

# Scientometric profile of global rice research during 1985–2014

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**A bibliometric analysis is conducted to study the history and status of rice research from 1985 to 2014. We find that the number of publications has grown rapidly over the past 30 years, especially in Asia. However, the gap of research output quality between Asian countries/regions and USA is obvious. The key-words co-occurrence analysis shows that the genetic analysis for agronomic traits is a hot topic. It could be expected that more technologies such as metabonomics and proteomics will be integrated to accelerate the comprehensive analysis of rice genome function.**

**Keywords:** Agronomic traits, bibliometric analysis, CiteSpace, rice research, scientometrics.

RICE takes the core position in grain crops<sup>1</sup>. It is a staple food providing calories for about half of the world's population<sup>2</sup>. Especially in Asian countries, rice is the major cereal crop as it is well adapted to monsoon conditions with high productivity and nutritive value<sup>3</sup>. The crop is significant for maintenance of food security. Also, rice exerts an adverse impact on climate change since it has considerable amount of CH<sub>4</sub> emission. Extensive research on rice has yielded good results. Rice yield has undergone two big leaps in the last half a century<sup>1</sup>. In particular, rice production in China has more than tripled in the past five decades, mainly due to increased grain yield rather than increased planting area<sup>4</sup>. Similarly, for India, which takes the second place in terms of rice production world over the yield has increased by 64.06% from 1985 to 2014, according to numbers from FAOSTAT. However, rapid population growth poses pressure on food production. To further increase the yield potential, several major national and international programmes have helped increase investment in rice research<sup>5,6</sup>.

Using bibliometric analysis, we can further understand the status of global rice research<sup>7</sup>. In recent years, bibliometrics has been broadly used as a quantitative analysis method in many scientific research fields such as graphene<sup>8</sup>, nanotechnology<sup>9,10</sup>, tuberculosis<sup>11</sup> and neurosciences<sup>12</sup>. With regard to agricultural research, studies have

been publications in the realm of agriculture and even crop science adopting bibliometric methods<sup>13,14</sup>.

Research on rice had a long history. The earliest rice-related literature retrieved from Science Citation Index (SCI) database was published in 1902 (ref. 15); however, bibliometric analysis of multi-disciplinary perspective on rice research is rare. There are very few related papers in the Web of Science (WoS). Morooka *et al.*<sup>3</sup> have analysed interdisciplinarity in Japanese rice research and technology development using bibliometric method. In the present study, we analyse rice-related publications which are indexed by SCI in the recent 30 years (1985–2014). Global scientific research on rice is analysed at the level of overview, subject category, journal, country/region, institution and author. We also explore the hot spots for rice research by analysing articles published in high-quality journals. These efforts will provide a blueprint of the mainstream research on rice the world over, as well as clues about relevant hot research topics.

## Data and methodology

This study aims at analysing the distribution and trend of rice research. The bibliometrics data were collected from WoS on 26 May 2015. It is necessary to note that because the attribute of natural science of rice research, only *SCI Expanded* in WoS is selected. The cultivated rice consists of two species, *Oryza sativa* L. and *Oryza glaberrima* Steud (ref. 1). Thus 'Rice', '*Oryza sativa*' and '*Oryza glaberrima*' have been used as keywords, with the query TI = (rice or '*Oryza sativa*' or '*Oryza glaberrima*'). The study covered the time-period from 1985 to 2014, while document type included only articles, and the language was restricted to English. We used title search rather than topic search to retrieve the literature, so as to control the precision of retrieval. All the downloaded data from WoS were parsed into a designed database in SQL server for analysis, specifically including publishing trend, related journals, top countries/regions, top institutions and top authors.

The transformative activity index (TAI) suggested by Guan and Ma<sup>16</sup> and developed by Garg *et al.*<sup>17</sup> was used to compare the relative change in output during three blocks, i.e. 1985–1994, 1995–2004 and 2005–2014.

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Mathematically

$$TAI = [(C_i/C_o)/(W_i/W_o)] \times 100,$$

where  $C_i$  is the publication counts of the specific country in the  $i$ th block,  $C_o$  the total publication count of the specific country during the study period,  $W_i$  the publication count of all countries in the  $i$ th block and  $W_o$  is the publication count of all the countries during the study period.

