Mapping the scientific research on maize or corn: a bibliometric analysis of top papers during 2008–2018

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Keywords: *Bibliometric analysis; Essential Science Indicators (ESI); Maize; Corn; Top papers; VOSviewer.*

Abstract

Based on the Essential Science Indicators (ESI) database, this study analyzed 966 top papers of maize and corn research from 2008 to 2018, which include 964 highly cited papers and 15 hot papers in the field. Results showed that all papers written in English, were from 4,353 authors, 1,287 organizations and 84 countries/territories, listed in 290 core journals. Top 5 core journals with higher impact factor ranked as *Plant Physiology, PNAS, Plant Cell, Food Chemistry and Bioresource Technology*. Top six countries and regions were USA, Peoples R China, Germany, France, Australia, England. Top 5 organizations were Cornell Univ, Chinese Acad Sci, Univ Minnesota, Iowa State Univ, Univ Wisconsin. Based on the analysis of network map of VOSviewer, was highlighted cooperation for authors, organizations and countries or regions. The analysis of all keywords showed that maize or corn research was separated six clusters. In addition, this study demonstrates that there are more top papers come from journals with the higher IF and higher rank in WoS Category. So, authors can choose their ideal journal with a high impact factor or Q1 in Category to publish their papers in the English language related to their research field.

Abbreviations

ESI: Essential Science Indicators; IF: Impact Factor;JCR: Journal Citation Report; PY: Public year; *PNAS (Proceedings of The National Academy of Sciences of the United States of America)*; QR: Quartile Rank in Category; SCIE: Science Citation Index-Expanded; TP: total publication; TS:Topic; WoS: Web of Science.

Introduction

Maize (*Zea mays* L.) was originally domesticated in Mexico 7000-10,000 years ago and the country also hosts the world's richest diversity of maize varieties (Juárez-Hernández et al., 2019). Nowadays, maize is an important cereal crop all over the world and has been recently ranked at first among all cereal crops (Shafiq et al., 2019). In recent years, bibliometrics has been broadly used as a quantitative analysis method in many scientific research fields, such as planthopper (Hu and Cao, 2018), water footprint research (Zhang et al., 2017), wastewater irrigation (Maassen, 2016), biomass energy and environment (Mao et al., 2018), transgenic maize (Li et al., 2018), green and sustainable science and technology(Yuan and Sun, 2019), water resources (Sun and Yuan, 2020). Using bibliometric analysis, we can further understand the status of global maizeor corn research.

Based on Clarivate Analytics' ESI, top papers are the sum of hot papers and highly cited papers. 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. There are other description for highly cited papers, such as, publications receiving 100 or more citations are considered as highly (or top) cited articles (Elangoand Ho, 2017, 2018; Ivanović and Ho, 2019), and Stavropoulou et al. (2019) searched the Scopus database to identify authors from the UK with extremely highly-cited papers, which are defined as papers with more than 1,000 citations.

The purpose of this paper was to use bibliometric methods to analyze 966 top papers on maize or corn research status during 11 years period from 2008 to 2018. Co-authorship network visualization of author, organizations and countries, co-occurrence network visualization of all keywords were done by VOSviewer.

Data and methodology

WoS and ESI

Clarivate Analytics's WoS is the world's leading scientific citation search and analytical information platform.

ESI is an unique compilation of performance statistics and trends extrapolated from counts of articles published in scholarly journals and the citations to those articles. In this paper, 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. 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

The data for this paper consist of the top 1 % papers as listed in the Clarivate Analytics' ESI.It was completed on the single day on April15, 2019 to avoid the bias caused by daily updating open database.

We first conducted a search in the WoS using the following query:

(TS=Maize or Corn) and (PY=2008-2018)and document types: Article or Review.

Then, we refined papers 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 1.6.11, 2019, Leiden University, Leiden, The Netherlands) for further citation analysis.

The following ranks were obtained: document type, language, output, subject category, journal, country, institute, source title, all keywords were all analyzed. The contribution of different countries and institutes was estimated by the location of the affiliation of at least one author of the published papers. The impact factors (IF2017 and IF5 year) were taken from the Journal Citation Report (JCR) published in 2018, which had the latest data available.

VOSviewer

VOSviewer is a software tool for the processing of keywords and the grouping analysis used for the visualization of network maps through a coincidence matrix, which allows grouping by co-authorship and by co-occurrence (Van Eck and Waltman, 2010). VOSviewer is widely used for showing maps of global scientific collaboration, such as, advances in water use efficiency in agriculture and sustainable water use in agriculture (Velasco-Muñoz et al., 2018a, 2018b), global research on biosimilars (Hernández-Vásquez, et al., 2018), bibliometric mapping of microbiology research topics (Dehdarirad et al., 2019), bibliometric analysis of research on the trends in autophagy (Hong et al, 2019), bibliometric analysis of research on the role of intestinal microbiota in obesity (Yao et al, 2018), bibliometric and mapping of top papers inthe subject category ofgreen and sustainable science and technology (Yuan and Sun, 2019), mapping of top papers in the subject category of water resources(Sun and Yuan, 2020). 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.

