



Recebido: 11/03/2024 | Revisado: 02/04/2024 | Aceito: 12/04/2024 | Publicado: 06/06/2024

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DOI: 10.31416/rsdv.v12i2.439

Sclerotinia sclerotiorum research from Brazil (2000-2022) *Pesquisas sobre Sclerotinia sclerotiorum no Brasil (2000-2022)*

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ABSTRACT

White mold is a significant disease caused by the fungus *Sclerotinia sclerotiorum* (Lib.) de Bary, which causes problems in more than 400 different crop species, such as *Phaseolus vulgaris* and *Glycine max*. Gathering knowledge from the perspective of bibliometric review can be an innovative action for the study of this pathosystem in Brazil. Therefore, the objective of this article was the bibliometric production of *Sclerotinia sclerotiorum* from Brazil. For this, the present time frame (2002-2022) was used, with the markers “*Sclerotinia sclerotiorum*” and “Brazil”, in the Web of Science, with analyses carried out in the VosViver program. As a result, 286 articles were viewed, with an average citation of 12.2 per item/year and 28845 citations. The ten most cited works would describe information on genetics, ecology, and biocontrol with the highest production of articles in the year 2019. At EMBRAPA, the author Dr. Fernando Juliatti, and the periodicals of Phytopathology and Plant Production áreas were the protagonists in publications on the aforementioned theme. Research on *Sclerotinia sclerotiorum* has advanced on fronts such as genetics, ecology, and control, mainly biocontrol. During the referenced literature, an indication of the still emerging need for more effective control techniques for this pathosystem can be found, which can mainly permeate gene actions and alternative control.

Keywords: Soil Microbiology; Agriculture; Phytopathology.

RESUMO

O mofo branco é uma importante patologia causada pelo fungo *Sclerotinia sclerotiorum* (Lib.) de Bary, causador de problemas em mais de 400 espécies vegetais diferentes, como por exemplo *Phaseolus vulgaris* e *Glicine max*. Reunir conhecimentos com a perspectiva da revisão bibliométrica pode ser uma inovadora ação para o estudo deste patossistema em relação ao Brasil. Sendo assim, o objetivo deste artigo foi a produção bibliométrica sobre *Sclerotinia sclerotiorum* no Brasil. Para tal foi usado o recorte temporal (2002-2022), com os marcadores “*Sclerotinia sclerotiorum*” e “Brazil”, no *Web of Science*, com análises realizadas no programa *VosViver*. Com os resultados, foram visualizados 286 artigos, com média de citação de 12,2 por item/ano, com um número total de 28845 citações. Os dez trabalhos mais citados descreveriam informações sobre a genética, ecologia e biocontrole com a maior produção de artigos no ano de 2019. A EMBRAPA, o autor Dr. Fernando Juliatti e periódicos da área de Fitopatologia e de Produção Vegetal são os protagonistas em publicações sobre a referida temática. A pesquisa sobre *Sclerotinia sclerotiorum* tem avançado sobre frentes como genética, ecologia e controle, principalmente biocontrole. Em meio a literatura referenciada pode ser encontrada a indicação da necessidade ainda emergente de técnicas de controle mais eficazes para este patossistema, que possam permear principalmente ações gênicas e controle alternativo.

Palavras-chave: Microbiologia do solo; Agricultura; Fitopatologia.



Introdução

White mold is an important soilborne plant pathogen that parasite some different crops around the world, including cultures such as *Glycine max*, *Helianthus annuus*, and *Phaseolus vulgaris* grains, and the lack of monetarily from this pathology is so large in some countries, near to 70% of crops when these are attacked for it (ZANCAN et al., 2012; ZANCAN et al., 2013; ZANCAN et al., 2015 a, b). Other crops are infected by this fungus. This pathology has the Ascomycete fungus *Sclerotinia sclerotiorum* (Lib.) de Bary is your etiological agent (ABREU & SOUZA, 2015; AGUIAR et al., 2018).

Sclerotinia sclerotiorum is a monocyclic pathogen (someone host to parasite to complete the cycle), necrotrophic (cause the death of plants tissue), and still to can survive in organic matter (saprophytism) and in weeds or another crop (different host). Furthermore, the life cycle of *S. sclerotiorum* strains is favored in areas with high humidity and mild temperatures (ANDRADE et al., 2016; AMARO et al., 2023). This pathogen can produce sclerotia (resistant structures) weeds (JULIATTI et al., 2013 a; JULIATTI et al., 2013 b; JULIATTI et al., 2013 c; JULIATTI et al., 2014).

