2-4-2020

A Bibliometric Survey on the Diagnosis of Plant Leaf Diseases using Artificial Intelligence

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A Bibliometric Survey on the Diagnosis of Plant Leaf Diseases using Artificial Intelligence

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ABSTRACT

Due to uncertain environmental conditions such as untimely rainfall, hailstorms, draught, fog the agriculture sector faces huge loss in crop yield. One of the biggest reason is plant leaf diseases. Therefore the need arises to diagnose the plant leaf diseases beforehand so that the diseases could be avoided and crop yield loss could be minimized. The paper represents the bibliometric study of plant leaf disease diagnosis using Artificial Intelligence. The study focuses on 472 scientific documents such as journals, articles, book chapters publicized in various journals. These documents are extracted from Scopus database after querying it with keywords related to plant diseases classification and Artificial Intelligence. The articles are analyzed for the time period of 2010 to 2018. The analysis was done using tools such as VOSviewer, NodeXL and Gephi which are open source tools. The survey prominently focuses on the type of publications, language used in publicizing the documents, year wise count of the publications the field, based on geographical locations of the publications, trends of keywords found in the articles, based on discipline area, top authors contributing to the area, institutions and universities contributing to the area and the number of citations the documents received. It was observed that the English language is primarily used for publication of the documents. India contributes the maximum numbers of documents in the field of plant leaf disease followed by China. The study also discovered that the journal that has maximum number of publications count in this research field is Computer and Electronics in Agriculture.

Keywords: plant leaf disease, Artificial Intelligence, diagnosis, Bibliometric survey.

1. INTRODUCTION

Agriculture sector majorly contributes to the global economy [1]. Environmental uncertainty is spanning the world. The causes of environmental uncertainty being hailstorm, fog, untimely rainfall etc may lead to partial damage to crop, complete damage to crop or spread of infectious diseases in the crop. Plant diseases are the biggest challenge and becomes one of the major factors causing harm to the crops and in turn leading the farmers towards debts and suicides.

The traditional method to identify plant diseases was visual examination of the plants by the farmers or the agricultural experts [2]. However these techniques had certain limitations such as it was time consuming process, more laborious and the results was restricted for a small coverage area.

A pivotal role is played by technology in agricultural sector, agriculture based industries and in developing farms. Lately, the introduction of technology in agriculture sector has made it possible to grow crops even in deserts. The most demanded tool in agriculture sector is automation techniques. Many research suggests that deployment of automation technology in farms will increase crop production yield and ultimately increase farmer's annual income as well [3-7].

Plant disease can occur when all the three factors (host, pathogen and environment) that are favorable for the disease are present. The factors are host which means crop to be considered for disease detection, Pathogens are factors causing diseases like fungus, virus, bacteria and environmental conditions are the factors that will decide whether the disease will grow or not. If any one of the factors among these is absent, the disease will not occur [8]. Plant diseases are basically caused due to two factors namely biotic factors and abiotic factors. Biotic factors are the factors caused due to living organisms such as fungus, bacteria, virus and nematodes while abiotic factors are the factors caused due to ecological factors such as temperature, humidity, soil moisture, humidity etc [9].

The worldwide annual [10] crop yield production loss at the start of 21st century is estimated in Table 1.

Table 1 : Crop yield production loss estimation

Cause of loss in crop yield	**Loss in %**
Pests	25%
Plant diseases	20%
Weeds	35%
Others	20%

Data access information source : Oerke,2006

As shown in Table 1, it has been observed that on a global scale even though weeds is the major cause of crop yield loss, insects and plant diseases are also major causes due to which agricultural crops suffer loss [10]. Serious plant diseases are caused by pests as well, but fungi is the most probable cause for severe losses due to disease around the world [11-13].

Therefore the need arises to develop an automatic system that will diagnose the plant diseases well beforehand and thus can help farmers to grow more crops and protect them and produce quality farm products.

