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Major breakthroughs in the field of biopesticides in recent antiquity

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***Abstract*---**The world's population is rapidly increasing, putting a colossal strain on the world's food supply. Pesticides are one of the most frequent strategies for increasing food production, but their continued usage has some pessimistic consequences for the

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environment. Over the last two decades, there has been a surge in interest in biopesticides as a prospective replacement. A bibliometric study was conducted from 2002 to 2021 to identify the scientific evolution of biopesticides. In the dimension database, a total of 5680 documents were identified as suitable for this analysis. The documents were analyzed, and nations were ranked based on authors, productivity, article citations, and co-authorship using parameters such as the number of papers, article citations, keywords, source impact, and country of publication. From 2002 to 2021, Pest Management Science and the Journal of Economic Entomology produced the most articles as well as the top contributions in biopesticide publishing by authors Benelli (first) and Tyagi (second). In 2006, Halkier received the highest degree of citation, while Berg received the highest level of citation in 2009. The University of Queensland and the University of Florida were the top two institutes that contributed to the publication of biopesticides. India and China, Asia's two most populous countries, were placed first and third, respectively, in terms of the most prolific countries in the field of plant biopesticides, with the United States coming in second. However, given their heavy use of pesticides, countries in Europe and Africa have fewer publications in this field than one might expect. India, the US, and China have 6.60 percent, 4.04 percent, and 7.27 percent of MCPs, respectively, with India collaborating the most. Finally, this research shows that India, the United States, and China are leading the way in replacing synthetic pesticides with natural plant biopesticides.

***Keywords*---**Biopesticide, bibliometric analysis, India, Pest, organic farming.

Introduction

Excessive use of chemical pesticides on the environment and natural resources, including humans, has recently been a major cause of concern (Pimentel, 1996; Margni *et al.,* 2002). Synthetic pesticides have long been known to harm the environment, affecting animal and plant biodiversity, as well as terrestrial and aquatic ecosystems (Mahmood *et al.,* 2016). Chemical pesticides have long been used to manage agricultural pests and weeds, as well as insects that cause human disease. However, their use has led to a plethora of concerns, including increased disease and insect resistance to many chemical compounds, as well as pollution and its effects on human health, including cancer and a variety of immune system disorders. Consumers are increasingly demanding pesticide-free meals as a result of the hazard that pesticides pose to human health and the environment through their direct action and lingering effects (Compant*et al.*, 2005). In this setting, microbial insecticides have emerged as viable alternatives to chemical insecticides for the control of pests (Bravo *et al.,* 2011; Montesinos, 2006), disease vectors (Matthews *et al.,* 2011; Hurwitz *et al.,* 2011), and animals (Dunstand-Guzmán*et al.,* 2015).

The detrimental effects of synthetic pesticides have necessitated the development of a safer and more ecologically friendly alternative. Biopesticides are thought to be less hazardous, better for the environment, and safe for people and non-target creatures (Walia *et al.*, 2017). Botanical pesticides are not a new phenomenon. Botanical pesticides were used in agricultural methods by ancient China, Egypt, Greece, and India as early as the 17th century (Isman, 2006). Biopesticides have sparked a lot of attention in the last decade as a way to replace synthetic pesticides. According to research by Isman and Grieneisen (2004), the number of yearly articles published on biopesticides has increased from 61 papers in 1980 to 1207 publications in 2012. This indicates that plant biopesticides are becoming more widely known and used. Despite the growing demand for natural pest management, plant biopesticides account for less than 1% of total pesticide usage (Walia *et al.*, 2017).

