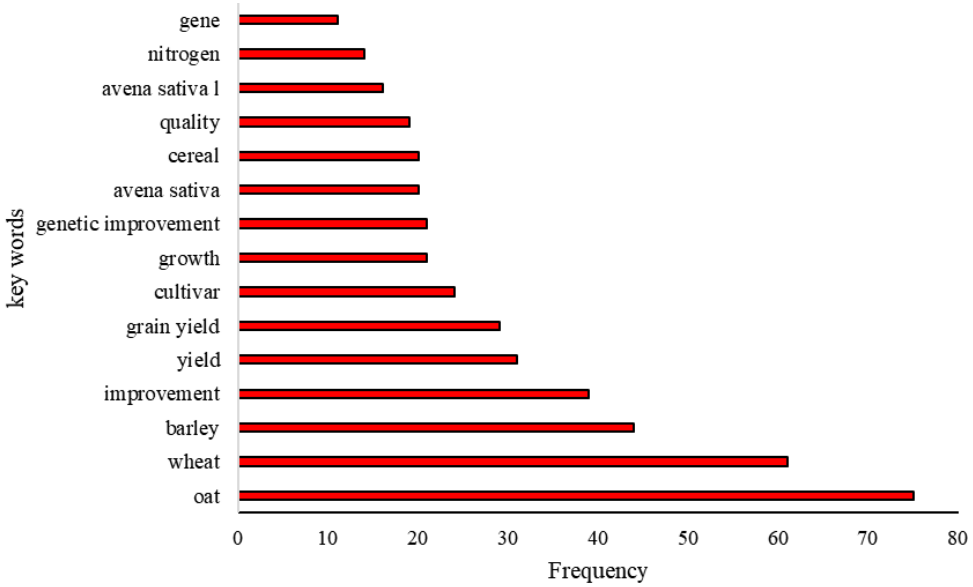

Figure 8. The top 15 keywords in terms of frequency.

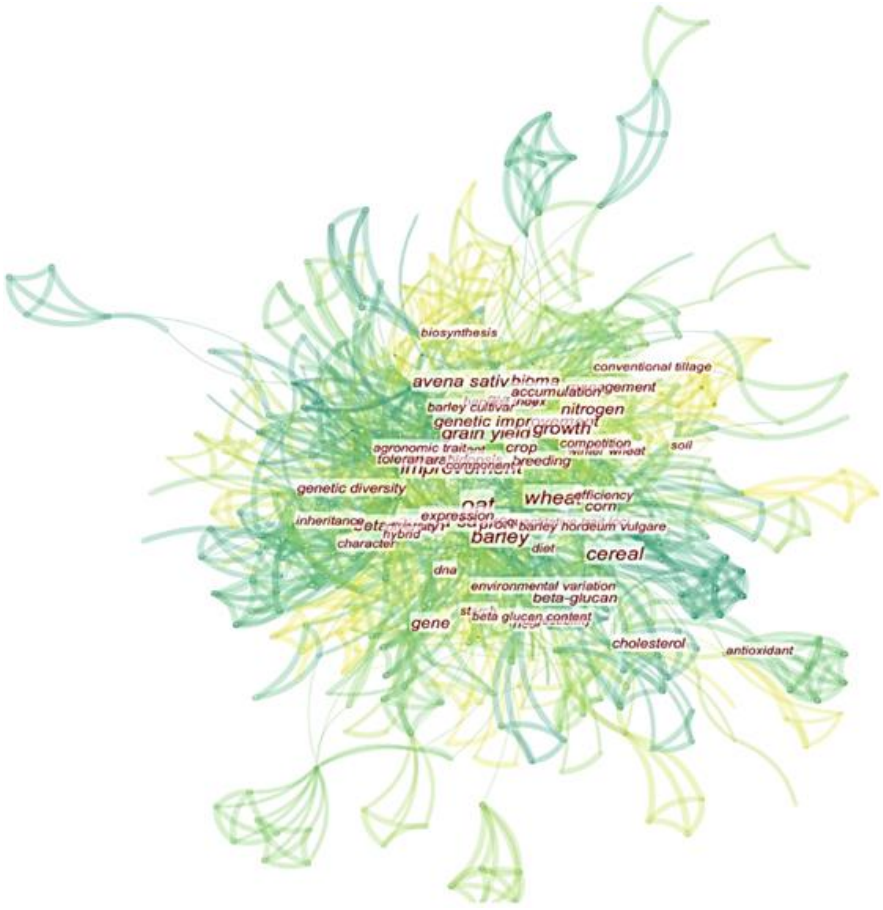

Figure 9. Network organized by cited keywords.