Maize research mapping analysis

Document type and language of publication

Of the 966 papers in the ESI database, most of them were articles (680,70.393%), followed by reviews (286,29.607%), proceedings paper (25, 2.588%) and book chapter (20, 2.07%). All of these papers were published in English.In the frame of the 966 top papers, there are 15 hot papers and 964 highly cited paper that means 13 papers are both hot papers and highly cited papers.

Publication Output

With the aim of knowing the top paper research trend in maize or corn research, a total number of 966 publications were obtained from the online version of SCIE database between 2008 and 2018. The publication trend was displayed in the Figure 1. The annual number of publications fluctuated over the 11years. The mean publication was 87.82 each year, and the highest for the articles published is 100 in the year 2011. Total citations were power increased from 2008 to 2018.

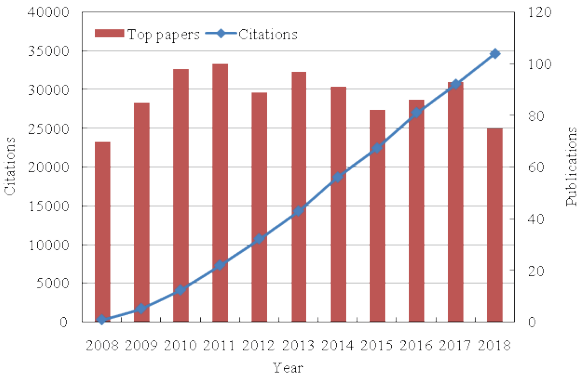

Fig. 1 - Number of top papers and citations for maize or corn research per year from 2008 to 2018.

WoS Categories and research areas

Each article indexed by the WoS belongs to one or more subject categories. These top papers are belonging to total of 92 WoS subject categories and 66 research areas (Table1). Among these, the five top categories include Plant Sciences (236 papers,24.431% of 966papers), Food Science Technology (116, 12.008%),

Energy Fuels(111,11.491%), Agronomy (108,11.18%) and Multidisciplinary Sciences (102, 10.559%). The six top research areas include Plant Sciences (236 papers, 24.431% of 966 papers), Agriculture (224, 23.188%), Science Technology other Topics (150, 15.528%), Food Science Technology (116,12.008%), Energy Fuels (111, 11.491%) and Environmental Sciences Ecology (100, 10.352%). Journals or papers may be classified in two or more categories in the WoS, shows the multidisciplinary character of this research field (Elango and Ho, 2018).

Table 1 - Top 15 WoS Categories and research areas for maize or corn research top papers during 2008-2018.

Rank	Web of Science Categories	Total publications (%, Ratio of 966)	Research areas	Total publications (%, Ratio of 966)
1	Plant Sciences	236 (24.431)	Plant Sciences	236 (24.431)
2	Food Science Technology	116 (12.008)	Agriculture	224(23.188)
3	Energy Fuels	111 (11.491)	Science Technology Other Topics	150(15.528)
4	Agronomy	108 (11.18)	Food Science Technology	116(12.008)
5	Multidisciplinary Sciences	102 (10.559)	Energy Fuels	111(11.491)
6	Environmental Sciences	88 (9.11)	Environmental Sciences Ecology	100(10.352)
7	Biotechnology Applied Microbiology	75 (7.764)	Chemistry	89(9.213)
8	Chemistry Applied	60(6.211)	Biotechnology Applied Microbiology	75(7.764)
9	Nutrition Dietetics	54(5.59)	Engineering	63(6.522)
10	Biochemistry Molecular Biology	53(5.487)	Biochemistry Molecular Biology	60(6.211)
11	Soil Science	52(5.383)	Nutrition Dietetics	54(5.59)
12	Green Sustainable Science Technology	45(4.658)	Cell Biology	32(3.313)
13	Agricultural Engineering	37(3.83)	Entomology	27(2.795)
14	Engineering Chemical	36(3.727)	Meteorology Atmospheric Sciences	26(2.692)
15	Cell Biology	32(3.313)	Genetics Heredity	23(2.381)

Core Journals

All the 966 top papers were published in 290 Journals. The top 24 core journals were displayed in the Table 2 with total articles each more than 10 papers, Journal IF2017 and IF5 year, QR,as the data from the 2017 edition of JCR. These top 24 journals have produced 407 (42.13%) literature on the total of 966 top papers. *Plant Physiology* was the most productive journal with 41top papers (4.244%), followed by PNAS (*Proceedings of The National Academy of Sciences of the United States of America*) (35,3.623%), Plant Cell (27,2.795%), Food Chemistry (25,2.588%) and Bioresource Technology (24, 2.484%).

