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Mapping of the world rice research: A bibliometric analysis of top papers during 2008–2018

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Based on the Essential Science Indicators database, this study analyzed 1225 top papers of rice research from 2008 to 2018, which include 1219 highly cited papers and 24 hot papers in the field. VOSviewer software was used to visually analyze documents. Results showed that 5100 authors belonging to 1428 organizations from 84 countries/territories authored the papers in 277 core journals. There are 10 papers that have received more than 1000 citations. Top five core journals are *Plant Cell, Plant Physiology, PNAS, Food Chemistry* and *Journal of Experimental Botany*. Top 5 countries and regions were China, USA, Japan, England and Germany. Top 5 organizations identified are Chinese Academy of Science, Chinese Academy of Agricultural Science, Huazhong Agricultual University, Nanjing Agricultural University and Zhejiang Univ.

Keywords: Bibliometric analysis; Essential Science Indicators; Rice; Top papers; VOSviewer; Web of Science.

Introduction

Rice (*Oryza sativa L.*) is the staple food for more than half of the global population, and the main staple in tropical Latin America and east, south and southeast Asia[1]. Especially in Asian countries, rice is the major cereal crop as it is well adapted to monsoon conditions with high productivity and nutritive value[2]. The rice cropping systems are of global importance in terms of food security[3].

Bibliometrics is a statistical analysis of extant literature and is used to provide quantitative analysis of publications in a given field. In recent years, bibliometrics has been broadly used as a quantitative analysis method in many scientific research fields, such as planthopper[4], rice physiology and management in China[5], water footprint research[6], wastewater irrigation[7], biomass energy and environment[8], transgenic maize[9] and so on.

Top papers in a field are hot papers and highly cited papers, based on Clarivate Analytics' Essential Science Indicators (ESI). Highly cited paper is a paper that belongs to the top 1% of papers in a research field published in a specified year. Hot paper is a paper published in the past two years that received a number of citations in the most recent two-month period that places it in the top 0.1% of papers in the same field. To provide an overview of the characteristics of research in China, a bibliometric evaluation of highly cited papers with high-level representation was conducted during the period from 1999 to 2009 based on the Essential Science Indicators (ESI) database[10]. Another paper studied the high-impact papers presented in the subject category of water resources in the Essential Science Indicators database[11].

Highly cited articles are presumably much more influential than typical articles. There are other descriptions for highly cited papers, such as, publications receiving 100 or more citations are considered as highly (or top) cited articles[12-13], and Stavropoulou et al searched the Scopus database to identify authors from the UK with very highly-cited papers, which are defined as papers with more than 1,000 citations[14].

The purpose of this paper was to use bibliometric methods to analyze 1225 top papers on rice research during 11 years period from January 1, 2008 – December 31, 2018, hoping to gain a deeper understanding on research status by analyzing their publication year, category, author, affiliations, country, journals, all keywords and other key features. Co-authorship network visualization of author, organizations and countries, co-occurrence keyword network, etc were done using VOSviewer.

Methodology

This paper is based on two main steps, namely, data collection and preprocessing, which gathers citation datasets from major online database, and bibliometric analysis based on the resulting data.

WoS and Essential Science Indicators (ESI)

Clarivate Analytics's Web of Science (WoS) is the world's leading scientific citation search and analytical information platform. It is a widely used database for carrying out bibliometric studies, with a selective coverage of the most prestigious and visible publications. Essential Science Indicators (ESI) is a unique compilation of performance statistics and trends extrapolated from counts of articles published in scholarly journals and the citations to those articles. The ESI database has been updated as of March 14, 2019, to cover an 11 year period from January 1, 2008 to December 31, 2018. Article counts for ESI are derived from 11727 journals indexed in Web of Science Core Collection (Science Citation Index Expanded and Social Sciences Citation Index only). Papers are defined as regular scientific articles and review articles. Each journal is assigned to one of 22 research fields. In ESI, a journal can be assigned to only one field.

Data collection and analysis

Bibliometrics is a set of methods to quantitatively analyze scientific and technological literature. The data for this paper consist of the top 1% most highly cited academics as listed in the Clarivate Analytics' Essential Science Indicators (ESI). A multi-level bibliometric information retrieval was performed on the Web of Science (Clarivate Analytics) website. It was completed on the single day on March 22, 2019 to avoid the bias caused by daily updating in the database. For bibliometric analysis, we first conducted a search in the Web of Science using the following query:

(TS=rice) AND (PY=2008-2018) and document types: (Article OR Review)

Then, papers were refined by top papers including highly cited papers and hot papers. Full record and cited references of the included papers were extracted and imported into VOSviewer (version 1.6.10, 2019, Leiden University, Leiden, The Netherlands) for further citation analysis.

