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## ► To cite this version:

Minjuan Liu, Lu Chen, Xue Yuan, Ting Wang, Yun Yan, et al.. The Knowledge Structure and Core Journals Analysis of Crop Science Based on Mapping Knowledge Domains. 9th International Conference on Computer and Computing Technologies in Agriculture (CCTA), Sep 2015, Beijing, China. pp.392-403, 10.1007/978-3-319-48354-2\_39 . hal-01614207

**HAL Id: hal-01614207**

**<https://inria.hal.science/hal-01614207v1>**

Submitted on 10 Oct 2017

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# The knowledge structure and core journals analysis of crop science based on mapping knowledge domains

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**Abstract:** This paper aims at revealing the potential structure of crop science and core journals distribution to provide reference and help for crop research and journal work. On the basis of journal co-citation analysis this paper draws the co-citation map of Crop Science Journal by means of mapping knowledge domains and information visualization technology. 86 crop science journals can be roughly divided into two groups and each group of journals can be subdivided into two regions. Plant science (including plant physiology, plant ecology, plant cell etc.) and biology and chemistry (including biochemistry and molecular biology, gene and genetics etc.) are the mainstream research field of crop science. Crop production and soil science is another important branch of crop science. In addition, there is the phenomenon of cross integration between crop science and environment, horticultural science, plant protection, food processing, animal husbandry etc.

**Keywords:** international Journals, crop science, journal co-citation analysis, mapping knowledge domains

## 1 Introduction

Crop Science is one of the core disciplines of agricultural science, the theory and technology of which plays an important role in agriculture and rural economic development as an important support. In the 21st century, the situation of international Crop Science and technology had a huge change, which is penetrated continually by the bio-technology and information technology. The combination of high-tech and traditional technology promote the rapid development of crop science and technology<sup>[1]</sup>. The rapidly change of technological development brings crop science with opportunities and challenges. If grasp the subject development dynamics, we can get opportunities in the fierce competition. Scientific researchers always want to publish the new results and findings as soon as possible to achieve the occupation of frontier research in this field, attention of academia and peer recognition and so on. Therefore, knowledge of paper, to some extent, represents the latest research level

when scientific papers published in the literature. Especially in those influential journals, many outstanding scientists of the world publish high-level scientific papers. Therefore, an core journal is not only an important media to disseminate research results, but also through the periodical analysis, it can help researchers to quickly understand the current research and grasp the latest trends.

Journals without external links can be organically linked by Journal co-citation analysis, which can reveal the relationship of interdependence and cross between journals, determine the professional scope, and help to identify core journals. The combination of Journal co-citation analysis and mapping knowledge domains can show up potential subject structure and power distribution of a field in a visually intuitive graph. The journals with a closer relationship concentrate together to form a different cluster result of different research directions and fields, which vividly depict the subject structure and core journals of the field<sup>[18]</sup>. Journal co-citation analysis started to develop on the basis of literature co-citation analysis. The concept of " literature Co-citation " was put forward in 1973 by the American intelligence scientist Henry Small<sup>[2]</sup>, after their studies were the first to carry out in 1974, extensive co-citation analysis followed up. In the later co-citation analysis, most of the research is literature co-citation analysis and author co-citation analysis represented by Small and White<sup>[3-9]</sup>. There were a lot of co-citation analysis and empirical research at home and abroad, but journal co-citation analysis and empirical research is not too much. For example, in 1991, McCain used journal co-citation analysis for practice to analyze the economics scholarly journals<sup>[10]</sup>; in 2000, Ding, Y use journal co-citation analysis and visualization to study the development process of Intelligence retrieves during 1987--1997<sup>[11]</sup>; in 2003, Tsay, MY visualized of the semiconductor areas with journal co-citation analysis<sup>[12]</sup>; in 2004, Liu Zao studied the literature of urban planning and visualized document structure with journal co-citation analysis<sup>[13]</sup>; in 2005, Marshakova Shaikevich, I. used journal co-citation analysis and visualization in the subject of women's studies and library and information science, and pointed out the distribution of its subject areas<sup>[14]</sup>; in China, in 2006, Hou H.Y. used co-citation analysis and draw the science map of international metrology core journals<sup>[15]</sup>; in 2008, Qiu J. P., Zhao W. H. used co-citation cluster analysis and core-periphery model to mainly analyze the 21 editing and publishing journals and determine the core journals of the discipline<sup>[16]</sup>; in 2009, Zhao Y. respectively used journal co-citation analysis and draw knowledge maps of Library and Information Science and biological hydrogen production<sup>[17-19]</sup>; in 2009, Qin C. J. draw the knowledge map of the relationship between agricultural history of China and neighboring discipline based on journal co-citation analysis<sup>[20]</sup>; in 2010, Liang Y. X. et al. used journal co-citation analysis method to learn the status of citation analysis discipline<sup>[21]</sup>.