Based on Table 2, the top 24 Journal are higher IF2017 and IF5 years, also belong to the Q1 in Category, excluded Agronomy Journal and Crop Science. It can conclude that there are more top papers come from journals with the higher IF and higher QR in WoS Category. According to this result, authors can choose their ideal journal to publish papers related to this research field. We have also demonstrated the importance of publishing in the English language and in a journal with a high impact factor (White-Gibson et al., 2019).

Authors co-authorship analysis

Internationally collaborative articles had the highest visibility and scientific impact followed by inter-institutional collaborative articles, single-country articles and single-author articles, respectively(Wambu and Ho, 2016). The network visualization of authorship in the field of maize or corn 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 the closer the collaboration. Reduce first names of authors to initials, authors with a minimum productivity of 5 publications were as thresholds. Of the 4,353 authors, there were 60 authors meet the thresholds, but 7 authors no connected to each other, so, left 53 authors in Figure 2, there were 9 clusters with different colors, authors in the same cluster usually suggested that they studied in a similar field and had close cooperation with each other.

Largest cluster consisted of 10 authors (red color). The second to ninth cluster consisted of 8 (green),7 (blue), 6 (yellow), 6 (violet), 5 (shallow blue), 5 (orange), 4 (brown), and 2 researchers (pink), respectively. The total link strength of a node is the sum of link strengths of this node over all the other nodes. Table 3 show top 11 authors published more than 9 paper and total link strength, citation and average citations.

Countries/regions co-authorship analysis

There are 84 countries contributing the 966 top papers in this study, Table 4 list the top 20 countries with more

Table 2 - Top 24 Journals published maize or corn research more than 10 papers during period from 2008 to 2018.

Rank	Journal	Records	Ratio of 966(%)	IF2017	IF5year	QR
1	Plant Physiology	41	4.244	5.949	6.62	Q1
2	Proceedings of the National Academy of Sciences of the United States of America	35	3.623	9.504	10.359	Q1
3	Plant Cell	27	2.795	8.228	9.378	Q1
4	Food Chemistry	25	2.588	4.946	4.879	Q1
5	Bioresource Technology	24	2.484	5.807	5.978	Q1
6	Renewable Sustainable Energy Reviews	22	2.277	9.184	10.093	Q1
7	Plos One	18	1.863	2.766	3.352	Q1
8	Journal of Experimental Botany	17	1.76	5.354	6.044	Q1
9	Science	17	1.76	41.058	40.627	Q1
10	Field Crops Research	16	1.656	3.127	3.967	Q1
11	Journal of Agricultural and Food Chemistry	16	1.656	3.412	3.791	Q1
12	Nature	15	1.553	41.577	44.959	Q1
13	Annual Review of Plant Biology	14	1.449	18.712	24.679	Q1
14	Global Change Biology	13	1.346	8.997	9.791	Q1
15	Food Hydrocolloids	12	1.242	5.089	5.501	Q1
16	New Phytologist	12	1.242	7.433	7.833	Q1
17	Plant and Soil	12	1.242	3.306	3.77	Q1
18	Agricultural and Forest Meteorology	11	1.139	4.039	5.035	Q1
19	Agronomy Journal	10	1.035	1.897	1.985	Q2
20	Crop Science	10	1.035	1.635	1.852	Q2
21	Nature Communications	10	1.035	12.353	13.691	Q1
22	Plant Biotechnology Journal	10	1.035	6.305	6.107	Q1
23	Plant Journal	10	1.035	5.775	6.101	Q1
24	Soil Biology Biochemistry	10	1.035	4.926	5.419	Q1

TP: total publication, Ratio of 966 (%). IF2017 and IF 5 years. QR:Quartile rank in Category. Data from the 2017 edition of Journal Citation Reports.