The "analyze results" option allows ranking the records by fields according to the record count or the selected field. The following ranks were obtained: document type, language, output, subject category, journal, country, institute, source title, all keywords were all analyzed by Microsoft Excel 2010 with functions. The contribution of different countries and institutes were estimated by the location of the affiliation of at least one author of the published papers. The impact factors (IF2018) were taken from the Journal Citation Report (JCR) published in 2019.

VOSviewer

VOSviewer is a software tool for the processing of keywords and the grouping analysis used for the visualization of topographic network maps through a coincidence matrix, which allows grouping by co-authorship and by co-occurrence[15]. VOSviewer is widely used for showing maps of global scientific collaboration for advances in water use efficiency in agriculture and sustainable water use in agriculture[16-17], global research on biosimilars[18], bibliometric mapping of microbiology research topics[19], etc. Co-authorship and co-occurrence networks were visualized using VOSviewer software, which was used for visual analysis, mapping network diagram of keyword co-occurrences and co-authored authors, countries and organizations. For the network map, full counting method was used, meaning that each co-occurrence link carried the same weight. The default "association strength method" was used for normalization of the co-occurrence matrix with default values of attraction and repulsion.

Results and discussion

In the ESI database, there are 1225 top papers on rice research. A bibliometric analysis of these papers was carried out to identify the leaders in this field. ESI papers were investigated to identify trends, leading journals, institutions, and countries.

Document type and language of publication

Based on Clarivate Analytics's Web of Science, the 1225 top papers from the Web of Science Core Collection were derived from the following databases: 1218 papers from The Science Citation Index Expanded (SCIE), 35 papers from Social Science Citation Index (SSCI) and 17 papers from Conference Proceeding Citation Index Science (CPCIS), 41 papers from Book Citation Index-Science, 4 papers from Arts and humanities Citation Index, 1 paper from Book Citation Index-Social Sciences and Humanities and 1 paper from Index Chemicus.

Of the 1225 papers in the ESI database, most of them were articles (891, 72.735%), followed by reviews (334, 27.265%), book chapter (41, 3.347%)

and papers of proceedings (17, 1.388%). All of these papers were published in English.

In the 1225 top papers, there are 24 hot papers and 1219 highly cited paper which means 18 papers are both hot papers and highly cited papers. This total discounts duplicates, so that a paper that is both hot and highly cited is counted only once. Currently, the ESI database is one of the most important tools in the world to evaluate the influence of researchers, universities, academic institutions, and countries.

Publication output

With the aim of knowing the top paper research trend in rice research, a total number of 1225 publications were obtained from the online version of SCIE database between 2008 and 2018. In the following subsections, the term publication paper refers to both document types selected from WoS (articles and reviews). The publication trend is given in Fig. 1. It is seen that number of publications is increasing over the past 11years but with some fluctuations. The mean publication was 111.36 each year, and the highest for the articles published is 156 in the year 2017.

Journals and books covered by Web of Science Core Collection are assigned to at least one Web of Science category. Each Web of Science category is mapped to one research area. Each publication article indexed by the Web of Science belongs to one or more subject categories. These top papers belonged to total of 86 Web of Science subject categories in the science edition (total 254 categories) and 60 research areas (total five broad categories and 153 research areas) (Table 1). Among these Web of Science categories and research areas, the top five web of science categories include plant sciences (486 papers, 39.673% of 1225 papers), multidisciplinary sciences (154, 12.571%), environmental sciences (131, 10.694%), biochemistry molecular biology (127, 10.367%), and food science technology (93, 7.592%).

The six top research areas with more than 100 papers include plant sciences (486 papers, 39.673% of 1225 papers), science, technology other topics (200, 16.327%), agriculture (138, 11.265%), environmental sciences ecology (137, 11.184%), biochemistry molecular biology (134, 10.939%), and engineering

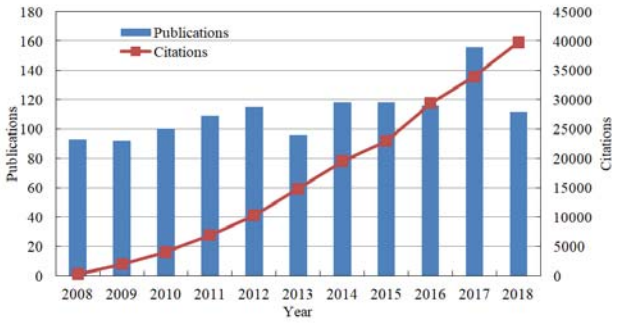

Fig. 1 — Number of top papers for rice research and citations per year from 2008 to 2018.