The efficiency of microbial insecticides has been tested on many pests of many crops across the world, including sugarcane (Sharma*et al.,* 2020), tobacco (Vianna *et al.,* 2020), wheat (Rojas *et al.,* 2020), potato (Abd-Elgawad, 2020), mango (Mathews *et al.*, 2010), tomato (Barra-Bucarei*et al.,* 2020), and berries (Dedej*et al.,* 2004). They've been put to the test in many environments, including labs (Chergui *et al.,* 2020), open fields (Ismoilov*et al.,* 2020), and greenhouses (El Arnaouty *et al.,* 2020). They've become an important part of a variety of integrated pest control strategies (Costa and Faria, 2010) and organic farming (Larkin, 2020). As previously stated, the abundance of published research on the subject makes it appropriate to employ data meta-analysis methods such as bibliometrics, which employ statistics and visualization techniques to investigate structures and patterns in scientific production (Tang *et al.,* 2018), allowing for a more comprehensive scientific evolution analysis of the field. This strategy concentrates on a single study issue; in this example, databases of internationally renowned publications were employed, allowing for a global and historical view of the phenomena. Due to the vast amount of material available on the subject, it is hard to provide a complete evaluation. As a result, a mini-review might still be beneficial for summarizing current findings. Based on papers in the Dimension database, the goal was to develop research trends in the use of biopesticides.

Materials and Methods

The published research outputs on biopesticides were retrieved from the dimension database on March 18, 2022. The key terms used to query the dimension database in this study were ("Microbial pesticide" OR "Bio-pesticide" OR "Biopesticide" OR "plant pesticides" OR "plant biopesticides" OR "plant-derived pesticides" OR "green pesticides" OR "botanical pesticides" OR "Phyto-pesticides"). These search parameters were used to find title-specific research from 2002 through 2021, yielding 5680 results. The papers were cleaned and downloaded in Excel file format (Larayetan*et al.,* 2020), after which VosViewer 1.6.18 was used to analyze bibliometric information. This study utilized bibliometric indices, annual scientific production, article citations per year, bibliographic coupling, most productive authors, most productive countries, most relevant keywords, and most productive journals/sources to assess current and potential future trends in plant biopesticide research. In this research, the yearly scientific indicator is counted by institute, organization, author, and nation. Citation analysis assesses

an author's or publication's relative relevance or effect based on how many times it has been cited by others. The citation counts, on the other hand, were used to calculate the influence of biopesticides on plant biopesticides per nation. As stated in (Aria and Cuccurullo, 2017; Perianes-Rodriguez *et al.,* 2016), the publication-citation matrix was utilized to examine the most productive authors/countries, co-citation, and bibliographic coupling. The VosViewer interface is used to extract keywords directly from papers, which are then used to investigate the conceptual structure of the green pesticide research sector.

Results

Statistics in the production of research articles from 2002 to 2021

A wide range of biopesticide keywords was utilized to query the database to identify the progression of research on green pesticides in this study. A total of 5680 published publications were found from various sources such as Scopus, PubMed, Google Scholar, and others. Articles (4658), book chapters (800), proceedings (80), preprints (74), edited books (62), and monographs (4658) are among the materials (6). Closed access came in with 3088 publications, followed by all open access (2592), gold (1546), bronze (426), hybrid (323), and green (323). The scholarly articles published on this topic increased exponentially from 56 in the year 2002 to 945 in 2021 (~ 1328 times increase) (Figure 1). During the last two decades (2002-2021), the citation frequencies trend was inconsistently increased from 3 to 17,225, moreover highest citations has been recorded in 2021 (Figure 2).