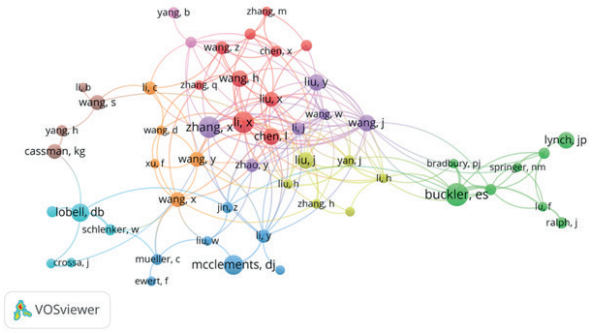

Fig. 2 - Network visualization map of top authors for maize or corn research from 2008 to 2018. Cooperation based on co-authorship between authors. Reduce first names of authors to initials, network visualization map of authors with minimum productivity of 5 publications in the studied field and exist within a collaborative research group. The author co-authorship network map with 53 nodes and 9 clusters, the bigger nodes represented the more maize or corn papers in this field. The distance and thickness of links represented the degree of cooperation among authors.

than 20 papers ranked by the number of total publications. USA was identified as the largest contributor, China was in the second place, and the third is Germany. Then other countries followed as France, Australia, England, Netherlands, Canada, India and Switzerland from fourth to tenth.

Figure 3 shows the country co-authorship network of maize or corn research related top papers from 2008 to 2018. 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 the each line reflects the tightness of cooperation and the number of collaborations between countries/regions.

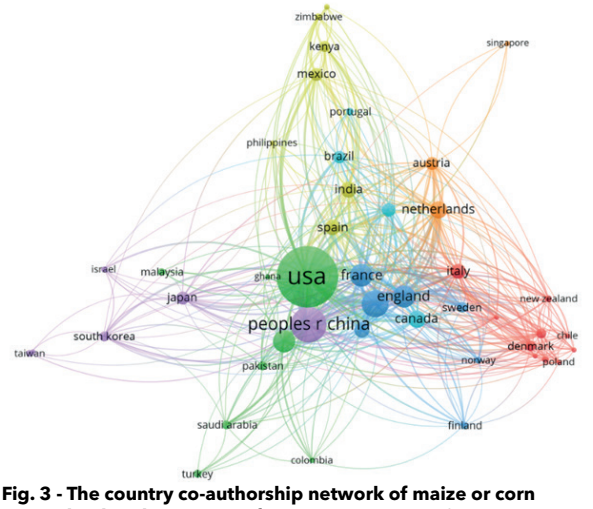

Fig. 3 - The country co-authorship network of maize or corn research related top papers from 2008 to 2018. The country co-authorship network map with 45 nodes and 7 clusters, the bigger-nodes represented the more influential countries in this field. The distance and thickness of links representedthe degree of cooperation among countries.

Table 3 - The top 11 most prolific authors for maize or corn research top papers.

Rank	Author	Cluster	Documents	Total link strength	Citations	Avg. citations
1	Buckler, ES	2	13	18	5848	449.8
2	Li, X	1	12	23	1600	133.3
3	Zhang, X	5	12	17	1248	104.0
4	Mcclements, DJ	3	11	3	1121	101.9
5	Lobell, DB	6	10	8	3608	360.8
6	Chen, L	1	9	18	1024	113.8
7	Wang, H	1	9	8	848	94.2
8	Lynch, JP	2	9	1	1236	137.3
9	Liu, J	4	9	15	1022	113.6
10	Liu, Y	5	9	16	912	101.3
11	Wang, J	5	9	25	1275	141.7

The threshold was set as 5, there are 45 countries/regions meeting the requirement, and these 45 circles were divided into 7 clusters. The different colors group,

Table 4 -Top 20 countries/regions publishing top papers in the field of maize or corn research.

Rank	Countries/ Regions	Cluster	Records	Total link strength	Citations	Avg. citations
1	USA	2	484	446	96639	199.7
2	Peoples R China	5	182	230	24116	132.5
3	Germany	3	111	247	18238	164.3
4	France	3	81	208	16819	207.6
5	Australia	2	76	129	14779	194.5
6	England	3	76	197	13305	175.1
7	Netherlands	7	50	157	9875	197.5
8	Canada	6	49	71	8661	176.8
9	India	4	42	79	9594	228.4
10	Switzerland	3	40	125	8687	217.2
11	Spain	4	39	119	9078	232.8
12	Italy	1	37	107	7537	203.7
13	Belgium	6	33	72	3951	119.7
14	Japan	5	30	70	4238	141.3
15	Austria	7	29	80	5160	177.9
16	Mexico	4	29	76	4399	151.7
17	Brazil	6	27	47	3000	111.1
18	Kenya	4	22	51	2323	105.6
19	Sweden	3	21	59	5840	278.1
20	Denmark	1	20	47	5490	274.5

Table 5 - Top 20 Organizations and institutes publishing top papers in the field of maize or corn research.