1.1 Bibliometric Analysis plant leaf diseases diagnosis using Artificial Intelligence :

Taking into consideration the above mentioned situation, the researchers have an urge to perform a bibliometric survey and understand the researches related to diagnosis of plant diseases using Artificial Intelligence. To mention the list of sources at the end of the book, article or a report is a normal procedure followed which indicates that the information from listed sources were used in order to write the book, article or report. The term “Bibliometrics” can be split up as ‘biblio’ which means books and ‘metrics’ means measurement. It is used to evaluate performance of research in universities and organizations. It is used as prominent tool to quantitatively analyze the research data based on articles, citation counts, geographical locations and various other parameters. This study also helps to find out the research gaps along with future scope that can be the contribution of the authors towards research area [14, 15].

To get a deeper idea about the research area, the need arise to perform a bibliometric survey on plant leaf diseases.

The objectives of this bibliometric study are as follows:

- To identify the types of publications in the field of research
- To find out the type of language used for publications
- To determine the trends in publications based on year
- To identify the geographical locations or countries contributing more to the research
- To determine trends based on source types
- To identify highly contributing authors
- To identify trends in publications based on affiliations (university/organization).
- To examine citation count for the publications.

This manuscript presents a bibliometric survey of plant leaf diseases through Section 2 that highlights initial collection of data related to plant leaf disease. Section 3 highlights on analysis of extracted data from Scopus. Two types of analysis is done in this section one being network analysis and the other being statistical analysis. Section 4 describes about the inferences drawn from the research. Section 5 represents the limitations of the survey and Section 6 is conclusion which concludes the research paper. References are cited at the end of the paper.

2. INITIAL COLLECTION OF DATA

The scientific articles, publications, documents can be accessed in two ways one way is to pay by paying the fees to get the access to the required article and the other way is to access it freely which is also called as open access [16]. If the researchers want to access the publications then they can access it by registering themselves to the respective websites or they can access it via the organizations or institutes library portals [17, 18]. There are certain other alternative methods to access the data from research databases. Some of the renowned research databases are Scopus, Web of Science, Science Direct, Research Gate and Google Scholar etc.

Scopus database as is one of the largest database or repository for the scientific documents such as journals, proceedings of conferences and book chapters. The articles are from various research disciplines such as science, medicine, arts and engineering that are reviewed in peer manner by the domain experts. It is international in coverage. Therefore Scopus is considered as relentless and accurate source whenever a research is to be carried out. The paper takes Scopus database

into consideration with the association of prominent keywords identified in Section 2.1.

2.1 Prominent keywords

The prominent keywords with respect to plant leaf diseases were divided into two parts namely: primary and secondary keyword. Table 2. shows selection of search keywords used as a search strategy for this research.

Table 2: Selection of search keywords for plant leaf disease

Primary keyword	"plant leaf disease "
Secondary keyword using (AND)	“Artificial Intelligence”
Secondary keywords using (OR)	“ prediction “, “ diagnosis”, “quantification”, “gradation”, “forecasting” , “identification”, “classification”, “ detection”

Thus the query used to search the documents in Scopus is : "plant leaf disease” AND “Artificial Intelligence” OR “ prediction “ OR “ diagnosis” OR “quantification” OR “gradation” OR “forecasting” OR “identification” OR “classification” OR “ detection”

2.2 Preliminary search results

The fundamental entity of this research paper is Scopus database. Initially, query with selected search keywords used as a search strategy was executed on Scopus database which returned 472 publications. The returned publications from query comprises of published as well as unpublished publications. Table 3. shows different types of publications in the plant leaf disease research area. 51.3% of the researchers have publicized their work in Articles followed by conference paper which contributes 41.31%. It is observed that publication in book is contributed least.

Table 3: Type of Publications in plant leaf diseases

Type of Publications	**Number of Publications**	**Percentage**
Article	242	51.3%
Conference Paper	195	41.31%
Review	13	2.75%
Book Chapter	12	2.54%
Conference Review	3	0.63%
Book	1	0.21%
Erratum	1	0.21%
Undefined	5	1.05%
	Total	100%

Dataset access information source: http://www.scopus.com (accessed on 18th October 2019)

The search result was analyzed on the basis of type of language used in for publishing documents. Table 4. summarizes about the trends in language used for publishing documents in plant leaf disease. English language is majorly used by the researchers to publicize their publications while other languages such as Polish, Russian, Spanish, Turkish are least used.