Although there is relatively little research on journal co-citation analysis, but it is not only an effective way to research subjects and the structure and characteristics of literature, but also has its unique in the study of the overall discipline structure and the nature and characteristics of professional journals<sup>[22]</sup>. However, in the previous studies, there were more empirical research on the library and information science, and lacked application and validation in other fields, especially in the agricultural area; Also, the selecting target journals of co-citation analysis more dependent on existing database journals category or used the way of the keywords retrieval, so it can not be used in the field whose journals classification are not covered in database or can not

use keywords retrieval. In this paper, it delineates the core journals gradually spreading from a single female parent journal based on citation analysis, in order to try to expand the applied disciplines of journal co-citation analysis, use visualization techniques to draw crop science map on the basis of the journal co-citation analysis of crop science journals. On the one hand, it can help researchers to understand Crop science knowledge structure and research focus. On the other hand, it can help researchers to know the characteristics of the journals and give reference for selecting the appropriate journal to submit the article.

## **2 Data source and methods**

The research data are all from the Science Citation Index Expanded database of Thomson Scientific, The last update time is May 2013.

This study uses the journal co-citation analysis methods to reveal the interdependence cross relationship between journals, what's more, with the emerging international method of mapping knowledge domain and information visualization technology, drawing the journal co-citation map of crop science to vividly reveal the structure of the crop science core journals groups. The mainly methods include factor analysis, cluster analysis and multidimensional scaling, which the factor analysis by principal components analysis and varimax orthogonal rotation, cluster analysis by Hierarchical Clustering and Multidimensional Scaling by ALSCAL. The research combined two analytical approaches, which are bibexcel and SPSS for obtaining visualizing information of crop science.

Analysis steps:

First, selecting CROP SCIENCE as the female parent, which is the most important journal in the field of the crop science, by the method of single co-citation analysis, there are 2008 papers with 78121 citations in CROP SCIENCE from 2008 to May 2013 were analyzed and evaluated.

Second, selecting the journals which are higher cited by Crop Science for further co-citation analysis, there are 5819 papers with 240823 citations in these journals from 2008 to May 2013, then 98 journals which the cited frequency over 300 times among these journals are chosen to do a further analysis.

Last, cleaning the data of 98 journals, and finally choosing 86 journals to do the co-citation analysis, which are much more important journals in the field of crop science. To establish co-citation matrix with the data of 86 journals by Bibexcel, then use the matrix do some factor analysis, cluster analysis and Multidimensional Scaling by SPSS to draw the journal co-citation map of Crop Science with 86 journals, which can vividly reveal the relationship between journals and disciplinary structure of Crop Science.

### 3 Results and Discussion

#### 3.1 Parental journal and citation analysis

The parental journal "CROP SCIENCE" which was founded in 1997, the impact factor is 1.513, published by the Crop Science Society of America (CSSA). The journal publishes crop genetics and breeding; crop physiology and metabolism; crop ecology, crop production and management; seed physiology, seed production and technology; lawn learning; genomics, molecular genetics and biotechnology; plant genetics resources and pest control and other aspects and original research papers. The journal is indexed in SCI belongs to Q2, covers most fields of crop science and well-known in crop science. Therefore, this study chosen "CROP SCIENCE" as the parental journal, which can be a good representation of crop science.