Rank	Organizations	Cluster	Records	Total link strength	Citations	Avg. citations	Countries
1	Cornell Univ	3	42	123	15934	379.4	USA
2	Chinese Acad Sci	7	40	93	7018	175.5	China
3	Univ Minnesota	3	39	130	8537	218.9	USA
4	Iowa State Univ	3	36	71	9089	252.5	USA
5	Univ Wisconsin	3	35	84	9155	261.6	USA
6	ARS	2	34	67	7449	219.1	USA
7	China Agr Univ	7	29	54	3863	133.2	China
8	USDA ARS	4	29	91	5431	187.3	USA
9	INRA	1	28	68	5268	188.1	France
10	Univ Nebraska	5	28	63	4852	173.3	USA
11	Michigan State Univ	3	27	82	7498	277.7	USA
12	Univ Illinois	2	25	66	5830	233.2	USA
13	Penn State Univ	1	24	59	3049	127.0	USA
14	Purdue Univ	2	24	84	7552	314.7	USA
15	Univ Calif Davis	1	24	53	5737	239.0	USA
16	Stanford Univ	5	21	58	7083	337.3	USA
17	Univ Queensland	2	19	26	2373	124.9	Australia
18	Chinese AcadAgr Sci	7	18	59	4412	245.1	China
19	Huazhong Agr Univ	7	18	27	2513	139.6	China
20	Univ Calif Berkeley	3	18	54	7406	411.4	USA

the different clusters formed by sets of countries.

As we can see from Figure 3, USA, China and Germany are the biggest nodes. The first cluster consisted of 10 countries (red color), Italy, Denmark, Scotland, New Zealand, Ireland, Chile, Poland, Slovakia, Argentina, Russia.The second cluster consisted of 8 countries (green), USA, Australia, Pakistan, Saudi Arabia, Turkey, Malaysia, Colombia, Ghana. The third cluster consisted of 7 countries (blue), Germany, France, England, Switzerland, Sweden, Finland, Norway. The fourth cluster consisted of 7countries (yellow), India, Spain, Mexico, Kenya, Zimbabwe, South Africa, Philippines. The fifth cluster consisted of 6 countries (violet), Peoples R China, Japan, South Korea, Taiwan, Israel, Hungary. The sixth cluster consisted of 4 countries (shallow blue), Canada, Belgium, Brazil, Portugal.The seventh cluster

Table 6 - Top 12 highly cited papers with total citations more than 1000 times.

Rank	Title	Authors	Source Title	Publication year	Volume, Pages	Total Citations	Average per Year
1	Mechanisms of salinity tolerance	Munns, Rana; Tester, Mark	Annual Review of Plant Biology	2008	59: 651-681	3919	326.58
2	Use of US croplands for biofuels increases greenhouse gases through emissions from land-use change	Searchinger, Timothy; Heimlich, Ralph; Houghton, R. A.; Dong, Fengxia; Elobeid, Amani; Fabiosa, Jacinto; Tokgoz, Simla; Hayes, Dermot; Yu, Tun-Hsiang	Science	2008	319(5867): 1238-1240	2465	205.42
3	The B73 Maize Genome: Complexity, Diversity, and Dynamics	Schnable, Patrick S.; Ware, Doreen; Fulton, Robert S.; Stein, Joshua C.; et al	Science	2009	326(5956): 1112-1115	1981	180.09
4	A Robust, Simple Genotyping-by-Sequencing (GBS) Approach for High Diversity Species	Elshire, Robert J.; Glaubitz, Jeffrey C.; Sun, Qi; Poland, Jesse A.; Kawamoto, Ken; Buckler, Edward S.; Mitchell, Sharon E.	Plos One	2011	6(5): e19379	1956	217.33
5	Biofuels from microalgae-A review of technologies for production, processing, and extractions of biofuels and co-products	Brennan, Liam; Owende, Philip	Renewable & Sustainable Energy Reviews	2010	14(2): 557-577	1859	185.9
6	Pretreatments to enhance the digestibility of lignocellulosic biomass	Hendriks, A. T. W. M.; Zeeman, G.	Bioresource Technology	2009	100(1): 10-18	1825	165.91
7	Pretreatment technologies for an efficient bioethanol production process based on enzymatic hydrolysis: A review	Alvira, P.; Tomas-Pejo, E.; Ballesteros, M.; Negro, M. J.	Bioresource Technology	2010	101(13):SI 4851-4861	1815	181.5
8	Methods for Pretreatment of Lignocellulosic Biomass for Efficient Hydrolysis and Biofuel Production	Kumar, Parveen; Barrett, Diane M.; Delwiche, Michael J.; Stroeve, Pieter	Industrial & Engineering Chemistry Research	2009	48(8): 3713-3729	1615	146.82
9	DNA methylation landscapes: provocative insights from epigenomics	Suzuki, Miho M.; Bird, Adrian	Nature Reviews Genetics	2008	9(6): 465-476	1529	127.42
10	The Sorghum bicolor genome and the diversification of grasses	Paterson, Andrew H.; Bowers, John E.; Bruggmann, Remy; et al	Nature	2009	457(7229):551-556	1446	131.45
11	Software News and Update MOLCAS 7: The Next Generation	Aquilante, Francesco; De Vico, Luca; Ferre, Nicolas; Ghigo, Giovanni; et al	Journal of Computational Chemistry	2010	31(1): 224-247	1213	121.3
12	Climate Trends and Global Crop Production Since 1980	Lobell, David B.; Schlenker, Wolfram; Costa-Roberts, Justin	Science	2011	333(6042): 616-620	1112	123.56