Table 4: Languages trends used for publishing in plant leaf diseases

Sr.No.	**Language used for Publishing**	**Count of Publications**
1	English	434
2	Chinese	33
3	Portuguese	2
4	Polish	1
5	Russian	1
6	Spanish	1
7	Turkish	1
Total		**473**

Data access information source: http://www.scopus.com (accessed on 18th October 2019)

2.3 Exploratory data highlights

The documents related to plant leaf disease were retrieved for the span of thirteen year starting from 2008 to 2020. Table 5. shows trends in the number of publication count per year in the research area of plant leaf disease. By analyzing this data, it can be easily analyzed that the research area has contributed more in the year 2018 and 2019. However very few researches was carried out in the span of year 2008 to 2011.

Table 5: Yearly publishing trends in plant leaf diseases

Year	**Publication Count**
2020	5
2019	173
2018	123
2017	62
2016	44
2015	28
2014	15
2013	10
2012	6
2011	3
2010	1
2009	1
2008	1

Data access information source: http://www.scopus.com (accessed on 18th October 2019)

Figure 1. is the graphical representation of Table 5. in the form of line chart that clearly represents prominent year for publicizing the research documents is 2019 with highest publication count of total 173 documents.

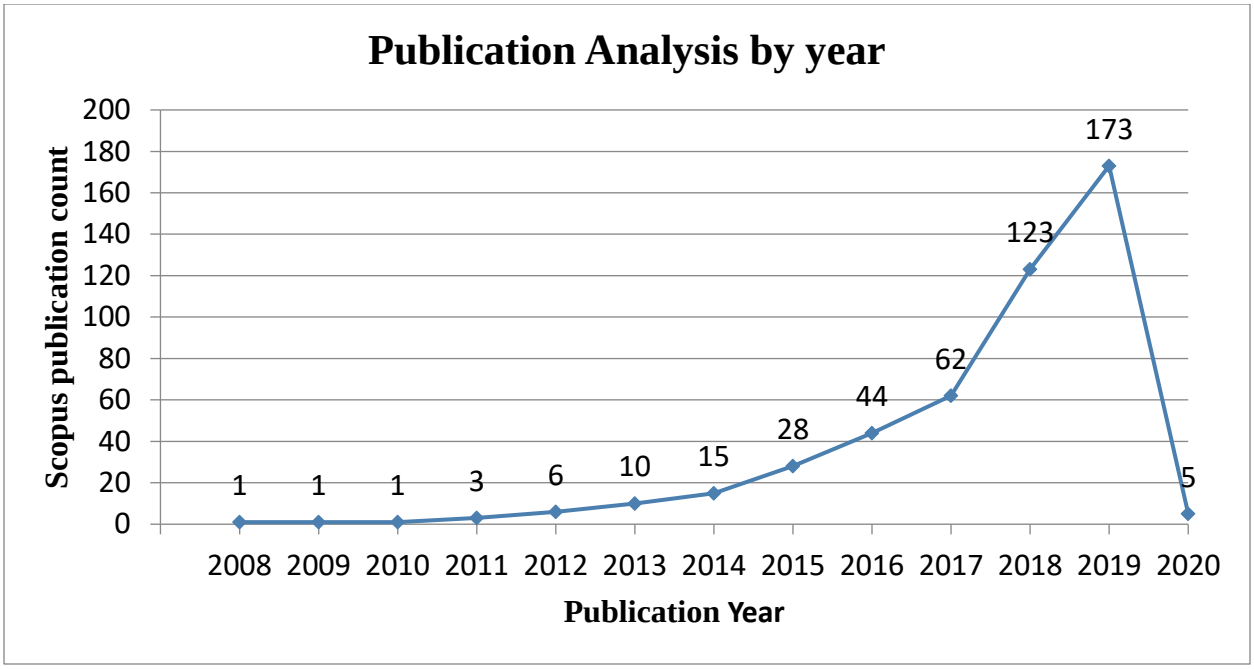

Figure 1: Yearly publishing trend in plant leaf diseases

2.4 Data Evaluation

A detailed bibliometric study is carried out in Section 3 to understand the diversity in the extracted literature, to know the significant researchers and the research problem statements in the area of plant leaf diseases. It shows distinctiveness in the research area via geographical locations where the research is conducted, via affiliations of the authors, author names and via journal titles where the research papers were published. The search analysis is done on the basis of keywords used in the extracted literature. The retrieved results are also analyzed on the basis of number of citations for each research paper and collaborative research work.