Then, aiming at further exploring the features of articles published by high-quality journals and to find out the hot topics of rice-related research, we selected 68 Nature Index journals and analysed the countries/regions, institutions and keywords of articles published in them. The list includes both multidisciplinary journals and some of the most highly selective journals within the main discipline of natural science. They represent less than 1% of the journals covering natural science in WoS, but account for close to 30% of total citations to natural science journals<sup>18</sup>. When the Nature Index journals are selected, articles published by these 68 journals from 1985 to 2014 are analysed.

CiteSpace II was used to perform the co-word analysis. This is a freely available software package used for visualizing and analysing trends and patterns in scientific literature retrieved from WoS<sup>19,20</sup>. The program makes it possible to systematically identify the developments of the specific knowledge domain<sup>21</sup>. This analysis offers researchers a comprehensive picture of the overall development of rice research.

## Results

### Publishing trend

WoS includes several types of documents like articles, reviews, letters, conference papers published as research papers, etc. among which only articles are selected in this study for analysis. A total of 38,732 rice-related articles have been indexed during the 30-year time-period. The number of publications on rice has increased rapidly over the last three decades – from 446 articles in 1985 to 3124 articles in 2014 (Figure 1 and Table 1). The average annual growth rate of publications is found to be 6.95%. The considerable increase in annual publications indicates that rice research has been receiving more attention the world over.

Figure 2 shows the annual total citations and average citations per article from 1985 to 2014. Articles in the year 2005 have the greatest total citations (39,697), while articles in 2002 have the greatest average citations per article (31.46).

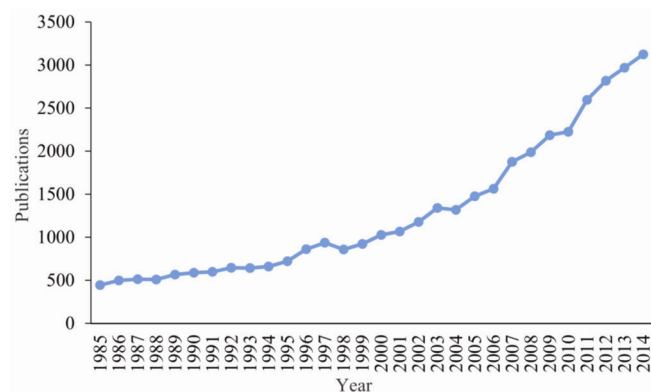
### Subject categories

Based on the subject categories defined by WoS, 38,732 articles on rice-related research have been classified into

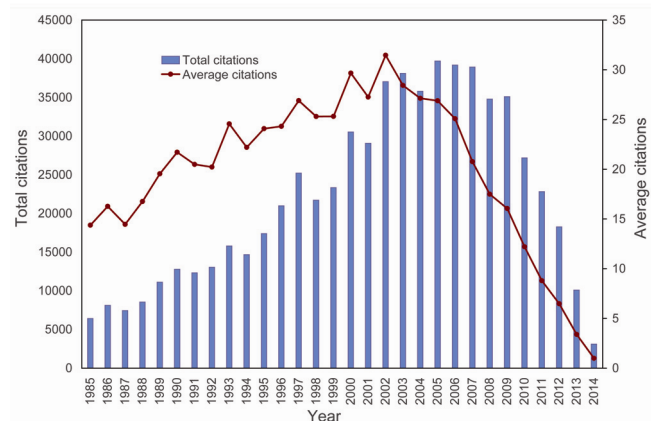
124 subject categories. The top 10 most productive subject categories and their total citations, average citations and  $h$ -index were statistically analysed (Table 2). Agriculture has the largest number of publications during the last 30 years, whereas plant sciences has the largest number of citations and highest  $h$ -index. Genetics/heredity has the highest average citation per article. From the perspective of countries/regions, all related articles are published by authors from a total number of 157 countries. For both China and Japan, plant sciences is the hottest subject. However, for USA, India and the Philippines, the largest number of publications is in the realm of agriculture.

### Related journals

The 38,732 rice-related articles are published in a wide range of 2,565 journals. The number of journals has increased from 51 in 1985 to 93 in 2014. Table 3 shows the top 10 countries/regions with respect to distribution of related journals. USA has the largest number of journals (933, 36.37%), followed by England (639, 24.91%), The Netherlands (288, 11.23%), Germany (148, 5.77%) and Japan (101, 3.94%).



