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Mapping Global Research Progress in Rice Blast Resistance Breeding: A Scientometric Analysis

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ABSTRACT

The present study was conducted during November, 2022–July, 2023 at the School of Agriculture, SR University, Warangal, Telangana, India, to analyze the global publication trends in rice blast resistance research from 2010 to 2021. Rice blast, caused by *Magnaporthe oryzae*, was one of the most devastating diseases affecting rice productivity worldwide, necessitating continuous research efforts in resistance breeding and disease management. A thorough literature review was done employing scientometric and network analysis methods to evaluate the growth, structure, and dynamics of research in the rice blast resistance domain. A total of 1,242 research papers indexed in the Scopus database, published during the period from 2010 to 2021, were used for the study. The mapping of the key aspects examined the following analyses: co-occurrence and co-citation. The literature data including citations, abstracts, bibliographic details, keywords, and funding information were evaluated using the VOS viewer software to generate visualization maps. The analysis helped to discover the major research institutions, leading countries, the most cited articles, the leading authors in terms of publication output and citations, and the main research sources on the blast resistance of rice. The findings of this research not only clarified the trends and contributions of the past research but also provided great support, direction and useful reference for researchers, policymakers, and academicians who would be tackling rice blast resistance.

KEYWORDS: Rice blast resistance, scientometric, scopus database, research trends

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1. INTRODUCTION

Rice is one of the leading food sources worldwide and is the main source of food in the Asian region that produces and consumes about 90% of the world's rice. India is the second-largest rice-producing country in the world, accounting for 22% of total global production. In 2020–21, India alone made a contribution of 124.36 mt of rice, which came from an area of 45.7 mha (Anonymous, 2020–21). The world population is anticipated to reach 9.8 billion by 2050, which results in noticeable increase in cereal crop demand, including rice. Hence, the production will need to be raised by 70–100% to guarantee food security (Godfray et al., 2010). Rice production is constrained by different types of biotic and abiotic stresses result in huge yield losses. Biotic stresses alone account for almost half of global rice production with plant diseases making up for about 30% of these losses (Yarasi et al., 2008). Blast disease caused by the fungus *Magnaporthe oryzae* is recognized as the most significant threat to rice farming (Zhang et al., 2024; Tan et al., 2024; Chandana et al., 2024; Zeigler et al., 1994; Prasad et al., 2009). The rice blast causes huge economic losses due its rapid and widespread incidence (Sahu et al., 2022; Agbowuro et al., 2020). It has been documented that blast affects nearly 85 countries worldwide (Miah et al., 2013; Ballini et al., 2008). In India, a 4% drop in rice production due to rice blast was already estimated in 1919 (Padmanabhan, 1965). Later with the outbreak's severity, Eastern India was affected with 50% yield loss (Khush and Jena, 2009). Similarly, in Japan the losses reached 20% to 100% (Khush, 2005). The annual global rice yield lost to blast is considered to be enough to feed approximately 60 million people for one full year (Parker et al., 2008). Although chemical fungicides remain a primary control method, their high cost and environmental risks have raised concerns regarding sustainability (Wang et al., 2015b; Wang et al., 2015a). Conventional breeding has produced several resistant cultivars (Miah et al., 2013), while molecular breeding techniques have further enhanced resistance through gene pyramiding and marker-assisted selection studies (Singh et al., 2023; Pote et al., 2022; Yang et al., 2022; Tian et al., 2019; Kumar et al., 2018; Luo et al., 2017; Ellur et al., 2016). Despite these advancements, rice blast continues to pose a serious challenge due to the high genetic variability of *Magnaporthe oryzae*, which enables it to evolve rapidly and overcome host resistance (Younas et al., 2024; Lin et al., 2024; Jiang et al., 2012; Bryan et al., 2000). Scientometric analysis has become an important tool for evaluating research trends and identifying knowledge gaps. Databases such as Web of Science (WoS) and Scopus are widely recognized for their extensive coverage and reliability (Singh et al., 2021; Martin et al., 2021; Gusenbauer et al., 2020; Afgan and Bing, 2021). Although there is considerable overlap between these databases, each also indexes unique publications (Chadegani et al., 2013; Vieira et al., 2009). In this study, data on rice blast resistance were retrieved from Scopus, one of the largest and most comprehensive abstract and citation databases (Meho, 2019; Bergman, 2012; Bosman et al., 2006). The present study focused on analyzing publication trends in rice blast resistance research from 2010 to 2021. It examined contributions from different countries, institutions, authors, and collaborative networks. The findings aimed to provide valuable insights for researchers, policymakers, and stakeholders by identifying emerging research areas and highlighting future opportunities in this domain.