Through citation analysis, there were 2736 journals cited by "CROP SCIENCE" ,the total citation frequency is 62950 times. In Table 1, the top 7 journals which were cited by CROP SCIENCE more than 1000 times are listed.

**Table 1.** Top 7 journals cited by CROP SCIENCE

Rank	Cited frequency	Cited journal
1	11483	CROP SCI
2	3905	THEOR APPL GENET
3	2576	AGRONOMY JOURNAL
4	1658	EUPHYTICA
5	1484	GENETICS
6	1304	PLANT PHYSIOL
7	1168	FIELD CROP RES

"CROP SCIENCE", "THE THEORETICAL AND APPLIED GENETICS", "THE AGRONOMY JOURNAL " and " EUPHYTICA " are cited by "CROP SCIENCE" more than 1500 times , the total cited frequency can reach 19622, accounting for 31.17% of all journal, and " CROP SCIENCE", its self-cited frequency is 11483 times and accounts for 18.24%. Therefore, this study chosen the 4 journal as the parental journal to do further co-citation analysis to identify the important journals in the field of crop science.

Between 2008 and May 2013, these 4 journals has published 5819 papers with 240823 citations, there were 7113 journals cited by these 4 journals and the total cited frequency is 198362 times. Table 2 gives 98 journals which were cited more than 300. It's necessary to clean the data of 98 journals, merge the same journals, eliminate the

review journals and the journal that was not indexed in SCI, eventually retained 86 journals to do co-citation analysis.

**Table 2.** 98 journals cited more than 300 by 4 parental journals

Rank	Cited journal	Cited frequency	Journal ID	Rank	Cited journal	Cited frequency	Journal ID
1	CROP SCI	19947	a25	50	GENOME RES	588	a35
2	THEOR APPL GENET	18898	a94	51	J CEREAL SCI	586	a47
3	AGRON J	8868	a6	52	PLANT PATHOL	583	a83
4	GENETICS	6804	a33	53	AM J BOT	573	a7
5	EUPHYTICA	6575	a28	54	COMMUN SOIL SCI PLAN	563	a24
6	PLANT PHYSIOL	3447	a84	55	ADV AGRON	563	a2
7	P NATL ACAD SCI USA	3047	a70	56	ANNU REV PHYTOPATHOL	558	a11
8	GENOME	2927	a34	57	PLANT CELL ENVIRON	549	a76
9	FIELD CROP RES	2806	a31	58	MOL ECOL	535	a61
10	PLANT BREEDING	2443	a73	59	MOL GEN GENET	527	a62
11	PHYTOPATHOLOGY	2414	a72	60	J ANIM SCI	523	a46
12	PLANT DIS	2290	a79	61	J ECON ENTOMOL	522	a49
13	MOL BREEDING	2075	a60	62	J SCI FOOD AGR	518	a56
14	PLANT CELL	1985	a75	63	ANN APPL BIOL	506	a8
15	SCIENCE	1860	a89	64	SOIL TILL RES	504	a92
16	PLANT J	1821	a80	65	ACTA HORTIC	460	a1
17	J EXP BOT	1688	a51	66	GENOMICS	456	a36
18	SOIL SCI SOC AM J	1674	a91	67	WEED TECHNOL	454	a98
19	Crop & Pasture Science	1594	a14	68	J PLANT NUTR	434	a53
20	CAN J PLANT SCI	1568	a21	69	MOL BIOL EVOL	424	a59
21	PLANT MOL BIOL	1299	a81	70	J DAIRY SCI	419	a48
22	PLANT SOIL	1273	a86	71	BIOMETRICS	415	a18
23	J HERED	1217	a52	72	T ASAE	409	a93
24	NATURE	1210	a67	73	PLANT CELL PHYSIOL	401	a77