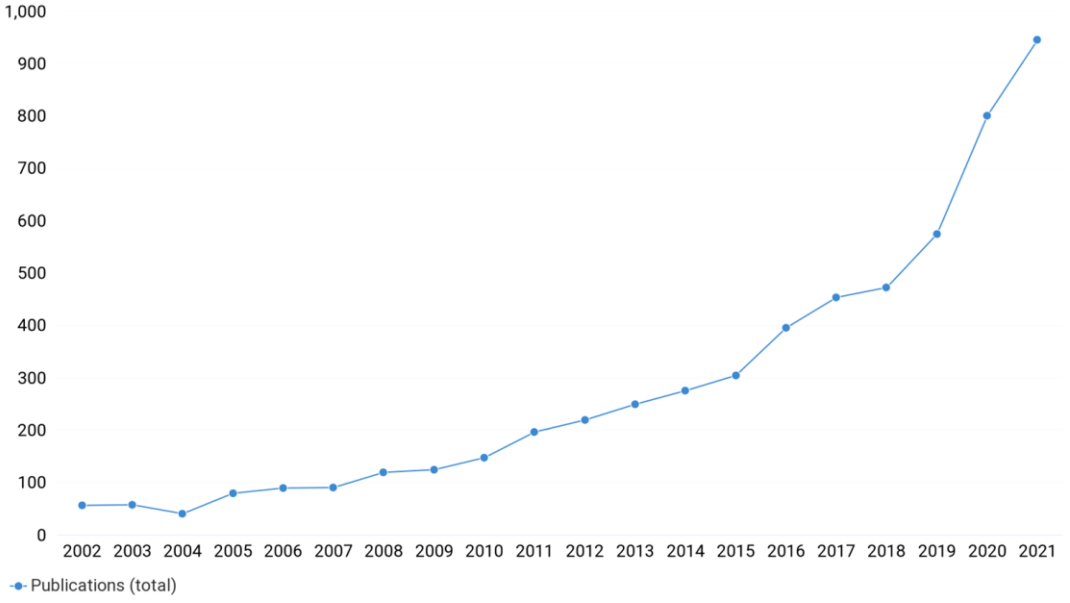

Figure 1: Bibliometric scholarly publications trend during 2002-2021

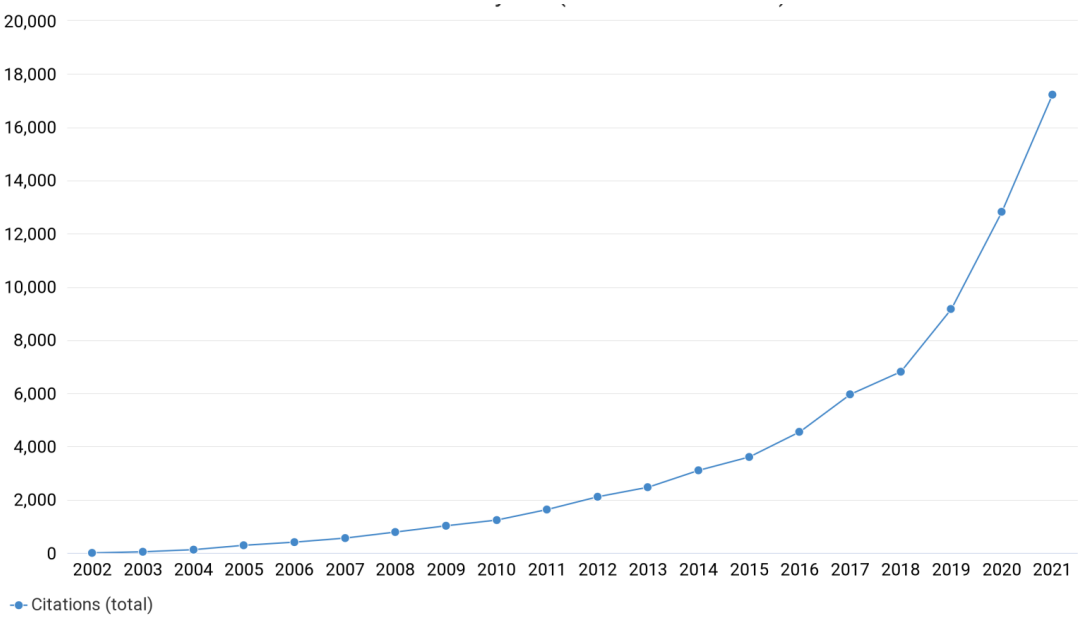

Figure 2: Year-wise citation trend on research articles published during 2002-2021

Active authors and most potential journals

The journal "Pest management science" published the most research articles (97) with highest citation (2052) over the last two decades (2002-2021). A total of 1784 co-authors from different countries published several scholarly articles on this topic (Figure 3). An eminent scientist Benelli, giovanni from University of Pisa, Italy has published maximum research articles (46) on this topic that gained the highest citations (2091), while Tyagi R. D. from the National Institute of Scientific Research, Canada got the highest number of citations (792) on 24 published articles (Figure 4) (Table 2).