2. MATERIALS AND METHODS

The study was conducted during November, 2022– July, 2023 at School of Agriculture, SR University, Warangal, Telangana, India. This study provided a systematic analysis of research on rice blast resistance, using publication data retrieved from the Scopus database.

2.1. *Data collection, information source and search methodology*

The online Scopus database was used for the keyword search "rice blast resistance" focusing on the research articles published between the years 2010 and 2021. The keywords ("rice" AND "blast" AND "resistance") were used to search the "Article title, Abstract, keywords" fields to find out what combined research topics were studied on rice blast resistance during 2010–2021. After the first search, a total of two thousand two hundred and forty-six (n=2246) articles were discovered. After narrowing down the search limit to the years 2010 to 2021, the corresponding number of articles was revealed to be n=1422. The screening process was further refined by selecting papers published in specific subject areas, including Agricultural and Biological Sciences, Biochemistry, Genetics and Molecular Biology, Immunology and Microbiology, Multidisciplinary, and Environmental Science (n=1359). This was followed by filtering papers based on document type articles, reviews, and conference papers (n=1310) and restricting the selection to English-language publications (n=1243) in their final stage of publication. Articles in press, as well as publications from sources other than peer-reviewed journals and conference proceedings, were excluded from the analysis. After applying these criteria, the final research database for the study on *blast resistance in rice* comprised 1,242 research papers.

The search output of the topic was analyzed based on the country, author, source of publication, year of publication, institutional affiliation, subject area, and type of document. Key bibliometric indicators such as total number of publications, total number of citations, cites score for the countries, authors, journals, and papers were used for identifying top contributors in the research area "Blast resistance in rice". The whole procedure of data collection and analysis is presented in the Figure 1.

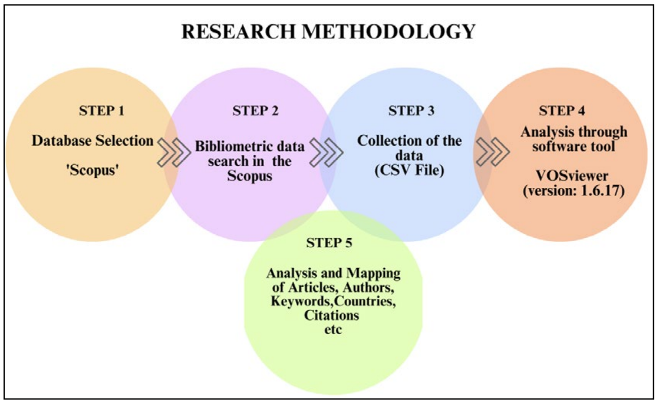

Figure 1: Schematic illustration of research methodology

2.2. Construction of bibliometric graphs and maps

Information retrieved from Scopus database on bibliography, citations, and keywords was analyzed using VOS viewer software for constructing bibliometric network maps between countries, authors, or keywords.

2.2.1. Co-authorship analysis

In the Co-authorship analysis, only those countries with at least sixteen articles have been taken into account. It demonstrated that just 19 of the 81 such countries affiliated with authors have published 16 or more publications. The co-authorship strength among 19 countries was analyzed, with each country's overall connection to others computed. The affiliated countries were categorized into four clusters, and the total link strength of each was determined using VOS viewer software.