Rank	Cited journal	Cited frequency	Journal ID	Rank	Cited journal	Cited frequency	Journal ID
25	ANN BOT-LONDON	1106	a9	74	PLANT CELL REP	398	a78
26	HORTSCIENCE	1089	a40	75	ANNU REV PLANT PHYS	381	a13
27	NUCLEIC ACIDS RES	1066	a69	76	WEED RES	378	a96
28	HEREDITY	925	a39	77	AGR ECOSYST ENVIRON	378	a3
29	J ENVIRON QUAL	904	a50	78	AGR FOREST METEOROL	370	a4
30	GENET RESOUR CROP EV	900	a32	79	PLANT MOL BIOL REP	369	a82
31	NEW PHYTOL	861	a68	80	J AGRON CROP SCI	368	a43
32	TRENDS PLANT SCI	854	a95	81	NAT REV GENET	368	a66
33	NAT GENET	839	a65	82	ANN EUGENICS	362	a10
34	J AGR FOOD CHEM	794	a41	83	J AM OIL CHEM SOC	361	a44
35	J AM SOC HORTIC SCI	794	a45	84	REMOTE SENS ENVIRON	354	a88
36	J AGR SCI	782	a42	85	SOIL BIOL BIOCHEM	353	a90
37	MOL GENET GENOMICS	727	a63	86	AUST J PLANT PHYSIOL	352	a16
38	J PROD AGRIC	700	a55	87	AUST J EXP AGR	347	a15
39	PLANT SCI	699	a85	88	AGR WATER MANAGE	334	a5
40	MAYDICA	697	a58	89	ANNU REV PLANT BIOL	326	a12
41	EUR J AGRON	680	a29	90	J PLANT PHYSIOL	326	a54
42	CURR OPIN PLANT BIOL	660	a26	91	CAN J PLANT PATHOL	316	a20
43	BIOINFORMATICS	653	a17	92	HEREDITAS	310	a38
44	WEED SCI	644	a97	93	CAN J SOIL SCI	307	a22
45	PHYSIOL PLANTARUM	643	a71	94	ECON BOT	306	a27
46	MOL PLANT MICROBE IN	643	a64	95	Plant Breeding Reviews	304	a74
47	CEREAL CHEM	629	a23	96	GRASS FORAGE SCI	304	a37
48	BREEDING SCI	615	a19	97	J SOIL WATER CONSERV	300	a57
49	PLANTA	603	a87	98	EUR J PLANT PATHOL	300	a30

### 3.2 Journal co-citation analysis and map knowledge domain

#### 1) Journal co-citation matrix

By bibexcel to count the cited frequency of the 86 journals, and to establish journal co-citation matrix, that is the original matrix, which laid a foundation to further reveal the relationship and structural characteristics between journals(Fig 1. 86 journal co-citation matrix). The matrix is a symmetric matrix, is co-diagonal journal citations, diagonal value is 0, the matrix range is between 0-2379. Meanwhile, transform the original matrix into Pearson correlation matrix as a similarity matrix, where similarity is measured by the correlation coefficient, the positive correlation is stronger, the two journals of the field of study or research is more similar, also showed that more similar academic backgrounds. (Fig 1.)

	V1	a3	a4	a5	a6	a7	a8	a9	a10	a14	a16	a17	a18
1	a3	0	38	34	220	13	41	35	0	46	15	2	4
2	a4	38	0	38	143	6	16	58	0	37	35	2	4
3	a5	34	38	0	148	4	22	45	3	56	31	3	8
4	a6	220	143	148	0	60	119	315	17	359	116	37	90
5	a7	13	6	4	60	0	30	106	21	28	14	69	13
6	a8	41	16	22	119	30	0	85	14	108	40	27	21
7	a9	35	58	45	315	106	85	0	27	178	94	68	20
8	a10	0	0	3	17	21	14	27	0	61	4	48	8
9	a14	46	37	56	359	28	108	178	61	0	103	67	68
10	a16	15	35	31	116	14	40	94	4	103	0	10	8
11	a17	2	2	3	37	69	27	68	48	67	10	0	30
12	a18	4	4	8	90	13	21	20	8	68	8	30	0
13	a19	11	0	2	40	31	15	58	43	45	4	57	14
14	a20	5	5	1	29	5	24	11	33	75	2	14	7
15	a21	53	31	34	426	37	54	126	32	181	29	24	42
16	a22	42	8	14	148	1	7	15	0	12	0	0	1
17	a23	2	4	2	60	1	1	20	11	75	13	33	9
18	a24	67	17	26	324	7	20	41	0	34	9	1	5