Clusters

Each cluster is a group of closely linked documents representing different research directions. From the topics in this group of documents, representative terms were extracted as group labels using a log-likelihood ratio, expressed in the form of "# + cluster ID + representative term" (Rorissa & Yuan, 2012).

Cluster analysis grouped similar words together to form a cluster representing related areas of study. The set size is the number of terms included in each set. CiteSpace assigns ID # 0 for the largest cluster, ID # 1 for the second largest etc. In Figure 10, the clusters were constructed and described using the keywords indicated by the authors.

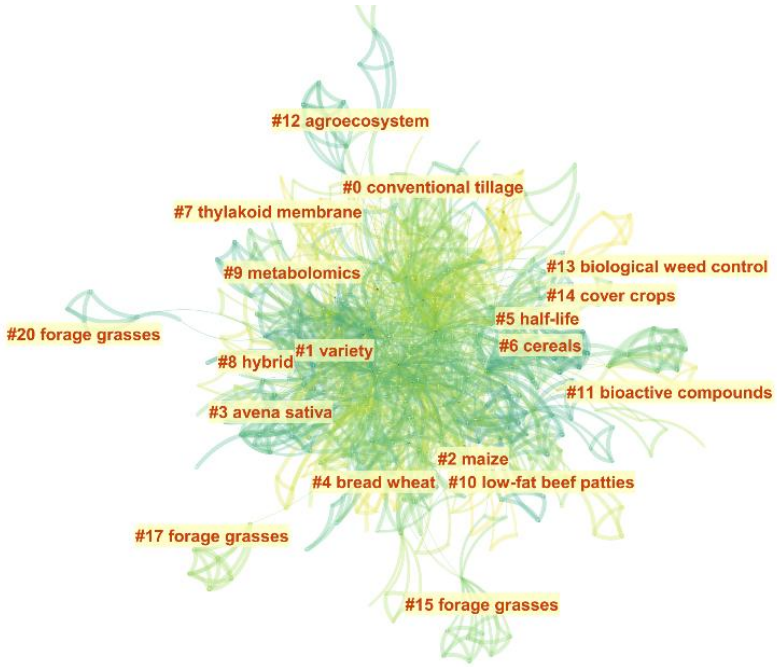

Figure 10. The 15 main clusters labeled by keyword in the field of black oat breeding.

The main keyword-labeled cluster in the field of black oat breeding was # 0 conventional tillage, followed by # 01 variety, and # 02 maize.

Therefore, the results show that research on genetic improvement of black oats is relevant. In recent years, publications in the area have increased; however, future research on genetics and improvement of the species is necessary to increase the variability and introduce new materials. Through this study methodology, it was possible to evaluate the productivity of institutions, countries, and authors, and identify international collaborations and geographical distributions as well as research boundaries in specific fields (Chen, Dubin, & Kim, 2014).

Future perspectives

Plant genetic improvement is considered one of the most enduring activities performed by humans for selection of the most productive and useful plants. It has contributed substantially to the development of variability within oat crops, which are relevant species worldwide, as they are considered the main crops responsible for providing straw cover for the direct planting of soybean, and pasture for animals, especially in southern Brazil.

Currently, the artificial hybridization technique is considered the most efficient for increasing the variability of this species. Although black oats are not a crop of great interest to plant breeders because of the low usage rate of certified seeds (Associação Brasileira de Sementes e Mudas [ABRASEM], 2018), breeding companies that work with this crop in Brazil and in the world are increasing.