Table 1 — Top 20 of Web of Science categories and research areas for rice research during 2008-2018

Rank	Web of Science Categories	Total publications (%, Ratio of 1225)	Research areas	Total publications (%, Ratio of 1225)
1	Plant Sciences	486(39.673)	Plant Sciences	486(39.673)
2	Multidisciplinary Sciences	154(12.571)	Science Technology Other Topics	200(16.327)
3	Environmental Sciences	131(10.694)	Agriculture	138(11.265)
4	Biochemistry Molecular Biology	127(10.367)	Environmental Sciences Ecology	137(11.184)
5	Food Science Technology	93(7.592)	Biochemistry Molecular Biology	134(10.939)
6	Agronomy	83(6.776)	Engineering	113(9.224)
7	Energy Fuels	83(6.776)	Food Science Technology	93(7.592)
8	Cell Biology	82(6.694)	Energy Fuels	83(6.776)
9	Biotechnology Applied Microbiology	72(5.878)	Cell Biology	82(6.694)
10	Engineering Environmental	65(5.306)	Chemistry	77(6.286)
11	Engineering Chemical	56(4.571)	Biotechnology Applied Microbiology	72(5.878)
12	Chemistry Applied	53(4.327)	Nutrition Dietetics	50(4.082)
13	Nutrition Dietetics	50(4.082)	Genetics Heredity	23(1.878)
14	Green Sustainable Science Technology	41(3.347)	Microbiology	21(1.714)
15	Soil Science	36(2.939)	Meteorology Atmospheric Sciences	15(1.224)
16	Agricultural Engineering	26(2.122)	Geology	13(1.061)
17	Genetics Heredity	23(1.878)	Water Resources	12(0.980)
18	Microbiology	21(1.714)	Toxicology	11(0.898)
19	Ecology	19(1.551)	Biodiversity Conservation	10(0.816)
20	Meteorology Atmospheric Sciences	15(1.224)	Materials Science	10(0.816)

(113, 9.224%). It must be noted that journals or papers may be classified in two or more categories in the Web of Science. This shows the multidisciplinary character of this research field[20].

Core journals

The 1225 top papers were published in 277 Journals. The top 20 core journals are displayed in the Table 2 with total articles of each more than 19 papers, Journal impact factor as of IF-2018, IF-5 year and quartile rank, as per the data from the 2018 edition of Journal Citation Reports (published in 2019).

These top 20 journals have produced 588 (48%) of the 1225 top papers, and top 5, 10, 15 and 20 Journals published about 237(19.35%), 380(31.02%), 489(39.92%) and 588(48.00%) of the 1225 top papers. *Plant Cell* was the most productive journal with 58 top papers (4.735%), followed by *Plant Physiology* (53, 4.327%), *PNAS(Proceedings of The National Academy of Sciences of the United States of America)* (51, 4.163%), *Food Chemistry* (38, 3.102%) and *Journal of Experimental Botany* (37, 3.02%).

TP: total publication, Ratio of 1225 (%). IF2018 and IF 5years. QR: Quartile rank in Category. Data from the 2018 edition of Journal Citation Reports.

Based on Table 2, the top 20 journals also belong to the Q1 quartile in Category except *PloS One*. It can be concluded that there are more top papers from journals with the higher IF and higher rank in Web of Science Category, because these papers are the top 1% papers in the research field. According to this result, authors can choose their ideal journal to publish papers related to this research field. An earlier paper has stated the importance of publishing in the English language and in a journal with a high impact factor[21].

Authors co-authorship analysis

By analyzing high-impact authors, the development and research trajectories of scientific studies can be determined, and the authors' academic influence can be determined according to the number of publications and the frequency of citations[22]. Collaborations among researchers, research institutions and countries play a pivotal role in contemporary science. In general, international collaborative articles had the highest visibility and scientific impact followed by inter-institutional collaborative articles, single-country articles and single-author articles, respectively[23]. Collaboration networks are used to show how authors or institutions relate to others in the field of scientific research. The most common kind of collaboration network is co-author network.