(a) Original matrix

	V1	a3	a4	a5	a6	a7	a8	a9	a10	a14	a16	a17	a18
1	a3	1.000	.8520	.8814	.6389	.1803	.4328	.5375	.0604	.5178	.5791	.0750	.4032
2	a4	.8520	1.000	.9409	.6382	.2321	.5204	.6042	.0603	.5658	.7333	.0955	.4125
3	a5	.8814	.9409	1.000	.6900	.2812	.5598	.6829	.1189	.6003	.7920	.1616	.4636
4	a6	.6389	.6382	.6900	1.000	.4242	.6461	.6265	.3277	.6797	.6489	.3297	.6264
5	a7	.1803	.2321	.2812	.4242	1.000	.7984	.7995	.8608	.7887	.5732	.9194	.8127
6	a8	.4328	.5204	.5598	.6461	.7984	1.000	.8591	.7689	.9310	.7503	.7353	.8734
7	a9	.5375	.6042	.6829	.6265	.7995	.8591	1.000	.6826	.8613	.8569	.7371	.8077
8	a10	.0604	.0603	.1189	.3277	.8608	.7689	.6826	1.000	.7539	.4011	.9224	.7896
9	a14	.5178	.5658	.6003	.6797	.7887	.9310	.8613	.7539	1.000	.7248	.7323	.8976
10	a16	.5791	.7333	.7920	.6489	.5732	.7503	.8569	.4011	.7248	1.000	.4527	.6028
11	a17	.0750	.0955	.1616	.3297	.9194	.7353	.7371	.9224	.7323	.4527	1.000	.7990
12	a18	.4032	.4125	.4636	.6264	.8127	.8734	.8077	.7896	.8976	.6028	.7990	1.000
13	a19	.1380	.1733	.2448	.3999	.9350	.8187	.7957	.9414	.8073	.5429	.9601	.8317
14	a20	.1922	.1773	.2014	.4488	.6340	.7845	.5497	.7881	.7373	.3609	.6608	.7273
15	a21	.6805	.6986	.7360	.7228	.6934	.8864	.8472	.6299	.9184	.7654	.6160	.8654
16	a22	.8547	.6704	.6915	.4550	-.077	.1230	.2079	-.157	.2201	.2557	-.162	.1390
17	a23	.3163	.3514	.4256	.5558	.7789	.8141	.8008	.7700	.8342	.6441	.7831	.8384
18	a24	.9012	.7839	.8090	.5305	.0630	.2824	.3884	-.050	.3747	.4407	-.044	.2754

(b) Pearson correlation matrix

Fig.1. 86 journals co-citation matrix (parts)



## 2) Factor analysis

On the basis of the Multidimensional Scaling, this study combined factor analysis and cluster analysis to supplement and improve the multidimensional scaling. This study did a principal components analysis on the Pearson correlation matrix of 86 journals by SPSS , It extract three main components factors and cumulative variance reached 86.709%, which means three components factors have been able to explain the information contained in all variables well. TABLE 3 make a list of variables (journals) which factor loading is over 0.7.