2.2.2. Co-occurence analysis

A co-occurrence analysis was conducted on author keywords, identifying 2,437 out of a total of 5,658 keywords. Before importing them into VOS viewer software, synonymic single words and related phrases were reviewed. In VOS viewer, 713 keywords met the required threshold when the minimum occurrence was set to five, while 20 keywords had occurrences exceeding 15. The frequency and link strength of these top 20 keywords were further analyzed.

3. RESULTS AND DISCUSSION

3.1. Number of documents analysis

The first article registered in Scopus was published in the year 1950. From 1950 to 1999 the number of articles published in the rice blast area were less whereas from 2000 the publications number has increased progressively with most articles being published during 2019 and 2020, totaling 156 articles. As shown in the Figure 2 there was continuous

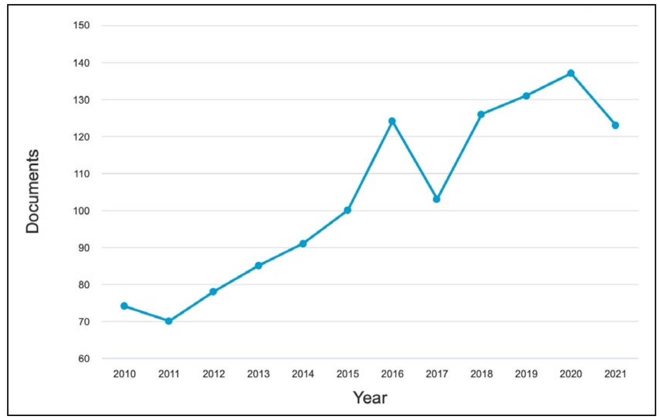

Figure 2: The annual publications on rice blast resistance indexed in scopus from 2010-2021

increase in the publications number throughout the years except during the years 2016 and 2021.

3.2. Leading journals

The top most five productive journal publishing articles related rice blast resistance were Rice followed by Frontiers in plant science, Plos One, Molecular Breeding and Euphytica (Figure 3) of the top five journals, three journals i.e., Rice, Molecular Breeding and Euphytica were published by Springer Nature while Frontiers in plant science and Plos One were published by Frontiers Media S.A and Public Library of Science, respectively.

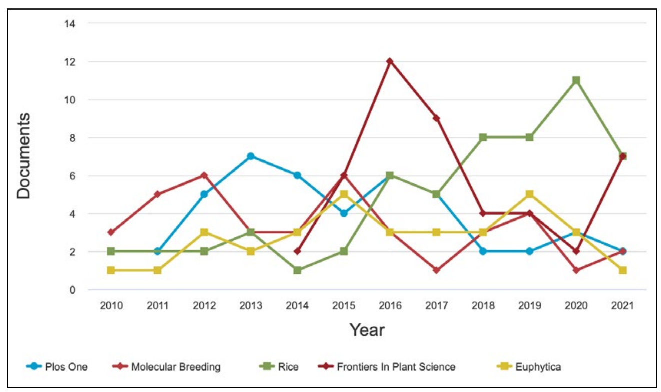

Figure 3: The leading journals on rice blast resistance

CiteScore (CS) is an academic journal metric that represents the average number of citations received per document published in a specific journal over a defined period. Introduced by Elsevier in December 2016, it served as an alternative to the widely used JCR impact factor calculated by Clarivate. According to the 2021 CiteScore report, four of the top five journals had a CiteScore above 5, with Frontiers in Plant Science achieving the highest score of 8.0, while Euphytica had a score of 3.4. The publication trends of these top five journals in the field of rice blast resistance from 2012 to 2021 were illustrated in Figure 3.