Sexual reproduction is more important for it, this fungi produced a structure called apothecium. This structure produced for this sclerotia can eject some ascospores in the crop field and promote parasitism, this is a critical dissemination method for it. Contaminated seeds, soil, and fomites also can be a positive factor in the transmission of *S. sclerotiorum* (GARCIA, JULIATTI & BARBOSA, 2013; GARCIA & JULIATTI, 2014; GARCIA et al., 2020). The productivity losses around the world caused by *S. sclerotiorum* were estimated at more than 30% and they were caused by the parasite action of white mold in the hosts (BALLARIS et al., 2014; FRANÇA et al., 2021).

The control of this disease has been effective in potential crops. Still, in general, there are some differences in research for this, and some more can be directed to improve some conditions for Brazilian crops, for example. Biocontrol with antagonist bacteria and fungus, cultural methods, and gene-silencing are important areas of current research in Brazil (BARROS et al., 2015; BAPTISTA et al., 2022). The chemical control research was becoming more in the second plan, probably because the populations of white mold had some resistance to chemical molecules (FONTANA et al., 2021; FANTIN et al., 2022).

In relation to *S. sclerotiorum* resistance and problems in crops in world, according to Ibrahim et al. (2021) and Carpenter et al. (2020). Faria et al. (2022) and Huang et al. (2000) describe more relevant research to promote other's conditions to control or convivence with this pathosystem, however without the research being a repeated question.

For a consistent direction to research, the *Sclerotinia sclerotiorum* pathosystem, the use of bibliometric tools can be important, they said about the importance of this pathosystem in the crop around the word and the economical relevance. In the bibliometric tools, for example, there is the possibility of summarising the pieces of information in knowledge to improve the facility to use in other research for resolve problems, according to Mongeon and Paul- Hus (2016) and Kannan and Thanuskodi (2019). This research can be approved to dynamize other research and still, this paper is unanimous and primarily in the description of the importance of bibliometric research to improve some next steps of theme research in a particular period or region for *S. sclerotiorum* pathosystem



in Brazil. So, the aim of this text is to describe the *Sclerotinia sclerotiorum* research in Brazil (2000-2022).

Methods

The papers analyzed in this research between the crops, agriculture, and microbiological themes and the production of this bibliometric data were obtained from the Web of Science (WoS) platform, within the timeframe of 2002 and 2022; in systemic analysis considering the expansions SCI-EXPANDED, SSCI, A&HCI, CPCI-S, CPCI-SSH, ESCI; using the markers “Sclerotinia sclerotiorum” and “Brazil”. The types of biometric analysis carried out were: Citation, indicating the year and place where the subject Object of study is found (general characteristics). bibliographic Institution- and journal-specific engagements People who publish on this topic, co-author list Primary Author (Social Structure of Research), Emphasis on people you work with, and co-occurrence, which identifies which words were used more frequently in each case period.

Analysis of the type of platform and sensor and the variables studied (prior technique) were performed by reading the document separately and, subsequently tabular representation in an electronic spreadsheet. These arch took place on 12/28/2022, in site <https://www.webofscience.com/wos/woscc/summary/a415e6d3-684a-4cf6-afe4-618f5340121b-679be8c8/relevance/1>, with the permission of Capes Platform, registered at the State University of Paraíba, Brazil.

The data production means of this research were based on the writings of Mongeon and Paul-Hus (2016) and Kannan and Thanuskodi (2019). These were analyzed using the VOSviewer program, specifying at least 5 incidences of words, according to the methodology proposed by Van Eck and Waltman (2010) and Huang *et al.* (2020).

Results and discussions

The advanced research about *S. sclerotiorum* pathosystem in Brazil analyzed in this research described points of information about *S. sclerotiorum* Brazilian research (2002-2022). For example, the areas of Molecular Biology (TINOCO *et al.*, 2010), alternative control (ARAUJO, HENNING & HUNGRIA, 2005), Biological control (RODRIGUEZ *et al.*, 2011; GUILGER *et al.*, 2017), and physiology of parasitism (LOPES *et al.*, 2012; ANDRADE *et al.*, 2016; CUNHA *et al.*, 2010) were cited in this research. More information is described below.

The white mold in this research is an important plant pathogen with difficult control, because the effects of this pathogen are aggressive and speedy in crops (ZANCAN *et al.*, 2012; ZANCAN *et al.*, 2013; ZANCAN *et al.*, 2015 a, b) and this characters can be made an attempt unsuccessfully (ABREU & SOUZA, 2015; AGUIAR *et al.*, 2018). *Sclerotinia sclerotiorum* has some



different adaptations, and in these papers, the research described some preoccupations and problems of these actions (ANDRADE *et al.*, 2016; AMARO *et al.*, 2023), some positive control cases can be viewed too (JULIATTI *et al.*, 2013 a; JULIATTI *et al.*, 2013 b; JULIATTI *et al.*, 2013 c; JULIATTI *et al.*, 2014).