**Figure 1.** Publishing trend of rice-related Science Citation Index publications, 1985–2014.



**Figure 2.** Annual total citations and average citations per article for rice-related articles, 1985–2014.

**Table 1.** Number of yearly publications and growth rate of rice-related articles, 1985–2014

Year	Articles	Growth rate (%)	Year	Articles	Growth rate (%)
1985	446	-1.76	2000	1029	11.61
1986	499	11.88	2001	1066	3.60
1987	514	3.01	2002	1177	10.41
1988	510	-0.78	2003	1340	13.85
1989	569	11.57	2004	1319	-1.57
1990	589	3.51	2005	1476	11.90
1991	601	2.04	2006	1562	5.83
1992	645	7.32	2007	1875	20.04
1993	643	-0.31	2008	1988	6.03
1994	661	2.80	2009	2186	9.96
1995	722	9.23	2010	2226	1.83
1996	863	19.53	2011	2595	16.58
1997	937	8.57	2012	2818	8.59
1998	858	-8.43	2013	2970	5.39
1999	922	7.46	2014	3126	5.25

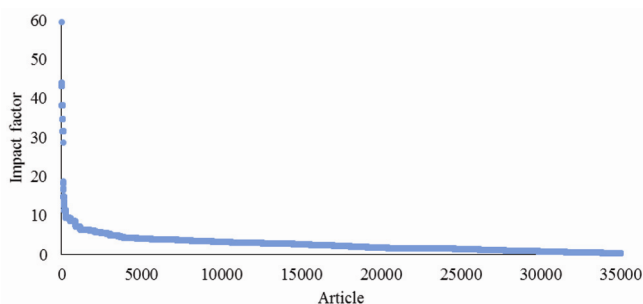
**Figure 3.** Distribution of articles with journal impact factors.

Figure 3 shows a plot of all the articles with journal impact factors. It can be seen from the figure that only a few articles are published in high-quality journals, and most articles are published in journals with low impact factor.

Table 4 shows the top 25 journals, which have the most publications. *Theoretical and Applied Genetics* ranks first with 723 (1.87%) publications, followed by *Indian Journal of Agricultural Sciences* (642, 1.66%) and *Field Crops Research* (605, 1.56%). *Theoretical and Applied Genetics* also has the most citations (30,247), and *Plant Journal* has the highest average citation per article (56.80), and *Plant Physiology* has the highest *h*-index (89).

### Top countries/regions

Table 5 shows the top 10 most productive countries/regions of rice research from 1985 to 2014, among which China has the most publications (8152, 21.05%), followed by Japan (7842, 20.25%) and USA (6318, 16.31%). USA has the highest *h*-index (154), followed by Japan (138) and China (122). USA also has the greatest number of total citations (172,062) among the top 10 most productive countries/regions. Although England is

only ranked tenth with 1030 publications, it is ranked second with respect to average citations per article. Whereas among the most productive countries in rice research, China is ranked eighth for average citations per article.

The values of TAI for different countries/regions (Table 5) suggest that the publication activity has decreased considerably for most countries/regions, including Japan, USA, India, the Philippines, England and Taiwan, China with the Philippines showing maximum decrease. For countries such as China, South Korea and Thailand, there is an increase in TAI, which indicates that there is an increase in the publication activity. It is obvious that the increase is maximum for China.

In the past 30 years, China has shown an increase in the number of articles, total citations, average citations per article and *h*-index. Meanwhile, more Asian countries/regions have taken the top 10 positions in the recent decade. Overall, the results show that Asian countries/regions are gradually playing a key role in global rice research throughout the study period.

### Top institutions

Table 6 lists the top 25 most productive institutions for rice research from 1985 to 2014, along with the number of articles, total citations, average citation per article and *h*-index. According to the results, the International Rice Research Institute (IRRI) in the Philippines ranks first with the most publications (2046, 5.28%), and total citations (59,930). Cornell University, USA has the highest average citations (67.36) and National Institute of Agrobiological Sciences in Japan has the greatest *h*-index (104). Japan has 8 out of the top 25 most productive institutions followed by China (6) and USA (5). It is consistent with our previous results (top countries/regions) that these three countries and IRRI are leading the rice-related research. Among the top 25 institutions, 20 are from Asia while 5 from USA.