3.3. Contribution of authors, institutions and countries

A large number of authors have made significant contributions to advancing rice blast resistance studies. Figure 4 highlighted the ten most prolific authors ranked according to the total number of published papers indexed in the Scopus database.

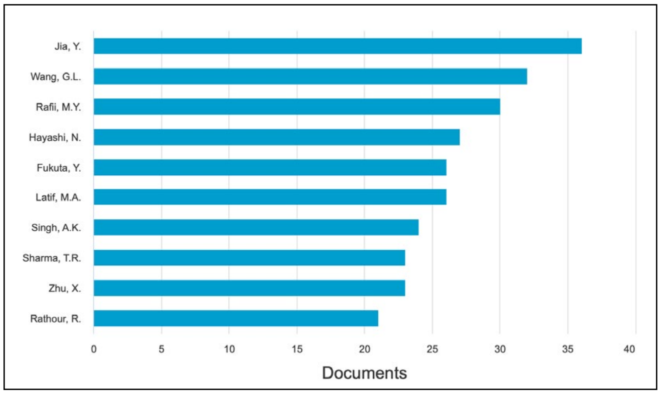

Figure 4: Ten prominent authors actively contributing to rice blast resistance studies

Jia, Y. topped with 36 publications in rice blast resistance followed by Wang, G.L (32 papers) and Rafi, M.Y. (30 papers). The top two active researchers were from United states affiliated to different institutions. Jia, Y. was affiliated to USDA ARS while Wang, G.L and Rafi, M.Y was affiliated to Universiti Putra Malaysia, Serdang, Malaysia. Notably, several top researchers were affiliated with CSK Himachal Pradesh Agricultural University, Department of Agricultural Biotechnology, Palampur. Among the top ten authors, two were from Japan, while China, Malaysia, and Bangladesh each have one representative.

Among the various countries involved in rice blast resistance research, Figure 5 highlighted the ten most productive countries based on their overall contribution to the global advancement of this field. With 475 publications, China leads the world in this category, (475) accounting for 38.2% of total publications on rice blast resistance. India with 210 papers stands second followed by USA (188) and Japan (187) in third and fourth place with almost equal publications. It was clearly observed that there was a massive difference between top first and top second country in the number of publications by 44.2%. Similarly, Malaysia (63), which stood in the fifth place after Japan (187) also had enormous difference in their total publications. From the figure it was clearly understood that China was sole producer of large number of publications in rice blast resistance. Philippines (59), Thailand (41), Brazil (40), Germany (38) and United Kingdom (37) were the other countries in the top ten.

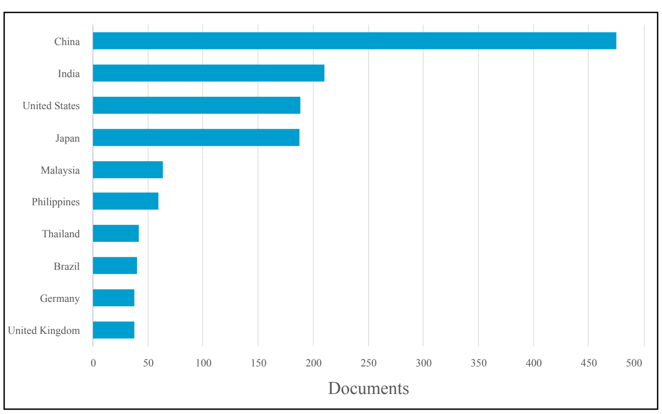

Figure 5: The leading ten productive countries in rice blast resistance publications

The top twelve countries with high Citations were presented in the Table 1. China as usually took the top position with highest number of citations followed by United States, Japan, and India in second, third and fourth place, respectively. China was leading in both total publications and citations and ranked first in both the categories. India was the second most prolific country in terms of total publications but ranked fourth based on citations, with the United States and Japan ranking second and third regarding citations, respectively. Based on citations, the United States and Japan surpassed India, ranking second and third, respectively. It was intriguing to see France, Bangladesh, and Iran in the top 10 countries by number of citations despite not ranking among the top ten based on total publications.