**Table 3.** Variables (journals) which factor loading is over 0.7

	<b>Rank</b>	<b>Journal</b>	<b>Factor</b>	<b>Rank</b>	<b>Journal</b>	<b>Factor</b>	<b>Rank</b>	<b>Journal</b>	<b>Factor</b>
		<b>ID</b>	<b>loading</b>		<b>ID</b>	<b>loading</b>		<b>ID</b>	<b>loading</b>
	<b>1</b>	a82	.978	<b>19</b>	a89	.927	<b>37</b>	a58	.813
	<b>2</b>	a63	.974	<b>20</b>	a80	.924	<b>38</b>	a77	.813
	<b>3</b>	a35	.974	<b>21</b>	a75	.917	<b>39</b>	a68	.807
	<b>4</b>	a17	.973	<b>22</b>	a7	.917	<b>40</b>	a72	.806
<b>Factor1</b>	<b>5</b>	a65	.970	<b>23</b>	a34	.916	<b>41</b>	a94	.772
	<b>6</b>	a69	.968	<b>24</b>	a70	.909	<b>42</b>	a23	.769
	<b>7</b>	a66	.965	<b>25</b>	a64	.908	<b>43</b>	a18	.769
	<b>8</b>	a59	.965	<b>26</b>	a32	.891	<b>44</b>	a51	.763
	<b>9</b>	a36	.964	<b>27</b>	a85	.890	<b>45</b>	a79	.758
	<b>10</b>	a19	.964	<b>28</b>	a78	.890	<b>46</b>	a83	.752
	<b>11</b>	a61	.947	<b>29</b>	a73	.881	<b>47</b>	a87	.748
	<b>12</b>	a39	.947	<b>30</b>	a33	.871	<b>48</b>	a25	.747
	<b>13</b>	a52	.944	<b>31</b>	a27	.864	<b>49</b>	a49	.746
	<b>14</b>	a67	.941	<b>32</b>	a84	.851	<b>50</b>	a30	.728
	<b>15</b>	a10	.940	<b>33</b>	a28	.843	<b>51</b>	a40	.724
	<b>16</b>	a38	.937	<b>34</b>	a45	.833	<b>52</b>	a9	.703
	<b>17</b>	a81	.936	<b>35</b>	a41	.815	<b>53</b>	a14	.700
	<b>18</b>	a60	.930	<b>36</b>	a47	.814			

	<b>1</b>	a3	.958	<b>8</b>	a88	.919	<b>15</b>	a29	.827
	<b>2</b>	a24	.951	<b>9</b>	a53	.906	<b>16</b>	a37	.816
<b>Factor2</b>	<b>3</b>	a90	.949	<b>10</b>	a91	.900	<b>17</b>	a86	.811
	<b>4</b>	a92	.940	<b>11</b>	a5	.857	<b>18</b>	a48	.717
	<b>5</b>	a50	.935	<b>12</b>	a4	.843	<b>19</b>	a96	.714
	<b>6</b>	a57	.922	<b>13</b>	a98	.839	<b>20</b>	a43	.705
	<b>7</b>	a22	.922	<b>14</b>	a97	.829			
<b>Factor3</b>	<b>1</b>	a16	.716						

### 3) Cluster analysis

Meanwhile, this study did a cluster analysis on these 86 journals to further examine the similarity between the journals to supplement multidimensional scaling. Similar to factor analysis, the study choose Hierarchical Clustering to analysis the Pearson correlation matrix of 86 journals by SPSS. Figure 2 shows the result of cluster analysis. It's obviously to see that these 86 journals is better to classified into two clusters.