consisted of 3 countries (orange), Netherlands, Austria, Singapore. Therefore, geographical location is an important factor that determines international cooperation, increasing international exchanges have promoted academic communications.

Organizationsco-authorship analysis

Organization co-authorship analysis reflects the degree of communication between institutions as well as the influential institutions in this field (Reyes-Gonzalez, 2016). 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 the results for the top 20 organizations and institutions that the publications were above 18 papers ranked by the number of total publications. There are 14 organizations are in USA, 4 in China. Australia and Franceeach has one organization.

Of the 1,287 organizations, there were 107 organizations meet the thresholds of 5, but 1 organizations no connected to each other, so, left 106 organizations in Figure 4, each circle represents one organizations, the size of each circle represents the number of articles of each organization, denotes the activity of the organiza-

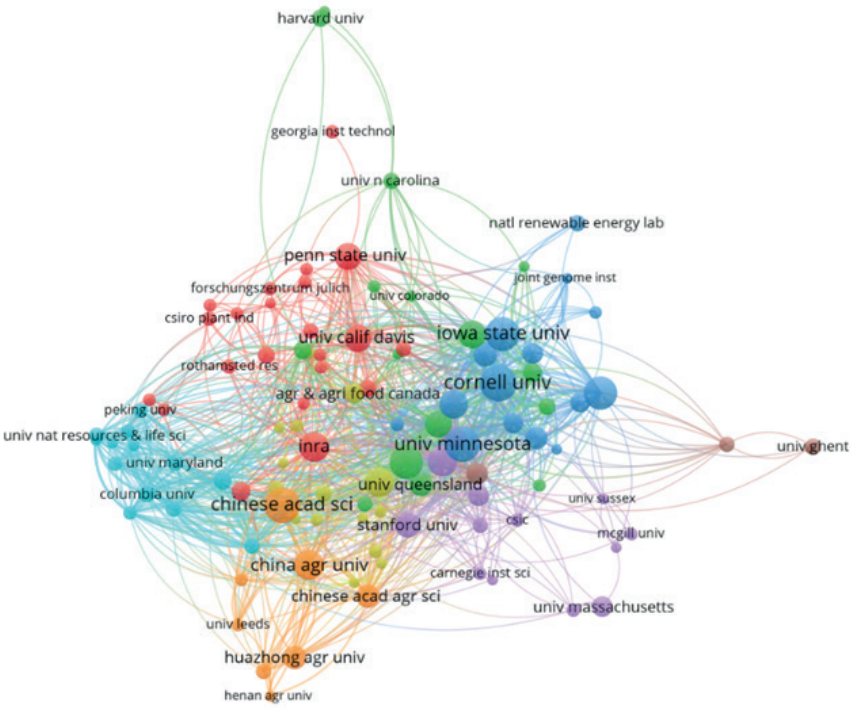

Fig. 4 - The organizations co-authorship network of maize or corn research related publications from 2008 to 2018. The institutions co-authorship network map with 106 nodes and 8 clusters, the bigger nodes represented the more influential institution in this field. The distance and thickness of links represented the degree of cooperation among organizations

tion. A line is established when two organizations have a collaborative relationship, the thickness of the 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 106 institutes into 8 clusters with different colors.

Keywords co-occurrence analysis

Of the all 7,034 keywords,there were only 376 keywords meet the threshold more than 5 times included in the map (Figure 5). The size of the circle represents the number of articles in which each keyword appears and the color 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. And a small distance between two keywords represent that a large number of co-occurrences of the keywords. There are six main clusters that represent six different viewpoints on maize or corn research.

The first cluster (red) is focused on maize or corn metabolism, including keyword terms as United-States, fructose corn syrup, digestibility, performance, metabolic syndrome, mycotoxins, protein, in-vitro, toxicity, food, metabolism, rheological properties, physicochemical properties, starch, bioavailability, et.al.