Analyzing co-authorship information will assist in identifying groups of people who work closely together. The network of authorship in the field of

Table 2 — Top 20 journals that published more than 19 papers during period from 2008 to 2018

Rank	Journal	Records	Ratio of 1225(%)	IF2017	IF5year	QR
1	Plant Cell	58	4.735	8.631	9.848	Q1
2	Plant Physiology	53	4.327	6.305	7.024	Q1
3	Proceedings of the National Academy of Sciences of the United States of America (PNAS)	51	4.163	9.580	10.600	Q1
4	Food Chemistry	38	3.102	5.399	5.488	Q1
5	Journal of Experimental Botany	37	3.02	5.360	6.305	Q1
6	Plant Journal	33	2.694	5.726	6.467	Q1
7	Journal of Hazardous Materials	29	2.367	7.650	7.336	Q1
8	Plant Biotechnology Journal	28	2.286	6.840	6.792	Q1
9	Trends in Plant Science	28	2.286	14.006	14.017	Q1
10	Frontiers in Plant Science	25	2.041	4.106	4.855	Q1
11	Field Crops Research	22	1.796	3.868	4.683	Q1
12	Nature	22	1.796	43.070	45.819	Q1
13	New Phytologist	22	1.796	7.299	8.344	Q1
14	Renewable Sustainable Energy Reviews	22	1.796	10.556	11.239	Q1
15	Annual Review of Plant Biology	21	1.714	18.918	25.776	Q1
16	Current Opinion in Plant Biology	20	1.633	7.508	7.889	Q1
17	Plos One	20	1.633	2.776	3.337	Q2
18	Science	20	1.633	41.037	43.644	Q1
19	Scientific Reports	20	1.633	4.011	4.525	Q1
20	Nature Plants	19	1.551	13.297	13.338	Q1

rice research is shown in Figure 2, each circle represents an author, and the circle sizes indicate the number of published articles. The link connecting two circles stands for the cooperative relation between two authors, and the thickness of the link stands for the intensity of cooperation, the closer the circles, closer the collaboration. The first names of authors were reduced to initials and only authors with a minimum of 5 publications retained. Of the 5100 authors, there were 184 authors who meet the thresholds, but 3 authors are no connected to each other. This leaves 181 authors and as can be seen in Figure 2, there were 9 clusters with different colours. Authors in the same cluster usually suggested that they studied in a similar field and had close cooperation with each other.

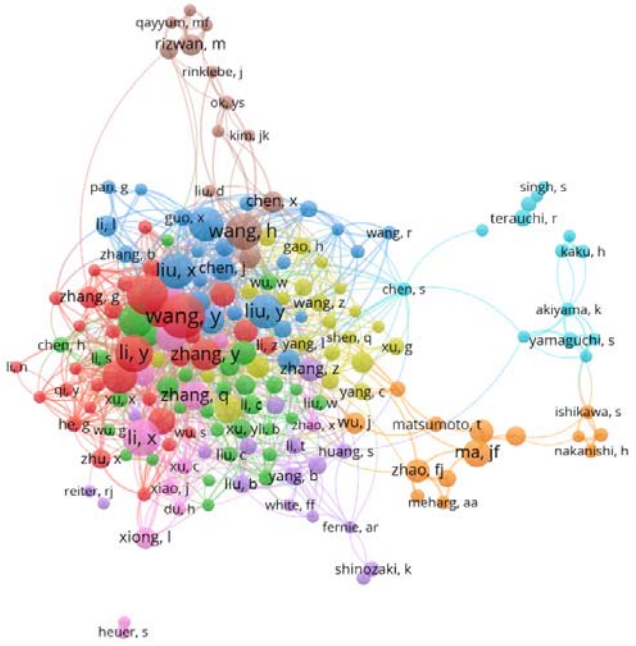

Fig. 2 — Network visualization map of top authors for rice research from 2008 to 2018.

The largest cluster consisted of 33 authors (red colour). The second cluster consisted of 31 authors (green), the third cluster consisted of 24 authors (blue), fourth consisted of 22 researchers (yellow), fifth- 17 researchers (violet), sixth- 14 researchers (shallow blue), seventh- 14 researchers (orange), eighth- 13 researchers (brown) and ninth - 13 researchers (pink). The total link strength of a node is the sum of link strengths of this node over all the other nodes. There are 1895 links and the total link strength is 2643. Table 3 show top 20 authors published more than 14 paper and total link strength, citation and average citations.