An important point related to *S. sclerotiorum* is the sexual reproduction that promotes some diversity (GARCIA, JULIATTI & BARBOSA, 2013; GARCIA & JULIATTI, 2014; GARCIA *et al.*, 2020) and the cosmopolite capacity of the parasite in different hosts (BALLARIS *et al.*, 2014; FRANÇA *et al.*, 2021). In Brazil, there were some different actions to decrease it (BARROS *et al.*, 2019; BAPTISTA *et al.*, 2022), but sometimes these have not been efficient (FONTANA *et al.*, 2021; FANTIN *et al.*, 2022).

Thinking about these ideas in this paper were collected a total of 286 articles were viewed in this research, with an average citation of 12.2 per item/year and a total of 28845 sources. The ten most cited works described information on genetics, ecology, and biocontrol with the highest production of articles in 2019 h-index de 24 (WoS, 2022). Other important information is the more cited papers about *S. sclerotiorum* in Brazil, this paper was delimitedated in Table 1.

TABLE 1 - Title, authors, Journal, publication date, and DOI of ten more important papers about *Sclerotinia sclerotiorum* in Brazil (2000-2022).

Authors	Cited	Year	DOI Link	WoS Categories
Abreu & Souza	36	2015	http://dx.doi.org/10.4238/2015.June.18.31	Biochemistry & Molecular Biology; Genetics & Heredity
Litholdo et al.	27	2011	http://dx.doi.org/10.4238/vol10-2gmr937	Biochemistry & Molecular Biology; Genetics & Heredity
Pannullo et al.	53	2019	http://dx.doi.org/10.1007/s40858-018-0266-5	Plant Sciences
Ribeiro et al.	20	2018	http://dx.doi.org/10.1021/acs.jafc.7b04197	Agriculture, Multidisciplinary; Chemistry, Applied; Food Science & Technology
Gomes et al.	44	2011	http://dx.doi.org/10.1111/j.1439-0434.2010.01724.x	Plant Sciences
Koga et al.	34	2014	http://dx.doi.org/10.1590/S0100-204X2014000400004	Agriculture, Multidisciplinary
Ferreira et al.	24	2021	http://dx.doi.org/10.32404/rean.v8i3.6161	Agronomy
Garcia et al.	11	2015	http://dx.doi.org/10.1590/S0100-204X2015000800011	Agriculture, Multidisciplinary
Andrade et al.	40	2016	http://dx.doi.org/10.1111/ppa.12447	Agronomy; Plant Sciences
Santos et al.	19	2022	http://dx.doi.org/10.2174/2210315512666220405084637	Chemistry, Medicinal

Fonte: Pesquisa direta.

About the areas of research described in this paper, there are 31 different areas with more



emphasis on Crop Science (31.46%), the Andrade *et al.* (2016 a) paper more cited; Agronomy (27.62%) and Agriculture (18.53%) areas, with Andrade *et al.* (2016 b) and Fialho *et al.* (2011) the more cited papers. In relation to the frequency of publications, the 2019 year was the most productive with around 34% of total publications. Guilger *et al.* (2017) and Amaro *et al.* (2019) were the most cited publications. The Brazilian Agricultural Research Corporation (Embrapa) was the most important center of research about *Sclerotinia sclerotiorum* with 24% of total publications.

The most important themes from this paper were Molecular Biology (TINOCO *et al.*, 2010), alternative and biological controls (ARAUJO, HENNING & HUNGRIA, 2005). The author Dr. Fernando Juliatti was the most important in this paper with thirty papers, around 10% of the research. Your contributions to Wei *et al.* (2017), Garcia e Juliatti (2012), and Garcia *et al.* (2012) were among the most important to Brazilian research about *Sclerotinia sclerotiorum*.

The journals more important for this research were the “Bioscience Journal” <<https://seer.ufu.br/index.php/biosciencejournal/index>> and “Pesquisa Agropecuária Brasileira” <https://www.scielo.br/scielo.php?script=sci_serial&pid=0100-2945&lng=pt>, for example, the paper of Zancan *et al.* (2013 and 2015 a, b) and Aguiar *et al.* (2018) and Koga *et al.* (2014), respectively.