The second cluster (green) represents maize or corn gene-expression and QTL, keyword terms ranked as maize, rice, Arabidopsis, quantitative trait loci, evolution, diversity, expression, gene, identification, *Zea-mays* L., biosynthesis, resistance, selection, barley, domestication, et al.

The third cluster (blue) is focused on maize or corn using as energy, including keyword terms as corn stover, biomass, enzymatic-hydrolysis, pretreatment, lignocellulosic biomass, wheat-straw, ethanol-production, ethanol, cellulose, biofuels, fermentation, hydrolysis, lignin, energy, bioethanol, et al.

The fourth cluster (yellow) represents effect of climate-change on crop yield, keyword terms ranked as wheat, yield, corn, agriculture, climate-change, management, food security, model, impacts, climate change, adaptation, productivity, temperature, impact, quality, et al.

The fifth cluster (violet) is focused on abiotic stress on maize or corn growth, including keyword terms as *Arabidopsis-thaliana*, growth, gene-expression, plants, grain-yield, abscisic-acid, *Oryza-sativa* L., plant, drought, maize *Zea mays* L., drought tolerance, tolerance, oxidative stress, responses, abiotic stress, et al.

The sixth cluster (shallow blue) is focused on maize or corn cropping systems with other crops, keyword terms ranked as nitrogen, biochar, black carbon, soil, charco-

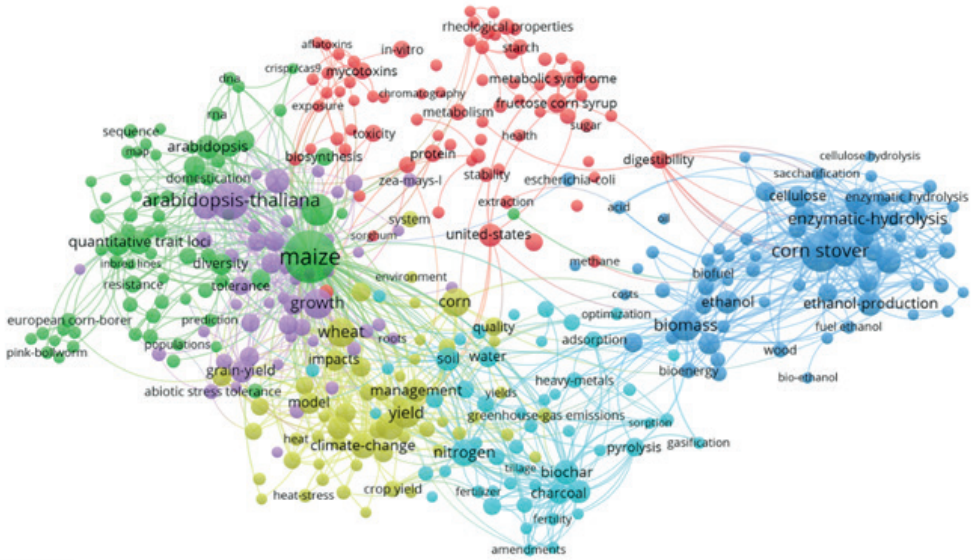

Fig. 5 - VOSviewer co-occurrence Network visualization mapping of most frequent all keywords (minimum of 5 occurrences) of maize or corn research. Co-occurrence network of all keywords including author keywords and keywords plus.

al, water, pyrolysis, cropping systems, organic-matter, carbon, carbon sequestration, adsorption, emissions, microbial biomass, physical-properties,et al.

The most frequently cited articles

The total citation count was obtained from WoS 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 6 shows the top 12 papers of total citations more than 1,000 times, three papers are from Science,two papers are from Bioresource Technology, one paper is each from *Annual Review of Plant Biology, Plos One, Renewable sustainable energy reviews, Industrial & Engineering Chemistry Research, Nature Reviews Genetics, Nature, Journal of Computational Chemistry.*

Conclusions

The 966 top papers include 964 highly cited papers and 15 hot papers for maize and corn research, all written in English, were from 4,353 authors, 1,287 organizations and 84 countries/territories, listed in 290 journals.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 maize or corn research were separated six clusters. This study demonstrates that there are more top papers come from journals with the higher IF and higher rank Q1 in Category. Therefore, authors can choose their ideal journal with a high impact factor to publish papers in the English language related to this research field.

Funding:

This research was funded by National Key R & D Program of China (2016YFD0300308); and Supported by the Research Fund Program of Hubei Academic Library Committee,2019-YB-04.

Conflicts of Interest:

The authors declare no conflict of interest.

References

Dehdarirad T, Sotudeh H, Freer J, 2019. Bibliometric mapping of microbiology research topics (2012–16): a comparison by socioeconomic development and infectious disease vulnerability values. FEMS Microbiology Letters 366: fnz004.