**Table 2.** Number of rice-related publications categorized by both subject field and country, 1985–2014

Country/region	Subject field										Total
	Agriculture	Plant sciences	Biochemistry/ molecular biology	Food science technology	Chemistry	Biotechnology/ applied microbiology	Environmental sciences/ecology	Genetics/ heredity	Engineering	Entomology	
China	2,241	2,774	1,317	680	689	673	681	854	274	636	8,152
Japan	2,581	3,263	1,324	743	581	782	622	660	157	179	7,842
USA	2,074	1,875	709	837	624	400	398	575	143	255	6,318
India	2,768	1,252	386	512	369	388	400	294	233	218	5,863
The Philippines	1,407	826	115	91	58	110	118	218	9	53	2,289
South Korea	409	635	409	456	236	308	103	120	71	47	2,201
Australia	516	326	74	115	84	45	89	41	30	28	1,146
Thailand	319	131	61	261	158	67	67	20	118	51	1,094
Taiwan, China	202	401	122	183	168	87	64	24	88	17	1,064
England	253	349	112	72	46	91	87	82	46	47	1,030
Others	3,266	2,625	758	1,050	976	745	796	404	583	280	10,128
Total publications	12,972	11,693	4,472	4,283	3,401	3,066	2,634	2,566	1,521	1,295	38,732
Total citations	163,069	263,943	117,544	53,017	49,158	57,230	42,348	81,804	23,635	11,176	660,440
Average citations	12.57	22.57	26.28	12.38	14.45	18.69	16.08	31.88	15.54	8.63	17.05
<i>h</i> -index	113	151	125	72	76	98	78	116	65	39	195

### Top authors

Table 7 shows the top 10 prolific authors based on complete count and top 10 corresponding authors of rice-related articles from 1985 to 2014. The reason why we analyse the top corresponding authors is that they are usually the principal investigators/senior authors who provide the intellectual input, approve the protocols to be followed in the study. Since WoS does not provide accurate author address information until 2007, analysis of the top corresponding authors is based on data from 2007 to 2014. According to the analysis, authors from China and Japan are prominent in the two lists showing outstanding performance. The most prolific author is Yano, M. from the National Institute of Agrobiological Sciences Japan, with 186 publications. Wan, J. M. from the Chinese Academy of Agricultural Sciences is the most prolific corresponding author with 126 publications, who is also among the top three most prolific authors with 154 publications.

Table 8 shows the top 10 highly cited authors based on complete count from 1985 to 2014 and top 10 corresponding authors from 2007 to 2014 of rice-related articles. Authors from Japan are prominent in both the lists (five each), while China and USA account for two each. Yano, M. from the National Institute of Agrobiological Sciences Japan with 16,447 (complete count) and 5,267 (corresponding author) citations ranks first in the two lists. McCouch, S. R. from Cornell University, USA with 11,018 (complete count) and 5260 (corresponding author) citations, ranks second in the two lists. Zhang, Q. F. from Huazhong Agricultural University, China with 10,805 (complete count) and 4842 (corresponding author) citations ranks third in the two lists.

### Features of articles published by high-quality journals

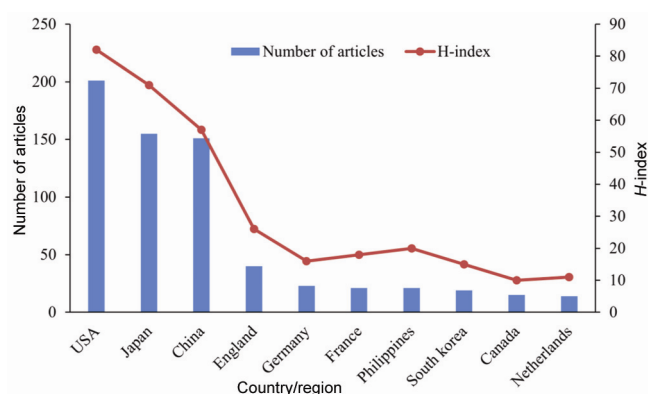
Here, we focus on the articles published by high-quality journals; so only 68 Nature Index journals were selected