Table 1: Countries with highest citation counts

S. No	Country	Documents	Citations
I.	China	475	11443
II.	United States	188	7410
III.	Japan	187	6677
IV.	India	210	3814
V.	Philippines	59	1372
VI.	Malaysia	63	1073
VII.	Bangladesh	31	691
VIII.	France	34	1314
IX.	Iran	21	318
X.	United Kingdom	37	1771
XI.	Brazil	40	383
XII.	Thailand	41	334

The choice of publication sources is essential for effectively sharing research findings and influencing society. One hundred and sixty institutions conducted research during and published their work in various journals. The top 15 contributing institutions in the field of blast resistance were presented in Table 2.

Table 2: List of topmost productive institutions

Sl. No.	Institutions	Documents	Country
1.	Institute of Agrobiological Sciences, NARO	76	Japan
2.	Ministry of Education China	55	China
3.	IRRI	54	Philippines
4.	Chinese Academy of Agricultural Sciences	53	China
5.	South China Agricultural University	50	China
6.	ICAR - IARI, New Delhi	47	India
7.	Universiti Putra Malaysia	47	Malaysia
8.	Sichuan Agricultural University	43	China
9.	Guangdong Academy of Agricultural Sciences	41	China
10.	ICAR-National Research Centre on Plant Biotechnology, New Delhi	41	India
11.	ICAR-NRRI, Cuttack	40	India
12.	Chinese Academy of Sciences	39	China
13.	Nanjing Agricultural University	38	China
14.	State Key Laboratory of Rice Biology	38	China
15.	Zhejiang University	37	China

Researchers from the Institute of Agrobiological Sciences, NARO from Japan have published large number of articles (76) followed by Ministry of Education China (55), IRRI, Philippines (54), Chinese Academy of Agricultural Sciences (53), South China Agricultural University (50 publications), ICAR-IARI, New Delhi (47) and Universiti Putra Malaysia (47).

It was surprising to see institutions from only five countries have occupied the top 15. It was observed from the list that out of top 15 institutions, more than half were from China while three institutions were from India one each from Japan, Malaysia, and Philippines.

3.4. Highly cited papers

The citation count of a paper was commonly regarded as a measure of its impact within the research community. While highly cited papers were generally considered landmark studies, this was not always the case. The significance of an article was typically evaluated based on its total citations. According to Table 3, the five most cited landmark publications were Deng et al. (2017), Li et al. (2017), Wang et al. (2016), Asano et al. (2012) and Guo et al. (2011).

3.5. Co-occurrence analysis of keywords

A keyword network provides a comprehensive overview of a research field, enabling a better understanding of the topics explored and their interconnections. Data retrieved from the Scopus database was analyzed to recognize the frequently occurring words in the titles, abstracts, and keywords of the selected publications. Researchers used a total of 2,437 unique keywords to categorize their studies. Table 4 presented the top 20 most frequently used keywords, with "Rice" being the most common, followed by "*Magnaporthe oryzae*," "Rice blast," "*Oryza sativa*" "Blast," "Disease Resistance," and "Blast Resistance."

Figure 6, generated using VOS viewer, provided a visual representation of keyword co-occurrences, with different colours indicating varying scores. The colour gradient spans from blue (denoting the lowest score) to green and yellow (signifying the highest score). Figure 6 highlighted the top 21 keywords with the strongest overall co-occurrence links. The size of every node reflected the frequency of keyword occurrence, whereas the connecting curves between nodes represented their co-occurrence within the same publication. The strongest links were among the following pairs of keywords: Rice-*Magnaporthe oryzae* (link strength=63); Rice blast-*Magnaporthe oryzae* (link strength=43); *Magnaporthe oryzae* and *Oryza sativa* (link strength=43); rice and blast (link strength=36); rice and blast resistance (link strength=28); rice and disease resistance (link strength=25); rice and blast disease (link strength=25); rice blast and resistance gene (link strength=18);