Countries/regions co-authorship analysis

The country affiliation provides information about the country in which the authors worked, within a certain research institution, at the time they were publishing their articles. Each author of an article has made an independent contribution to the manuscript[24], and therefore the country and institution the author affiliated could be considered the important contributors for the evaluation of research. There are

Table 3 — The top 20 most prolific authors for rice research top papers during period from 2008 to 2018

Rank	Author	Cluster	Documents	Total link strength	Citations	Avg. citations
1	Wang, Y	1	35	137	4696	134.2
2	Li, J	1	30	120	4379	146.0
3	Li, Y	1	27	93	3108	115.1
4	Li, X	9	26	102	3521	135.4
5	Liu, X	3	25	114	3533	141.3
6	Wang, H	8	25	117	2008	80.3
7	Zhang, H	1	23	55	2552	111.0
8	Wang, J	2	23	105	2985	129.8
9	Liu, Y	3	23	70	2285	99.3
10	Zhang, X	3	23	83	2709	117.8
11	Zhang, Y	1	20	65	2841	142.1
12	Liu, J	1	19	74	2755	145.0
13	Wang, L	9	19	68	2983	157.0
14	Zhang, Q	9	18	79	2753	152.9
15	Zhang, J	4	17	60	1129	66.4
16	Ma, Jf	7	17	25	3014	177.3
17	Wang, X	1	16	64	2301	143.8
18	Li, H	3	15	44	1314	87.6
19	Xu, J	1	14	47	997	71.2
20	Liu, L	2	14	45	1093	78.1

84 countries contributing the 1225 top papers in this study. Table 4 list the top 20 countries with more than 22 papers ranked by the number of total publications. China was identified as the largest contributor, USA was in the second place, and the third is Japan. Then other countries followed as England, Germany, Australia, France, India, Netherlands, Philippine from fourth to tenth.

Country co-authorship analysis reflects the degree of communication between countries as well as the influential countries in this field. By exploring the scientific literature of co-authorship between countries, we developed the international country co-authorship network map using VOSviewer software (Figure 3). In Figure 3, a circle represents a country/region, the size of each circle represents the number of articles of each country, denotes the activity of the country/region. A line is established when two countries/regions have a collaborative relationship. The thickness of each line reflects the

Table 4 — Top 20 countries/regions publishing top papers in the field of rice research

Rank	Countries/Regions	Cluster	Records	Total link strength	Citations	Avg. citations
1	Peoples R China	2	442	447	58450	132.2
2	USA	4	361	547	68214	189.0
3	Japan	3	153	232	24098	157.5
4	England	4	128	326	25086	196.0
5	Germany	2	124	345	23561	190.0
6	Australia	2	99	255	14460	146.1
7	France	1	81	262	12996	160.4
8	India	3	81	118	19072	235.5
9	Netherlands	6	56	157	12479	222.8
10	Philippines	3	49	108	7258	148.1
11	Canada	2	48	115	10382	216.3
12	South Korea	2	46	89	4560	99.1
13	Spain	5	45	120	6917	153.7
14	Italy	1	35	138	5227	149.3
15	Pakistan	2	34	60	4267	125.5
16	Switzerland	1	31	168	6658	214.8
17	Brazil	1	26	51	4155	159.8
18	Belgium	1	25	88	3932	157.3
19	Malaysia	2	25	16	4637	185.5
20	Scotland	3	22	86	6123	278.3

Fig. 3 — The country co-authorship network of rice research related top papers from 2008 to 2018.

tightness of cooperation and the number of collaborations between countries/regions. We set the threshold as 5, there are 45 countries/regions meeting the requirement. The VOSviewer software divides these 45 circles into 6 clusters.

Organizations co-authorship analysis

The contribution of different institutes was estimated by the institute of the affiliation of at least one author of the published papers.

Table 5 lists top 20 organizations and institutions that contributed 18 or more papers. Organization co-authorship analysis reflects the degree of communication between institutions as well as the influential institutions in this field[25]. Of the 1428 organizations, there were 157 organizations meet the thresholds of 5, but 3 organizations were not connected to each other, so, this left us with 154 organizations as shown in Figure 4. Each circle represents one organization and the size of each circle represents the number of articles of each organization. A line is established when two organizations have a collaborative relationship, the thickness of each line reflects the tightness of cooperation and the number of collaborations between organizations, the closer the circles the closer the collaboration. The VOSviewer software divided these 154 institutes into 11 clusters with 11 different colours.