**Table 3.** Distribution of rice-related journals by publishing country/region, 1985–2014

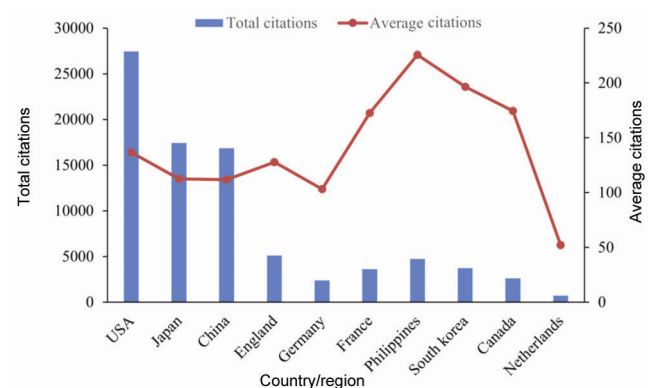
Country/region	Number of journals	Percentage
USA	933	36.37
England	639	24.91
The Netherlands	288	11.23
Germany	148	5.77
Japan	101	3.94
Switzerland	73	2.85
Thailand	72	2.81
India	66	2.57
Canada	60	2.34
China	54	2.11
Others	132	5.15
Total	2565	100

for the analysis and 511 articles published by these journals were considered. Figures 4 and 5 show the top 10 most productive countries/regions for rice research from 1985 to 2014. USA, Japan and China are the top three countries. USA has the most publications (201, 39.34%), followed by Japan (155, 30.33%) and China (151, 29.55%). USA also has the highest total citations (27,469) and *h*-index (82), while the Philippines has the highest average citation per article (225.67).

Table 9 shows the top 10 most productive institutions from 1985 to 2014. Asia has eight institutions in the list. Chinese Academy of Sciences is the most productive institution (73, 14.29%), which has the highest total citations (11,041). National Institute of Agrobiological Sciences Japan is ranked second in terms of publication count and has the highest *h*-index (41). Cornell University is ranked tenth, but has the highest average citation per article (300.05). Japan has 3 as many as 4 out of the top 10 most productive institutions. China has 3 of the top 25 institutions, USA has 2, and the Philippines has 1. Figure 6 shows the keywords co-occurrence analysis of the selected 511 articles published by Nature Index journals, using CiteSpace. The pivotal nodes in Figure 6



**Figure 4.** Number of articles of top 10 most productive countries/regions, 1985–2014.



**Figure 5.** Total citations of top 10 most productive countries/regions, 1985–2014.



**Table 5.** Distribution of rice-related articles by country/region during 3 time periods, 1985–2014

Country/region	Articles	Total citations	Average citation	<i>h</i> -index	Output in 1985–1994 (TAI)	Output in 1995–2004 (TAI)	Output in 2005–2014 (TAI)	
China	8,152	128,262	15.73	122	155 (12.90)	1,269 (58.97)	6,728 (139.97)	
Japan	7,842	168,611	21.50	138	1,298 (112.89)	2,524 (121.78)	4,020 (87.06)	
USA	6,318	172,062	27.23	154	1,258 (135.91)	1,971 (118.13)	3,089 (82.98)	
India	5,863	57,482	9.80	80	1,132 (131.56)	1,684 (108.57)	3,047 (88.33)	
The Philippines	2,289	59,335	25.92	101	578 (172.37)	803 (132.85)	908 (67.34)	
South Korea	2,201	37,607	17.09	77	45 (13.65)	445 (76.60)	1,711 (131.89)	
Australia	1,146	21,055	18.37	65	196 (116.75)	328 (108.39)	622 (92.09)	
Thailand	1,094	15,483	14.15	49	71 (43.64)	174 (60.18)	849 (131.80)	
Taiwan, China	1,064	18,328	17.23	57	151 (96.96)	323 (115.07)	590 (94.02)	
England	1,030	27,809	26.99	82	198 (121.27)	389 (139.96)	433 (76.85)	
Others	10,128	164,635	16.26	126	1,178	2,622	6,328	
Total	157	38,732	660,440	170.5	195	5,677	10,233	22,822