Thus, through scientometric analysis, it is possible to demonstrate the growth in the number of publications related to the theme of genetic improvement of black oats, thus demonstrating the growth and importance of this area. However, future perspectives should include the introduction of new techniques in molecular biology, such as molecular markers for the selection of phenotypic variations, and analysis of a broad genomic association (Maioli et al., 2020). Furthermore, studies should utilize the clustered regularly interspaced short palindromic repeats (CRISPR/Cas9) system, which is a simple tool for manipulating genes from bacteria, plants, and animals (ABRASEM, 2018).

These techniques are currently used in some annual crop improvement programs, such as those of soybean, wheat, and corn (Henning & Nepomuceno, 2020), thus allowing greater agility in the process of identifying estimated materials that can advance the improvement program. However, there are still no molecular markers for the culture of black oats, and improvement of these techniques for the culture under study would be of great value.

Thus, the current study highlighted the importance of developing further research on the genetic improvement of oats. Scientometric analysis enabled the examination of the trends, opportunities, and challenges of prior studies, thereby assisting in future research.

Conclusion

Scientometric surveys allow inference of the trends in scientific publications and contribute to determining their biases and gaps. The results of the scientometric analysis of oat genetic improvement indicated a growing trend in the number of publications and in the number of citations over the years studied. The countries with the largest number of publications were the United States and Canada, and the two areas with the most publications were "Agriculture" and "Plant Science." The "Journal of Agronomy and Crop Science" presented the most published works in this area. The main keywords were gene, nitrogen, and *Avena sativa* L.

References

Associação Brasileira de Sementes e Mudas [ABRASEM]. (2018). *Anuário*. Retrieved on April 18, 2021 from http://www.abrasem.com.br/wpcontent/uploads/2019/04/Arte_Anuario2018_COMPLETO_WEB.pdf

Barros, V. L. N. S. (2013). Aveia preta - alternativa de cultivo no outono/inverno. *Pesquisa & Tecnologia*, *10*(2), 1-5.

Bernardo, A. (2017). O inglês como idioma da comunicação científica e as implicações para o seu ensino na escola. *TICs & EaD em Foco*, *3*(especial), 181-198.

Borém, A., & Miranda, G. (2013). *Melhoramento de plantas* (6. ed.). Viçosa, MG: Editora UFV.

Chandra, A., Bhatt, R. K., & Misra, L. P. (1998). Effect of water stress on biochemical and physiological characteristics of oat genotypes. *Journal Agronomy and Crop Science*, *181*(1), 45-48. DOI: https://doi.org/10.1111/j.1439-037X.1998.tb00396.x

Chen, C. (2014). *The CiteSpace manual.* Drexel, US: College of Computing and Informatics; Drexel University.

Chen, C., Dubin, R., & Kim, M. C. (2014). Emerging trends and new developments in regenerative medicine: A scientometric update (2000-2014). *Expert Opinion on Biological Therapy*, *14*(9), 1295-1317. DOI: https://doi.org/10.1517/14712598.2014.920813

Clarivate. (2021). *Clarivate Analytics*. Retrieved on Jan. 28, 2021 from http://apps.webofknowledge.com/WOS_GeneralSearch_input.do?product=WOS&search_mode=GeneralSearch&SID=7BuS6AZ6aeoW1aZ9xPi&preferencesSaved=

Coimbra, J. L., Carvalho, F. I. F., Oliveira, A. C., Silva, J. A. G., Lorencetti, C. (2005). Comparação entre mutagênicos químico e físico em populações de aveia. *Ciência Rural*, *35*(1). DOI: https://doi.org/10.1590/S0103-84782005000100008

Cover, C., Federizzi, L. C., & Pacheco, M. T. (2011). Caracterização fenotípica e genotípica de caracteres agronômicos em uma população de linhagens recombinantes de aveia (*Avena sativa* L.). *Ciência Rural*, *41*(4), 573-579. DOI: https://doi.org/10.1590/S0103-84782011005000030

Cruz, C. D. (2011). *Programa Genes: aplicativo computacional na área de genética e estatística experimental*. Viçosa, MG: UFV.

Dias-Filho, M. B. (2014). *Diagnóstico das pastagens no Brasil*. Belém, PA: Embrapa Amazônia Oriental.