Countries, citation and Affiliations

Among all the countries worldwide, India contributed maximum scholarly publishing growth including 655 research articles with a total of 9922 citations (Figure 5). Moreover, the United State contributed the highest citations per document (24.73), followed by the China (13.76) and Brazil (15.73) on the concerned topic. All around the world, a total of 1014 research organizations or affiliations have published scholarly work on this topic during the last two decades (Figure 6). Among these affiliations, University Of Queensland from the Australia has published the maximum number of research articles (53) on this topic followed by the University Of Florida (51) from Florida, and the University Of Pisa (50) from Italy (Table 2). All around the world, a total of 1213 citations have published scholarly work on this topic during the last two decades (Figure 6). Among these citations, Six in 2006 has maximum number of citations (1160) on this topic followed by the Bossio (796) in 1998, and the Hartmann (670) in 2016 (Figure 7).

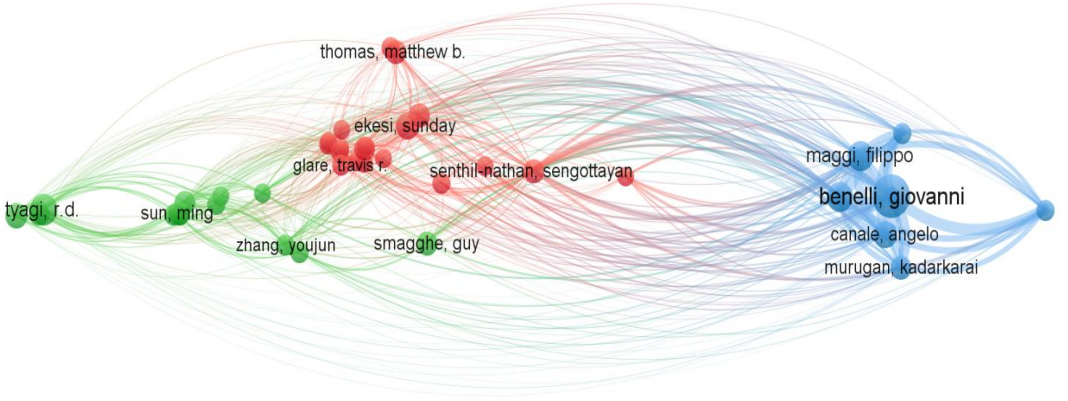

Figure 3: Bibliographic coupling network of the author that worked on biopesticide