**Table 6.** Distribution of rice-related articles by institution, 1985–2014

Institute	Country/region	Articles	Percentage	Total citations	Average citation	<i>h</i> -index
International Rice Research Institute	The Philippines	2,046	5.28	59,930	29.29	100
Chinese Academy of Sciences	China	1,937	5.00	47,735	24.64	92
National Institute of Agrobiological Sciences	Japan	1,336	3.45	51,599	38.62	104
Zhejiang University	China	1,149	2.96	21,487	18.70	61
United States Department of Agriculture	USA	1,107	2.86	29,169	26.35	74
National Agricultural Research Center	Japan	1,090	2.81	21,751	19.96	65
University of Tokyo	Japan	973	2.51	27,775	28.55	77
Nanjing Agricultural University	China	685	1.77	9,949	14.52	43
Chinese Academy of Agricultural Sciences	China	679	1.75	11,154	16.43	49
Huazhong Agricultural University	China	621	1.60	18,693	30.10	66
Nagoya University	Japan	609	1.57	19,482	31.99	70
University of California Davis	USA	568	1.47	17,981	31.66	63
University of Arkansas Fayetteville	USA	552	1.42	9,871	16.25	41
Louisiana State University	USA	480	1.24	8,775	18.28	43
Tohoku University	Japan	471	1.22	10,497	22.29	51
Kyoto University	Japan	467	1.21	9,960	21.33	51
Council of Scientific Industrial Research	India	460	1.19	7,308	15.89	39
Indian Agricultural Research Institute	India	448	1.16	6,898	15.40	38
National Taiwan University	Taiwan, China	440	1.14	7,217	16.40	42
China Agricultural University	China	430	1.11	7,324	17.03	40
Central Rice Research Institute	India	388	1.00	2,748	7.08	24
Cornell University	USA	378	0.98	25,462	67.36	80
National Institute for Agro Environmental Sciences	Japan	370	0.95	8,279	22.38	49
Kyushu University	Japan	368	0.95	7,271	19.76	42
Seoul National University	South Korea	338	0.87	7,921	23.43	45
Others		32,570	84.10	542,335	16.65	182

include gene, protein, *Arabidopsis*, expression, plants, sequence, etc. Table 10 shows the most frequently used keywords in these 511 papers, among which gene is ranked first, followed by *Arabidopsis*, linkage map, etc. From Figure 6 and Table 10 we can see that the major goal of rice research during the past three decades has been to understand how the genome functions make the plant produce different phenotypes. Another important goal is applying these findings for genetic improvement of rice, which may also serve as a model for other crops (maize, wheat, etc.). The researches mainly focus on characterization of functional genes controlling important agronomic traits, such as yield (tiller number, grain size

and grain number), quality (grain chalkiness), abiotic resistance (drought, nutrient-use efficiency and submergence), biotic resistance (bacterial blight, blast disease and brown plant hopper), and head dating. Almost all studies published in the 68 high-quality journals covered by Nature Index focus on the natural variations of such important agronomic traits.

### Conclusion and prospect

A bibliometric analysis was conducted to study the status of rice research from 1985 to 2014. The number of rice-related publications has shown rapid growth over

## RESEARCH ARTICLES

**Table 7.** Top 10 prolific authors of rice-related articles, 1985–2014

All participated authors			Corresponding authors		
Authors	Current affiliation	Articles	Authors	Current affiliation	Articles
Yano, M.	National Institute of Agrobiological Sciences Japan	186	Wan, J. M.	Chinese Academy of Agricultural Sciences	126
Kao, C. H.	National Taiwan University	158	Kao, C.H.	National Taiwan University	92
Wan, J. M.	Chinese Academy of Agricultural Sciences	154	Komatsu, S.	National Institute of Crop Science	81
Zhang, Q. F.	Huazhong Agricultural University	144	Conrad, R.	Max Planck Institute for Terrestrial Microbiology	76
An, G.	Pohang University of Science and Technology	142	Takaiwa, F.	National Institute of Agrobiological Sciences Japan	75
Matsuoka, M.	Nagoya University	127	Siebenmorgen, T. J.	University of Arkansas	68
Qian, Q.	Chinese Academy of Agricultural Sciences	126	Fageria, N.K.	Embrapa, National Rice and Bean Research Center Brazil	67
Takaiwa, F.	National Institute of Agrobiological Sciences Japan	125	Zhang, Q.F.	Huazhong Agricultural University	65
Siebenmorgen, T. J.	University of Arkansas	123	Matsuoka, M.	Nagoya University	58
McCouch, S. R.	Cornell University	114	Wu, P.	Zhengjiang University	57