Therefore, rice, *Magnaporthe oryzae*, rice blast, blast

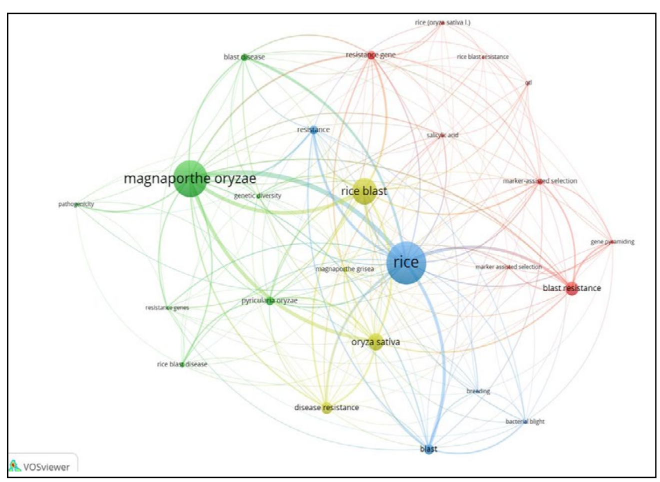

Figure 6: The co-occurrence of keywords with the greatest total link strength

Table 3: Most cited research articles as of July, 2022

Sl. No.	Author	Title of the article	Year	Journal	Citations
1.	Wang et al., 2016	Enhanced rice blast resistance by CRISPR/ Cas9-Targeted mutagenesis of the ERF transcription factor gene OsERF922	2016	PLoS ONE	354
2.	Deng et al., 2017	Epigenetic regulation of antagonistic receptors confers rice blast resistance with yield balance	2017	Science	282
3.	Li et al., 2017	A Natural Allele of a Transcription Factor in Rice Confers Broad-Spectrum Blast Resistance	2017	Cell	268
4.	Guo et al., 2011	The bZIP transcription factor MoAP1 mediates the oxidative stress response and is critical for pathogenicity of the rice blast fungus magnaporthe oryzae	2011	PLoS Pathogens	221
5.	Asano et al., 2012	A rice calcium-dependent protein kinase OsCPK12 oppositely modulates salt-stress tolerance and blast disease resistance	2012	Plant Journal	209
6.	Okuyama et al., 2011	A multifaceted genomics approach allows the isolation of the rice Pia-blast resistance gene consisting of two adjacent NBS-LRR protein genes	2011	Plant Journal	203
7.	Jiang et al., 2010	Abscisic acid interacts antagonistically with salicylic acid signaling pathway in rice-magnaporthe grisea interaction	2010	Molecular Plant-Microbe Interactions	195
8.	Li et al., 2014	Multiple rice MicroRNAs are involved in immunity against the blast fungus Magnaporthe oryzae	2014	Plant Physiology	188
9.	Hayashi et al., 2010	Durable panicle blast-resistance gene Pb1 encodes an atypical CC-NBS-LRR protein and was generated by acquiring a promoter through local genome duplication	2010	Plant Journal	182
10.	Sharma et al., 2012	Rice blast management through host-plant resistance: retrospect and prospects	2012	Agricultural Research	179

resistance and resistance gene were the research hotspots. This clearly directed scholars for future research in this area. It was advised to use the most widely mentioned keywords, as this showed that many researchers were interested in the subject.

3.6. Global collaboration in rice blast research

Scientific collaboration was essential for advancing research, as it enabled knowledge sharing and diverse viewpoints (Beaver, 2013). In this study, whole counting was used to evaluate co-authorship networks. In the generated figure, each country was represented by a node, with the node size indicating the country's research contribution. The thickness of the connecting lines signifies the level of collaboration between nations. To refine the analysis, only countries with at least 16 publications were included. Out of 81 identified countries, 19 met this criterion. The total co-authorship link strength of these 19 countries was calculated, and those with the highest linkage were depicted in Figure 7.