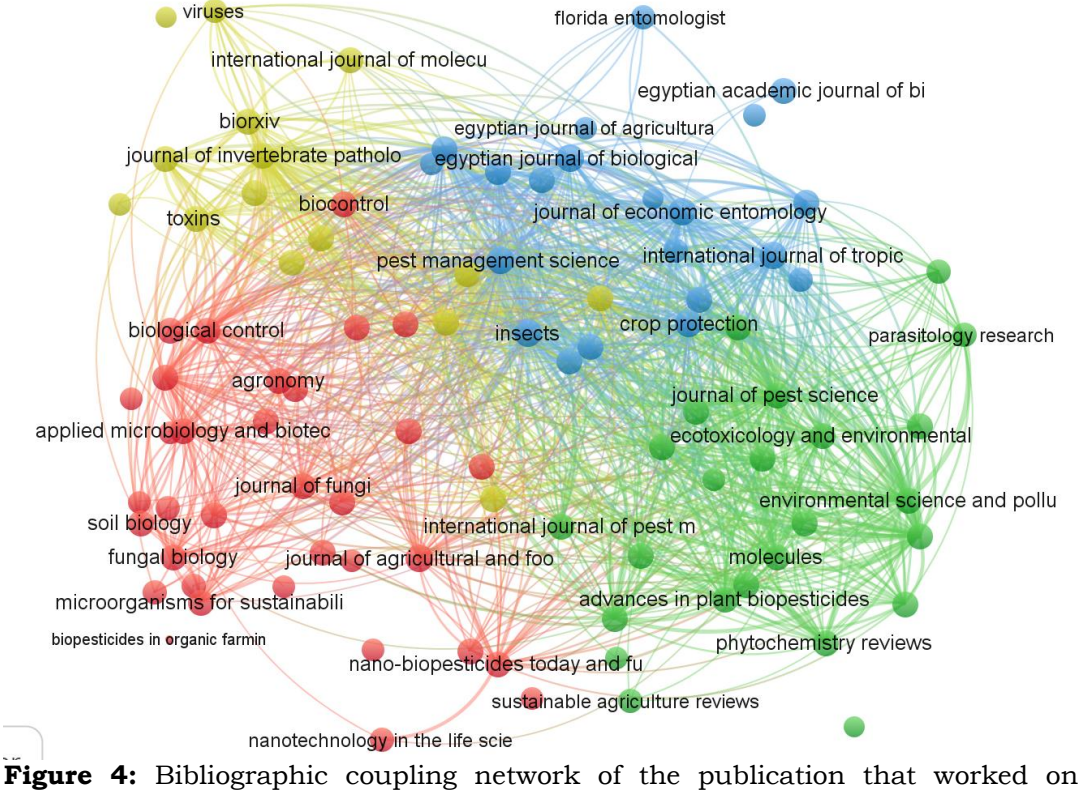

Figure 4: Bibliographic coupling network of the publication that worked on biopesticide

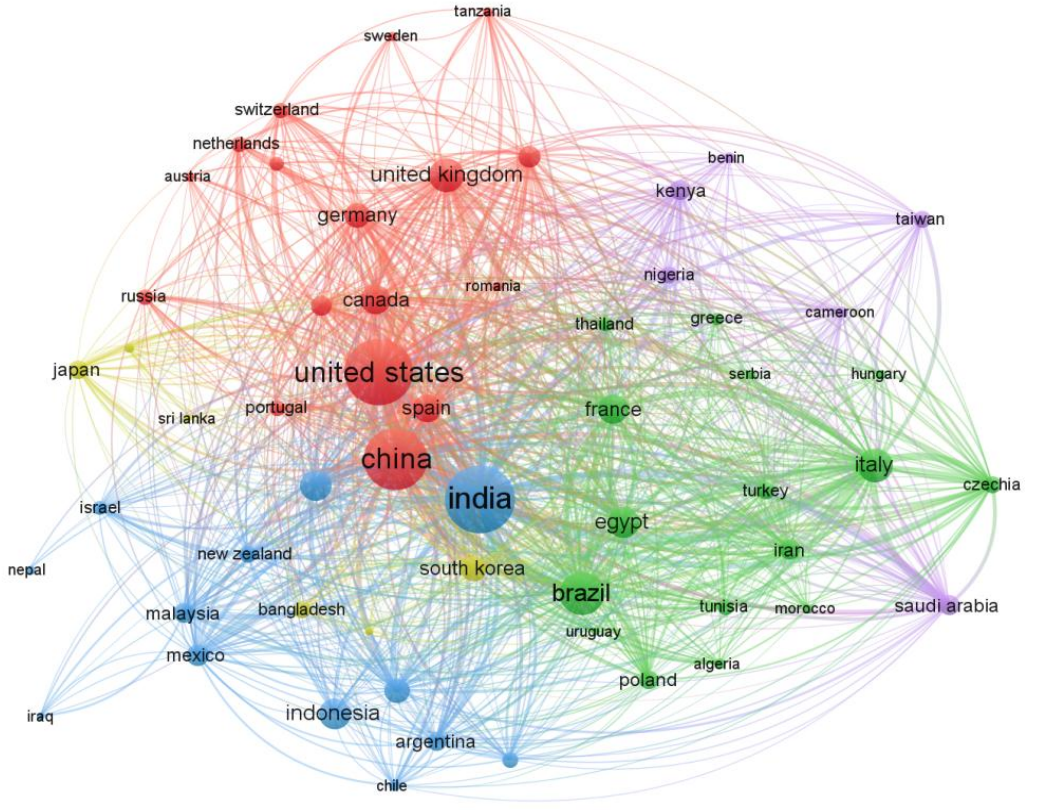

Figure 5: Bibliographic coupling network of the top country that worked on biopesticide