**Table 8.** Top 10 highly cited authors of rice-related articles, 1985–2014

All participated authors			Corresponding authors		
Authors	Current affiliation	Articles	Authors	Current affiliation	Articles
Yano, M.	National Institute of Agrobiological Sciences Japan	16,447	Yano, M.	National Institute of Agrobiological Sciences Japan	5,267
McCouch, S. R.	Cornell University	11,018	McCouch, S. R.	Cornell University	5,260
Zhang, Q. F.	Huazhong Agricultural University	10,805	Zhang, Q. F.	Huazhong Agricultural University	4,842
Sasaki, T.	National Institute of Agrobiological Sciences Japan	10,490	Matsuoka, M.	Nagoya University	4,605
Shimamoto, K.	Nara Institute of Science Technology	8,635	Shimamoto, K.	Nara Institute of Science Technology	4,202
Matsuoka, M.	Nagoya University	8,428	Conrad, R.	Max Planck Institute for Terrestrial Microbiology	3,841
Hirochika, H.	Nara Institute of Science Technology	7,897	Sasaki, T.	National Institute of Agrobiological Sciences Japan	2,991
An, G.	Pohang University of Science Technology	6,723	Meharg, A. A.	University of Aberdeen	2,741
Khush, G. S.	University of California Davis	6,394	Xiong, L. Z.	Huazhong Agricultural University	2,611
Qian, Q.	Chinese Academy of Agricultural Sciences	5,338	Takaiwa, F.	National Institute of Agrobiological Sciences Japan	2,352

**Table 9.** Top 10 most productive institutions for rice-related articles published in Nature Index journals, 1985–2014

Institution	Country/region	Articles	Percentage	Total citations	Average citation	<i>h</i> -index
Chinese Academy of Sciences	China	73	14.29	11,041	151.25	40
National Institute of Agrobiological Sciences	Japan	59	11.74	9,802	163.37	41
University of Tokyo	Japan	41	8.02	3,653	89.10	32
Nagoya University	Japan	31	6.07	2,808	90.58	27
Huazhong Agricultural University	China	28	5.48	3,613	129.04	21
Nara Institute of Science Technology	Japan	21	4.11	3,150	150.00	20
International Rice Research Institute	The Philippines	20	3.91	4,775	238.75	19
Chinese Academy of Agricultural Sciences	China	19	3.72	1,662	87.47	15
University of Georgia	USA	19	3.72	2,174	114.42	17
Cornell University	USA	18	3.52	5,409	300.50	16

the past 30 years, with Asian countries/regions, especially China showing maximum growth. China has published the most rice-related articles. However, the gap between Asian countries/regions and the USA is obvious considering the overall quality of publications. We have identified prolific authors as well as highly cited authors. USA,

Japan and China are the top three countries with most publications. Keywords co-occurrence analysis of the articles published by the Nature Index journals shows that genetic analysis for agronomic traits is the hot topic in rice research. It could be expected that more technologies such as metabonomics, proteomics, and phenomics will be



**Table 10.** The most frequently used keywords of rice-related articles published in Nature Index journals, 1985–2014

Frequency	Keywords	Frequency	Keywords
100	Gene	17	Transformation
80	<i>Arabidopsis</i>	16	Messenger-RNA
76	Linkage map	15	Biosynthesis
74	Plant	14	Wheat
65	Expression	12	Disease resistance
59	Protein	12	Family
49	<i>Oryza sativa</i>	12	Natural variation
47	Maize	12	Cultivated rice
44	Sequence	12	<i>Magnaporthe-grisea</i>
41	Evolution	11	Cell-death
35	Identification	11	Yeast
34	<i>Anigozanthos-preissii</i>	11	Cloning
30	Genome	11	Accumulation
29	Gene-expression	11	Domestication
25	Draft sequence	11	Transposable elements
20	Encodes	11	DNA methylation
20	<i>Saccharomyces-cerevisiae</i>	11	Abscisic-acid
19	Quantitative trait locus	11	Signal-transduction
18	Resistance	10	Diversity
18	Growth	10	Electronic-structure

integrated to accelerate the comprehensive analysis of rice genome function, so as to better apply the same to genetic analysis for agronomic traits of crops in the future. The results of this study can also be used as a reference for other plants as well.

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