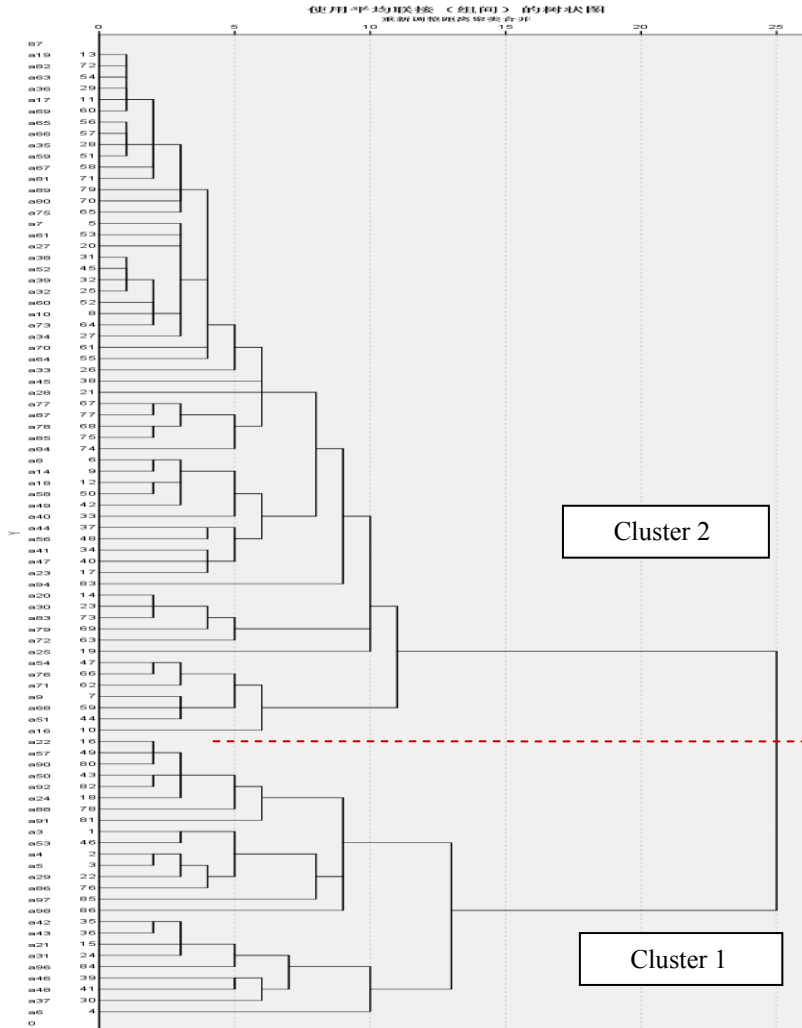


Fig.2. Hierarchical clustering tree diagram of 86 journals

#### 4) Multidimensional scaling analysis

In order to reveal the affinities between journals and further determine the discipline structure of journals in crop areas, we carried multidimensional scaling analysis by putting the journal similarity matrix into SPSS, which can display the relationship between the original high-dimensional data in low-dimensional space. As the picture 3, each dot represents a journal, and the location of periodicals show similarity (common disciplines or methods, etc.) between journals. The more similar the more

together, and then form a knowledge group. In the knowledge group, the journal which has the closest relation with other point is in the middle of the journal position map, which shows that it is the core of knowledge group; the other hand, more in the periphery.

On the basis of the results of the factor analysis and cluster analysis, we draw the co-citation multidimensional scaling analysis diagram of 86 journals, shown in Figure 3. The value of stress is 0.03653 and RSQ is 0.99662, so it reflects a very good fitting degree. The 86 journals are clearly divided into two parts, group 1 includes 26 journals, and group 2 includes 60 journals.

The group 1 can be divided into two parts. A1 has the most journals, which mainly includes the journals of crop production, soil science, agricultural resources and the environment and other related areas. The AGRON J, SOIL SCI SOC AM J, PLANT SOIL and some journals are the representations of this area, reflecting the inseparable relationship between crops and soil, water and environment. A2 area includes several agricultural comprehensive journals, and FIELD CROP RES is typical representation, which focus on crop production and cultivation, and become the connection of Journal group 1 and group 2.

The Group 2 can also be subdivided into two areas. B1 contains many journals which have tight connection and short distance from the origin, and some journals highly cited by the parental journal focused on here, which proves that this area is a core area concentrating crop science journals, covering the most important branches of Crop Science. It mainly includes the journals of crop genetics and breeding, plant science, biochemistry and molecular biology, gene and genetics, which attract more attention of crop science researchers and is the most core journals. The journal of CROP SCI, THEOR APPL GENET, GENETICS, EUPHYTICA, PLANT BREEDING, GENOME, P NATL ACAD SCI USA, PLANT PHYSIOL, PHYTOPATHOLOGY, PLANT DIS and other journals are the representation. From the view of position, B2 likes the bridge of journals group 2 and group 1, which has more closely relation with A2, including the journals more closer to A2 which has Crop & Pasture Science as a representative of agriculture comprehensive journals, also including the journals of ANN BOT-LONDON and HORTSCIENCE as a representative of botany and horticulture.