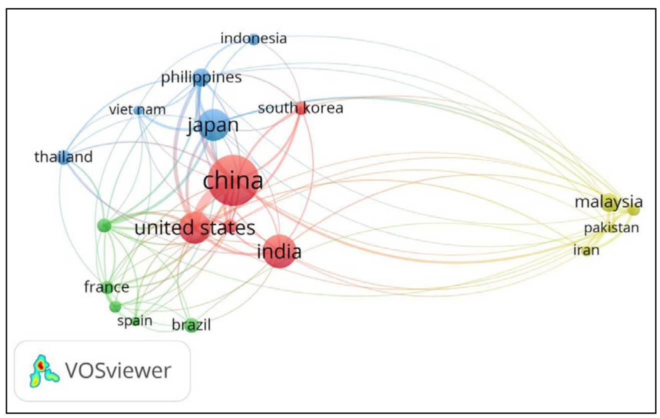

Figure 7: Co-authorship network visualization through bibliometric mapping

The software categorized these 19 countries into four distinct clusters, forming 97 connections with a total link strength of 466, as shown in Table 4. China exhibited the highest total link strength of 179, collaborating with 14 other countries. It shared the strongest research connection with the USA, followed by the Philippines and Germany,

Table 4: Top 12 Keyword search results

Sl. No.	Keyword	Frequency	TLS
1.	Rice	270	307
2.	Magnaporthe oryzae	233	262
3.	Rice blast	170	178
4.	Oryza sativa	110	153
5.	Blast	65	99
6.	Disease Resistance	77	94
7.	Blast Resistance	88	91
8.	Resistance gene	57	83
9.	Resistance	57	78
10.	Blast disease	50	68
11.	Pyricularia oryzae	60	67
12.	Marker-assisted selection	39	62
13.	Genetic diversity	28	42
14.	Magnaporthe grisea	30	41
15.	Bacterial blight	18	40
16.	Gene pyramiding	25	38
17.	Resistance genes	22	35
18.	Salicylic acid	21	35
19.	Rice blast disease	35	34
20.	Breeding	16	30

Table 5: The top 19 most participating countries

Countries	Cluster	Link	Total link strength	Documents
China	1	14	179	475
Germany	1	13	48	37
India	1	14	31	210
South Korea	1	8	26	34
U.S.A	1	15	176	188
Brazil	2	7	8	40
France	2	11	30	34
Italy	2	9	18	27
Spain	2	8	11	16
U.K	2	13	49	37
Indonesia	3	5	9	26
Japan	3	14	75	187
Phillipines	3	14	79	59
Thailand	3	8	17	41
Veitnam	3	9	18	16
Bangladesh	4	10	17	31
Iran	4	6	31	21
Malaysia	4	7	52	63
Pakisthan	4	9	28	16

while its linkage with India remained relatively weak. The United States followed closely with a total link strength of 176 across collaborations with 15 countries followed by Japan linked with 14 countries having total links strength of 75. India, with second highest number of publication on rice blast resistance was also linked with 14 countries having total links strength of 31. Out of 19, United States was having highest links (15) followed by China (14), India (14), Japan (14) and Philippines (14) whereas countries like Indonesia, Iran, Malaysia and Brazil were having less international collaboration with total links being 5, 6, 7 and 8, respectively.

4. CONCLUSION

The scientometric analysis of rice blast resistance research (2010–2021) revealed steady growth in publications, authorship, and global participation. China led in output followed by India and the USA while the USA and Japan ranked highest in citations, highlighting the importance of quality over quantity. Strong international collaborations, especially between China and the USA, enhanced research productivity. Key journals and recurring keywords reflected major research trends, emphasizing the significance of rice blast resistance in crop improvement and future research directions.

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