The keywords used on this date were, according to Figure 1:

a - green, the central theme in relation to *Sclerotinia sclerotiorum* specie, ecological behaviors, and genetics. In this theme is important the presence of papers that described the knowledge to understand *S. sclerotiorum* and your behavior in agroecosystems. This fact is important to supported diferentes reseracrh for control of this pathogen (ANTONIO *et al.*, 2008; AZEVEDO *et al.*, 2016; CIVARDI *et al.*, 2019);

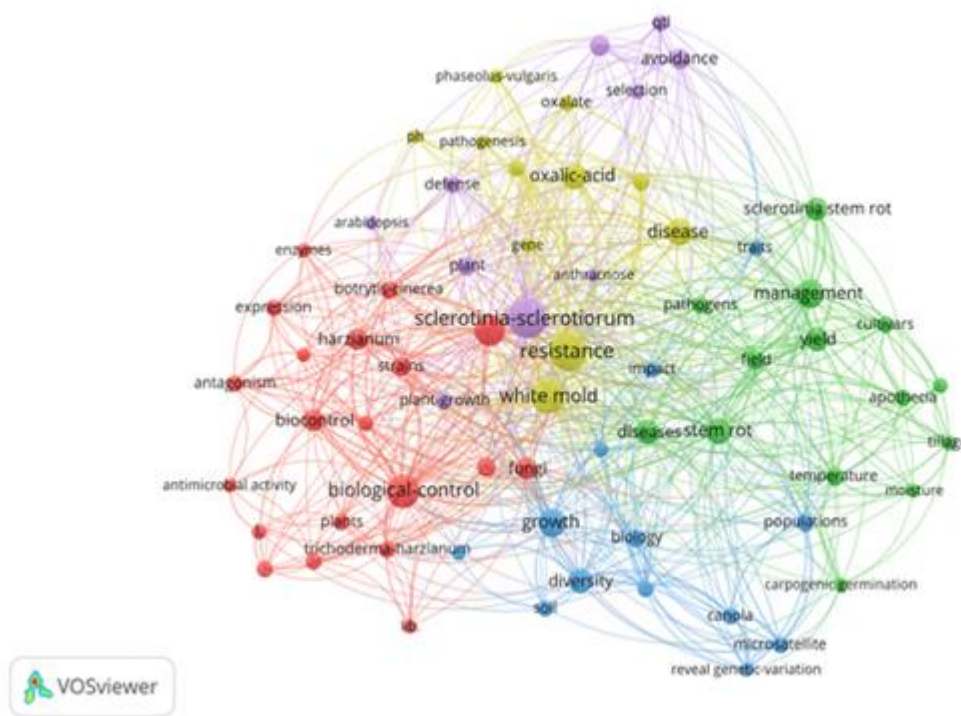
b - in red, the bioprospection of biological control agents, the use of *Trichoderma* species, and biochemical factors include to biocontrol, a important soilborne and endophiytoc fungi present and adaptable in tropical Brazilian conditions, include in Brazilian Cerrado crop área, and outthers microrganisms (ALVES *et al.*, 2021);

c - in green and yellow, the soybean and bean crops were interconnected in this paper with information about pathosystem factors, because this fungi is a important for some crops and weeds (ABREU & SOUZA, 2015; JULIATTI *et al.*, 2013 a; AGUIAR *et al.*, 2018);

d - molecular markers and genetics, in purple, were important insights for this research to identification the presence of *S. sclerotiorum* and your effects (BOTELHO *et al.*, 2010, BOTELHO *et al.*, 2015; GOLDFARB *et al.*, 2016; FONTANA *et al.*, 2021; FANTIN *et al.*, 2022).



FIGURE 1 - Keywords and your relationship with the theme *Sclerotinia sclerotiorum* in Brazil (2000- 2022).



Also, in relation to thematics in Figure 2, we can observe that:

- a - there is a green center about the pathosystem information (ANTONIO *et al.*, 2008; BOTELHO *et al.*, 2010, BOTELHO *et al.*, 2015; AZEVEDO *et al.*, 2016; CIVARDI *et al.*, 2019);
- b - in yellow, the genetics and biochemicals characteristics (BOTELHO *et al.*, 2010; BALLARIS *et al.*, 2014; BOTELHO *et al.*, 2015; FRANÇA *et al.*, 2021);
- c - the management in relation to biological and physicals controls was detached in red (ABREU & SOUZA, 2015; AGUIAR *et al.*, 2018; JULIATTI *et al.*, 2013 a; JULIATTI *et al.*, 2013 b; JULIATTI *et al.*, 2013 c; JULIATTI *et al.*, 2014).
- d - in blue and purple the ecological and genetics interactions (BOTELHO *et al.*, 2010, JULIATTI *et al.*, 2013 a; JULIATTI *et al.*, 2013 b; JULIATTI *et al.*, 2013 c; JULIATTI *et al.*, 2014; ABREU & SOUZA, 2015; BOTELHO *et al.*, 2015; GOLDFARB *et al.*, 2016; AGUIAR *et al.*, 2018; FONTANA *et al.*, 2021; FANTIN *et al.*, 2022).



In the midst of the referenced literature, an indication of the still emerging need for more effective control techniques for this pathosystem can be found, which can mainly permeate gene actions and alternative control. The important research suggested for some papers is the inclusion of different models for the technology of application the biological based-products, genic silent, and host resistance.

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