Falagas, M. E., Pitsouni, E. I., Malietzis, G. A., & Pappas, G. (2008). Comparison of PubMed, Scopus, Web of Science, and Google Scholar: Strengths and weaknesses. *The FASEB Journal*, *22*(2), p. 338-342. DOI: https://doi.org/10.1096/fj.07-9492lsf

Fontaneli, R. S., Santos, H. P., Fontaneli, R. S., Oliveira, J. T., Lehmen, R. I., & Dreon, G. (2012). *Gramíneas forrageiras anuais de inverno*. Brasília, DF: Embrapa.

Fontanelli, R. S., & Piovezan, A. J. (1991). Efeitos de cortes na produção de forragem e grãos de aveia. *Pesquisa Agropecuaria Brasileira*, *26*(5), 691-697.

Hartwig, I., Carvalho, F. I. F., Oliveira, A. C., Silva, J. A. G., Lorencetti, C., Benin G., ... Schmidt, D. J. M. (2006). Phenotypic correlations between agronomic traits of interest in white oat diallel crosses. *Revista Brasileira de Agrociência*, *12*(3), 273-278.

Henning, L., & Nepomuceno, A. (2020). The challenge in the development of GM plants with new characteristics (TRAITS). *SeedNews*, Edição XXIV.

Leggett, J. M. (1998). Chromosome and genomic relationships between the diploid species *Avena strigosa*, *A. eriantha* and the tetraploid *A. maroccana*. *Heredity*, *80*, 361-363. DOI: https://doi.org/10.1046/j.1365-2540.1998.00305.x

Maioli, M. F. D. S. D., Pinto, R. J. B., Silva, T. A. D., Rizzardi, D. A., Matsuzaki, R. A., Sato, M. A., ... Garcia, G. D. L. (2020). Partial diallel and genetic divergence analyses in maize inbred lines. *Acta Scientiarum. Agronomy*, *43*(1), 1-11. DOI: https://doi.org/10.4025/actasciagron.v43i1.53540

Manova, V., & Gruszka, D. (2015). DNA damage and repair in plants – from models to crops. *Frontiers in Plant Science*, *6*(885), 1-26. DOI: https://doi.org/10.3389/fpls.2015.00885

Milach, S. C. K., Rines, H. W., & Phillips, R. L. (1997). Molecular genetic mapping of dwarfing genes in oat. *Theorical and Applied Genetics*, *95*(5), 783-790. DOI: https://doi.org/10.1007/s001220050626

Nunes, G. H. S., Melo, D. R. M., Dantas, D. J., Aragão, F. A. S., & Nunes, E. W. L. P. (2011). Divergência genética entre linhagens de melão do grupo Inodorus. *Revista Ciência Agronômica*, *42*(2), 448-456. DOI: https://doi.org/10.1590/S1806-66902011000200026

Pilhion, R. (2008). Vers une politique européenne de l'enseignement des languesTowards a European policy for language teaching. *Revue Internationale D'éducation de Sèvres*, *47*, 27-35. DOI: https://doi.org/10.4000/ries.325

Razera, J. C. C. (2016). Contribuições da cienciometria para a área brasileira de educação em ciências. *Ciência & Educação*, *22*(3), 557-560. DOI: https://doi.org/10.1590/1516-731320160030001

Rorissa, A., & Yuan, X. (2012). Visualizing and mapping the intellectual structure of information retrieval. *Information Processing & Management*, *48*(1), 120-135. DOI: https://doi.org/10.1016/j.ipm.2011.03.004

Santos, R. N. M., & Kobashi, N. Y. (2009). Bibliometria, cientometria, infometria: conceitos e aplicações. *Revista Eletrônica de Biblioteconomia e Ciência da Informação*, *2*(1), 155-172.

Vieira, G. S., Goulart, L. R., Viglioni, P. J. C., & Fernandes, J. J. (1995). Modification of morphofolical traits of common beans through gamma-ray irradiation: Analysis of three consecutive generations. *Revista Brasileira de Genética*, *18*(4), 599-604.

Ye, C. (2018). Bibliometrical analysis of international big data research: Based on CiteSpace and VOSviewer. In *International Conference on Natural Computation, Fuzzy Systems and Knowledge Discovery* (p. 927-932). Huangshan, CH: IEEE. DOI: https://doi.org/10.1109/FSKD.2018.8687153