Keywords co-occurrence analysis

Authors tend to list a number of keywords related to the field or subject matter most closely related to the topic addressed in their study. It is also common for reviewers and especially editors to expand such information with additional keywords obtained from databases based on the subject text in the publication[26]. Keywords provide a reasonable description of research hotspots, thus burst keywords represent research frontiers and predict emerging trends. We used all keywords both author's keywords (AK) and Keywords Plus (KP) in the evaluation[27] (Table 6). List the top 20 co-occurrence author keywords, keywords plus and all keywords in the field of rice research analyzed by VOSviewer software, there are total 3001, 5297 and 7691 keywords for author keywords, keywords plus and all keywords, respectively.

Figure 5 shows the network map of all keywords analyzed by VOSviewer software. Default parameters were used for the analyses and creation of network maps. Of the all 7691 keywords, there were only 516 keywords that were used at least 5 times. The size of the circle represents the number of articles in which each keyword appears and the colour represents the cluster in which the keyword is included based on the number of co-appearances. In general, the larger size of a circle, the more frequently the key word appears. Two words are nearer to each other if they co-occurred in the evaluated publications more frequently. There are seven main clusters that represent seven different areas of rice research.

Different colours related to different cluster of keywords such as red colour is largely related to

Table 5 — Top 20 organizations and institutes publishing top papers in the field of rice research

Rank	Organizations	Cluster	Records	Total link strength	Citations	Avg. citations	Countries
1	Chinese Acad Sci	2	139	248	21191	152.5	China
2	Chinese AcadAgr Sci	6	52	125	8537	164.2	China
3	Huazhong Agr Univ	6	50	60	6765	135.3	China
4	Nanjing Agr Univ	11	42	100	6501	154.8	China
5	Zhejiang Univ	10	40	51	4155	103.9	China
6	Univ Tokyo	1	38	80	5835	153.6	Japan
7	Int Rice Res Inst	4	38	81	5600	147.4	Philippine
8	China Agr Univ	6	35	75	7052	201.5	China
9	Natl Inst Agrobiol Sci	1	31	59	5418	174.8	Japan
10	Cornell Univ	8	29	80	8814	303.9	USA
11	Univ Chinese Acad Sci	2	27	43	1526	56.5	China
12	Univ Calif Davis	8	26	44	4557	175.3	USA
13	Okayama Univ	1	24	37	4945	206.0	Japan
14	Kansas State Univ	7	24	54	5560	231.7	USA
15	Rothamsted Res	5	23	46	5085	221.1	UK
16	Univ Minnesota	3	20	61	5502	275.1	USA
17	Wageningen Univ	5	20	39	4109	205.5	Netherlands
18	Iowa State Univ	7	19	36	4856	255.6	USA
19	Peking Univ	3	18	50	1835	101.9	China
20	Univ Agr Faisalabad	9	18	44	1203	66.8	Pakistan

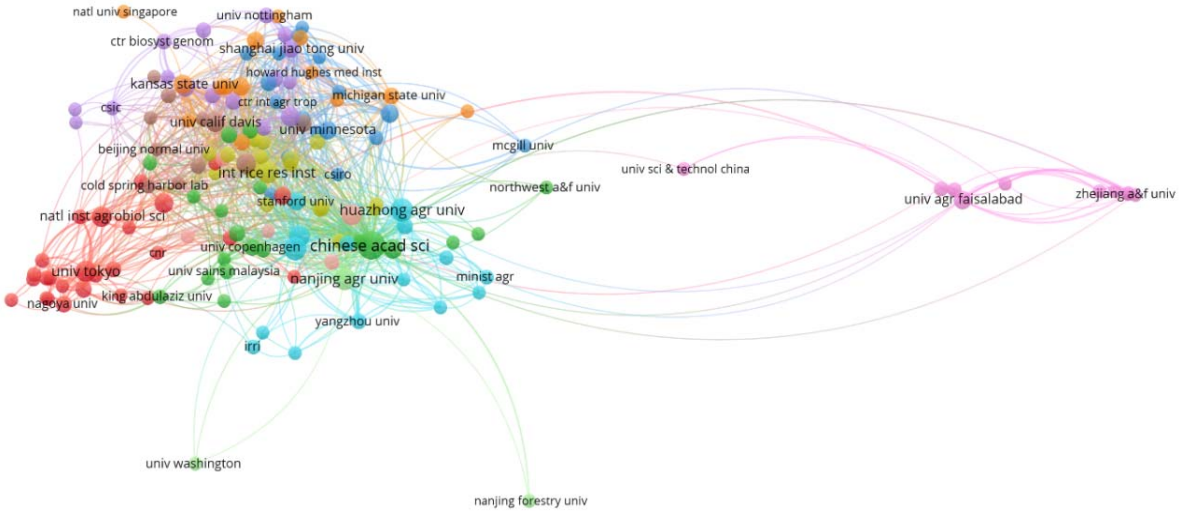

Fig. 4 — The organizations co-authorship network of rice research related publications from 2008 to 2018