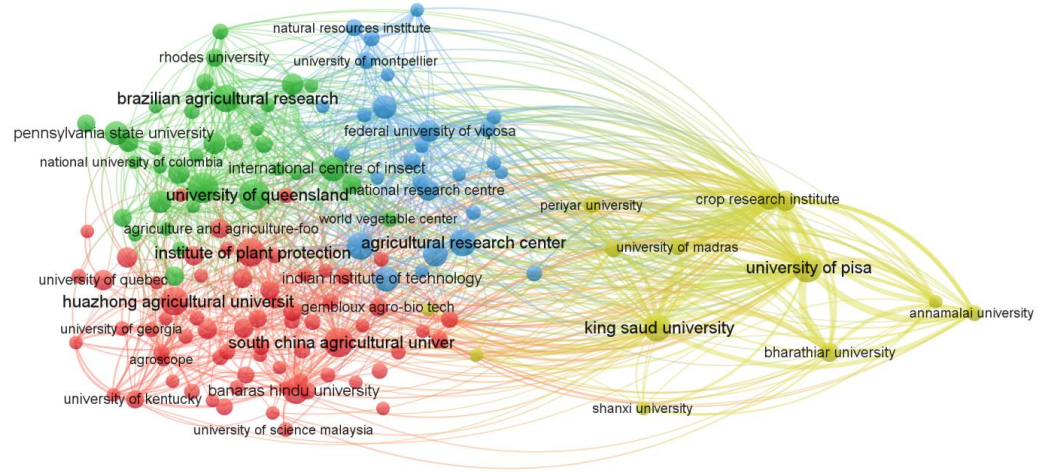

Figure 6: Bibliographic coupling network of the top organization and their linkage that worked on Biopesticide

Table 1: Top 10 authors and journal in biopesticides

Rank	Author	R	C	C/R	Rank	Journal	R	C	C/R
1	Benelli, giovanni	46	2091	45.45	1	Pest management science	97	2052	21.15
2	Tyagi, r.d.	24	792	33	2	Journal of economic entomology	61	647	10.61
3	Maggi, filippo	23	860	37.39	3	Journal of invertebrate pathology	59	2251	38.15
4	Pavela, roman	22	1300	59.09	4	Insects	53	711	13.42
5	Canale, angelo	18	569	31.61	5	Iop conference series earth and environmental science	53	27	0.51
6	ekesi, sunday	18	187	10.39	6	plos one	50	1273	25.46
7	surampalli, r.y.	17	572	33.65	7	Biocontrol science and technology	50	802	16.04
8	kim, jaesu	15	146	9.73	8	Journal of pest science	48	952	19.83
9	murugan, kadarkarai	15	594	39.6	9	Journal of agricultural and food chemistry	47	1110	23.62
10	subramanian, sevgan	15	117	7.8	10	Scientific reports	46	768	16.70

R = Number of research articles (2002–2021); C = Total citations (2002–2021); C/R = cites per research article

Table 2: Top 10 institutes and country in biopesticides

Rank	Institution	R	C	C/R	Rank	Country	R	C	C/R
1	University Of Queensland	53	1786	33.70	1	India	655	9922	15.15
2	University Of Florida	51	1195	23.43	2	United States	616	15235	24.73
3	University Of Pisa	50	2222	44.44	3	China	547	7526	13.76
4	South China Agricultural University	49	457	9.33	4	Brazil	263	4137	15.73
5	Institute Of Plant Protection	46	440	9.57	5	Italy	167	6108	36.57
6	Huazhong Agricultural University	43	695	16.16	6	United Kingdom	162	5436	33.56
7	Brazilian Agricultural Research Corporation	42	593	14.12	7	Indonesia	142	243	1.71
8	São Paulo State University	42	784	18.67	8	Australia	137	5222	38.12
9	Agricultural Research Center	41	409	9.98	9	Egypt	133	1323	9.95
10	King Saud University	40	665	16.63	10	Canada	131	4859	37.09