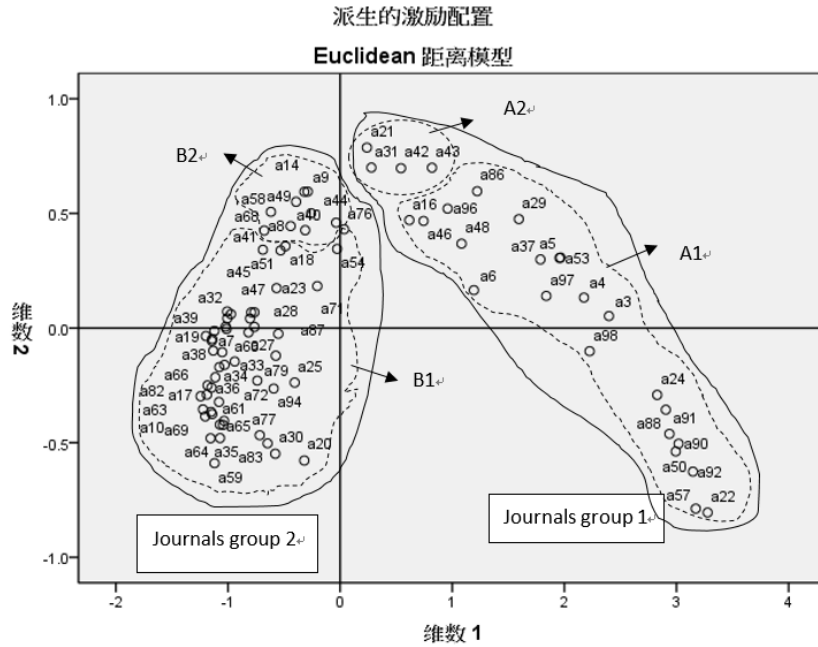


Fig. 3. The co-citation map of 86 important crop science journals

## 4 Conclusions

According to the result of Journal Citation analysis and co-citation mapping knowledge, we can see that the international crop science research can be divided into two parts in recent years. The first part focus on plants (crops) own research (Journal Group 2), including plant physiology, plant ecology, plant cells, etc. and biochemistry and molecular biology, gene and genetics, etc., which is mainstream areas and more concerned by crop science researchers now. Another part is more concerned about the relationship between plants (crops), soil, resources and environment, including crop production, soil science and environment science, which is another important branch of crop science. In addition, some journals of resource and environment, horticulture, crop protection, food processing, animal husbandry are found to be highly cited by crop science journals, which proves that interdisciplinary integration between crop science and other subjects, and the journals from these areas have become the journals concerned by crop researchers.

Overall, the journal co-citation analysis is an effective method for revealing core journals of disciplines. Journals co-citation analysis can reveal the structure of discipline by the way of cited journals co-citation analysis, which is from the perspective of the journal analysis. Thus, through the journal position in the different disciplines, we can judge core journals of different subjects to help researchers to find more useful information<sup>[19]</sup>. Comparing with the previous research, the difference is

that, it delineates the target journals group gradually spreading from a single parent journal, namely in the way of using an important journal of crop science based on citation analysis to gradually delineate the subject core journals. From the result of International crop science related Journals co-citation analysis, it is satisfactory that it can reflect objectively the crop science underlying structure and core journals distribution by the journal co-citation analysis combined with visualization techniques. It is successful that the applied discipline is expanded.

However, when using the journal co-citation analysis, it must pay more attention on data collection and processing methods and process control, or it will have a direct impact on the accuracy of the analysis results. I believe that there are two aspects need to be taken seriously. One is periodical cleaning, which is necessary because the journals abbreviated titles may be not unified and some journal title may change, so inattention could cause distortion of data and affect the final results. The other one is the choice of the study object, factor analysis, clustering and multidimensional scaling method and the error of statistical analysis, which will affect the results objectivity, so it must carefully plan in order to ensure effective and objective analysis of the results. In the future studies, we will continue to combine journal published papers and the integration of new technologies and analysis methods to explore more accurate and reliable methods of revealing potential knowledge structure and core journal distribution in different fields.

## Acknowledgment

Funds for this research was provided by the Chinese Academy of Agricultural Sciences Science and Technology Innovation Projects (CAAS-ASTIP-2015-AII).

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