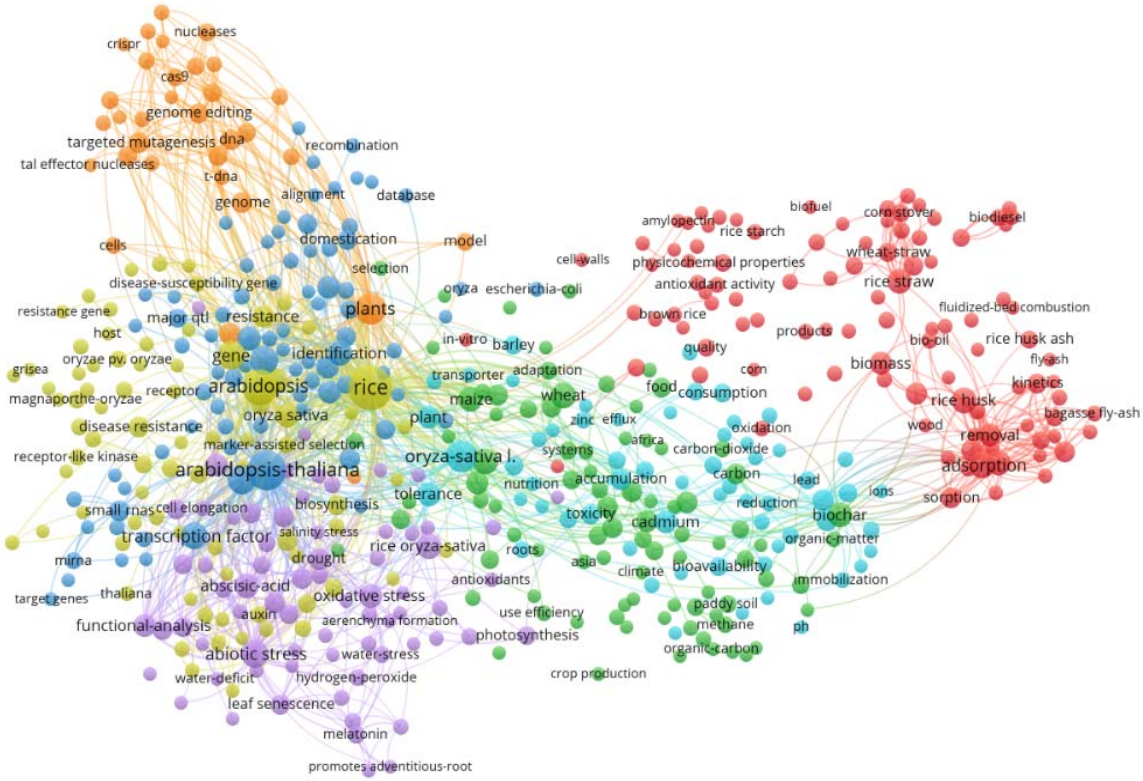

Fig. 5 — VOSviewer co-occurrence network visualization map of most frequent keywords

properties of the plant, blue colour is related to rice gene-expression, yellow on disease resistance, and so on.

The most frequently cited articles

The total citation count was obtained from Web of Science Core Collection, and this shows the total number of times that a particular article was cited by the journals listed in the SCIE database. Although a great many articles have been published, a relatively small number of individuals account for a large proportion of the citations within the period. Table 7 shows the top 10 papers that received more than 1000 times.