R = Number of research articles (2002–2021); C = Total citations (2002–2021); C/R = cites per research article

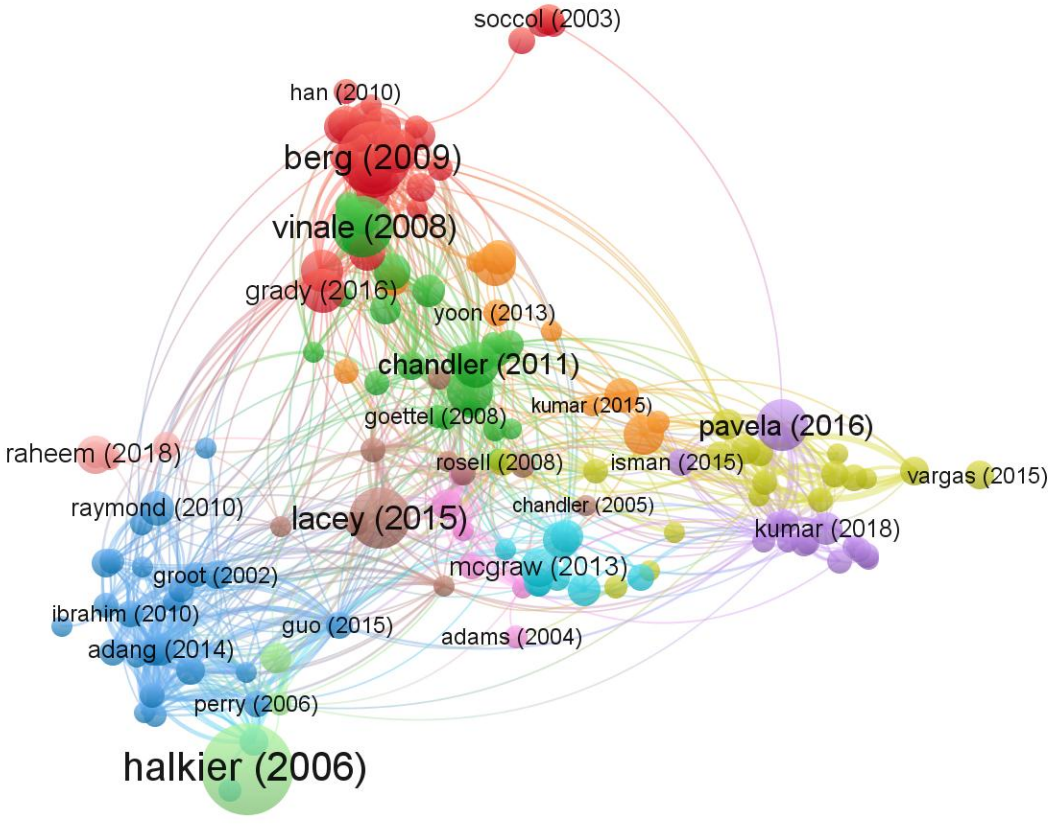

Figure 7: Bibliographic coupling network of the citation that worked on biopesticide

Conclusion

Based on papers obtained from dimensions, this bibliometric analysis examined the global trend in green pesticide research from 2002 to 2021. Despite the growing body of knowledge on green pesticides, commercial applications are still restricted. According to trends in yearly scientific output, research on green pesticides will continue to grow. Synthetic pesticides' negative impacts on the environment and human health might be one of the driving forces for increased research output in the alternative field of plant biopesticides. This analysis also discovered that India, the United States, and China are the top three nations in terms of producing green biopesticide research docs articles and total citations per country. Despite being heavy users of pesticides, Europe and Africa have much fewer published research documents than the nations indicated before. Europe and Africa need to step up their research on alternative pesticides, whether through government or privately financed initiatives, to promote ecologically friendly pesticides, particularly in Africa, where high-toxicity pesticides are still in use.

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