Elango B, Ho YS, 2017. A bibliometric analysis of highly cited papers from India in Science Citation Index Expanded. Current Science 112: 1653-1658.

Elango B, Ho YS, 2018. Top-cited articles in the field of tribology: A bibliometric analysis. COLLNET Journal of Scientometrics and Information Management 12: 289-307.

Hernández-Vásquez Akram, Alarcon-Ruiz Christoper A., Bendezu-Quispe Guido, Comandé Daniel, Rosselli Diego, 2018. A bibliometric analysis of the global research on biosimilars. Journal of Pharmaceutical Policy and Practice11: 6.

Hong T, Feng X, Tong W, Xu W, 2019. Bibliometric

analysis of research on the trends in autophagy. PeerJ 7: e7103; DOI 10.7717/peerj.7103

Hu CX, Cao LZ, 2018. Bibliometric and visual analysis of planthopper research between 1980 and 2017. Current Science 114: 2445-2452.

Ivanović Lidija, Ho Yuh-Shan, 2019. Highly cited articles in the Education and Educational Research category in the Social Science Citation Index: a bibliometric analysis. Educational Review 71(3): 277-286.

Juárez-Hernández Sergio, Usón Sergio, Pardo Claudia Sheinbaum, 2019. Assessing maize production systems in Mexico from an energy, exergy, and greenhouse-gas emissions perspective. Energy 170:199-211.

Li XT, Mao DH, Cheng JM, 2018. Study on map knowledge domains of transgenic maize based on Citespace. American Journal of Agriculture and Forestry 6 (3): 44-49.

Maassen S, 2016. Bibliometric analysis of research on wastewater irrigation during 1991–2014. Irrig and Drain 65: 644–653.

Mao GZ, Huang N, Chen L, Wang HM, 2018. Research on biomass energy and environment from the past to the future: A bibliometric analysis. Science of the Total Environment 635: 1081– 1090.

Reyes-Gonzalez L, Gonzalez-Brambila CN, Veloso F, 2016. Using coauthorship and citation analysis to identify research groups: a new way to assess performance. Scientometrics 108:1171–91.

Shafiq Sidra, AkramNudrat Aisha, Ashraf Muhammad, 2019. Assessment of physio-biochemical indicators for drought tolerance in different cultivars of maize (*Zea mays* L.). Pakistan Journal of Botany 51(4):1241-1247.

Stavropoulou C, Somai M, Ioannidis JPA, 2019. Most UK scientists who publish extremely highly-cited papers do not secure funding from major public and charity funders: A descriptive analysis. PLoS ONE 14(2): e0211460.

Sun Jie, Yuan Bao-Zhong, 2020. Mapping of top papers in the subject category of Water Resources based on the Essential Science Indicators. Annals of Library and Information Studies, 67(2):90-102.

Van Eck NJ, Waltman L, 2010. Software survey: VOSviewer, a computer program for bibliometric mapping. Scientometrics 84:523–538.

Velasco-Muñoz Juan F, Aznar-Sánchez José A, Belmonte-Ureña Luis J, López-Serrano María J, 2018a. Advances in water use efficiency in agriculture: a bibliometric analysis. Water 10: 377.

Velasco-Muñoz Juan F, Aznar-Sánchez José A, Belmonte-Ureña Luis J, Román-Sánchez Isabel M, 2018b. Sustainable Water Use in Agriculture: A Review of Worldwide Research. Sustainability 10: 1084.

Wambu Enos W,Ho Yuh-Shan, 2016. A bibliometric analysis of drinking water research in Africa. Water SA 42: 612-620.

White-Gibson Ailbhe, O'Neill Barry, Cooper David, Leonard Michael,O'Daly Brendan, 2019. Levels of evidence in pelvic trauma: a bibliometric analysis of the top 50 cited papers. Irish Journal of Medical Science 188:155–159.

Yao HQ, Wan JY, Wang CZ, Li LR, Wang J, Li YS, Huang WH, Zeng JX, Wang Q, Yuan CS, 2018. Bibliometric analysis of research on the role of intestinal microbiota in obesity. Peer J 6: e5091; DOI 10.7717/peerj.5091

Yuan Bao-Zhong, Sun Jie, 2019. Bibliometric and mapping of top papers inthe subject category of green and sustainable science and technology based on ESI. COLLNETJournal of Scientometrics and Information Management 13(2): 269-289.

Zhang Y, Huang K, Yu YJ, Yang BB,2017. Mapping of water footprint research: A bibliometric analysis during 2006-2015. Journal of Cleaner Production 149: 70-79.