Table 6 — Top 20 co-occurrence author keywords, keywords plus and all keywords in the field of rice research

Rank	Author keywords	Occurrences	Keywords plus	Occurrences	All keywords	Occurrences
1	rice	100	rice	193	rice	290
2	Abiotic stress	35	arabidopsis-thaliana	186	arabidopsis-thaliana	186
3	adsorption	34	arabidopsis	111	arabidopsis	132
4	oryza sativa	34	oryza-sativa l.	87	oryza-sativa l.	87
5	biochar	33	plants	83	plants	86
6	arabidopsis	24	expression	67	expression	67
7	drought	18	gene	65	gene	66
8	genome editing	18	gene-expression	62	gene-expression	62
9	biomass	17	transcription factor	46	abiotic stress	55
10	heavy metals	16	rice ryza-sativa	45	transcription factor	51
11	maize	16	protein	41	adsorption	50
12	cadmium	15	growth	40	rice husk	45
13	climate change	15	abscisic-acid	37	wheat	45
14	grain yield	15	identification	37	riceoryza-sativa	45
15	wheat	15	rice husk	36	growth	44
16	crispr/cas9	14	activated carbon	32	maize	41
17	lignocellulosic biomass	13	oryza-sativa	30	protein	41
18	melatonin	13	wheat	30	activated carbon	40
19	photosynthesis	12	functional-analysis	28	rice straw	38
20	pyrolysis	12	Naturalvariation	28	biochar	37

Table 7 — Top 10 highly cited papers with citation more than 1000 times

Rank	Title	Authors	Journal	Publication year	Volume, Pages	Total Citations	Average per Year
1	Reactive oxygen species and antioxidant machinery in abiotic stress tolerance in crop plants	Gill, Sarvajeet Singh; Tuteja, Narendra	*Plant Physiology and Biochemistry*	2010	48 (12) 909-930	2962	296.2
2	A protocol for data exploration to avoid common statistical problems	Zuur, Alain F.; Ieno, Elena N.; Elphick, Chris S.	*Methods in Ecology and Evolution*	2010	1(1) 3-14	2016	201.6
3	The Sorghum bicolor genome and the diversification of grasses	Paterson, Andrew H.; Bowers, John E.; Bruggmann, Remy; Dubchak, Inna; et al.	*Nature*	2009	457(7229) 551-556	1446	131.45
4	AgriGO: a GO analysis toolkit for the agricultural community	Du, Zhou; Zhou, Xin; Ling, Yi; Zhang, Zhenhai; Su, Zhen	*Nucleic Acids Research*	2010	38 W64-W70	1350	135
5	Breaking the code of DNA binding specificity of TAL-type III effectors	Boch, Jens; Scholze, Heidi; Schornack, Sebastian; et al.	*Science*	2009	326(5959) 1509-1512	1284	116.73
6	Recent advances in catalytic hydrogenation of carbon dioxide	Wang, Wei; Wang, Shengping; Ma, Xinbin; Gong, Jinlong	*Chemical Society Reviews*	2011	40(7) 3703-3727	1177	130.78

(*Contd.*)

Table 7 — Top 10 highly cited papers with citation more than 1000 times (*Contd*.)

Rank	Title	Authors	Journal	Publication year	Volume, Pages	Total Citations	Average per Year
7	Biocomposites reinforced with natural fibers: 2000-2010	Faruk, Omar; Bledzki, Andrzej K.; Fink, Hans-Peter; Sain, Mohini	*Progress in Polymer Science*	2012	37(11) 1552-1596	1134	141.75
8	Climate trends and global crop production since 1980	Lobell, David B.; Schlenker, Wolfram; Costa-Roberts, Justin	*Science*	2011	333(6042) 616-620	1109	123.22
9	Efficient design and assembly of custom TALEN and other TAL effector-based constructs for DNA targeting	Cermak, Tomas; Doyle, Erin L.; Christian, Michelle; Wang, Li; Zhang, Yong; Schmidt, Clarice; et al	*Nucleic Acids Research*	2011	39(12) e82	1046	116.22
10	A simple cipher governs DNA recognition by TAL effectors	Moscou, Matthew J.; Bogdanove, Adam J.	*Science*	2009	326(5959) 1501-1501	1028	93.45

Conclusions

The Essential Science Indicators (ESI) database is widely used to evaluate institutions and researchers. The 1225 top papers include 1219 highly cited papers and 24 hot papers for rice research, all written in English, were from 5100 authors, 1428 organizations and 84 countries/territories, listed in 277 journals. There are 10 highly cited papers with citation more than 1000 times. Based on the co-authorship analysis by VOSviewer, there are cooperation for authors, organizations and countries or regions. The analysis of all keywords showed that the rice researches were separated seven clusters of the important research fronts in the fields. This study demonstrates that there are more top papers come from journals with the higher IF and higher rank Q1 in Category, because these papers are the top 1% papers of the rice research field.Therefore, authors can choose their ideal journal with a high impact factor to publish papers in the English language related to this research field.

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