3. BIBLIOMETRIC SURVEY

In order to perform bibliometric survey of plant leaf disease two different methods are used. They are

- Statistical analysis based on country wise contribution to the research area, subject area wise contribution, author's affiliations, authors, source type, source titles.
- Networked analysis of research based on geographical locations, keywords, source title, publication title, citation count, year of publication and collaborative research with other authors.

3.1 Analysis based on geographic locations

Figure 2 shows the data about research papers published from various countries around the world. This interactive and dynamic map is created using Google sheets. The data from excel sheet which has two columns country and publication count is is copied to Google spreadsheet and it will generate a map based on the data provided in Google spreadsheet. In this world map, to know publication count data per country, use a computer mouse to position the cursor over a particular area of a computer screen. At the left bottom shows publication count scale. The region in green is India which has highest number of publications in the field of plant leaf diseases.

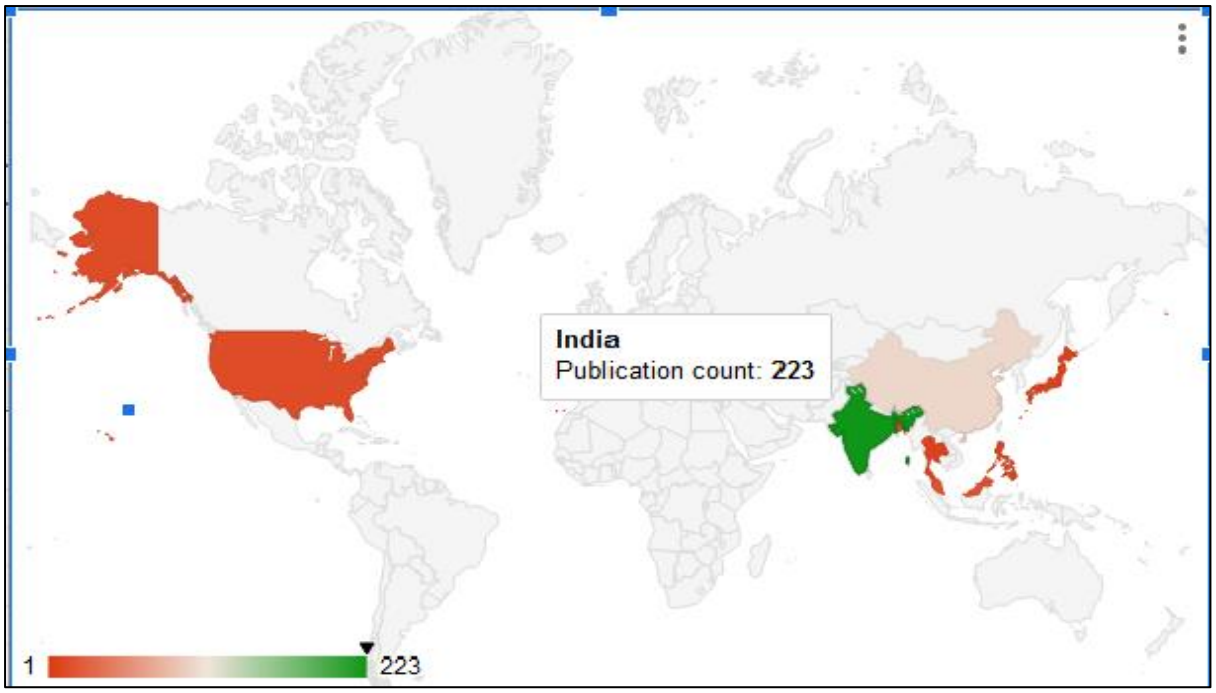

Figure 2. Geographical location of research plant leaf disease area
(Source : Google spreadsheet)

The top ten countries that have publications in the area of plant leaf disease is depicted in Figure 3. The bar graph shows that India has a share of 47.2% in publicizing documents in the plant leaf diseases research area followed by China with 21.6% contribution to the area. France, Japan and Thailand are the countries that contribute least to the plant leaf disease research area.

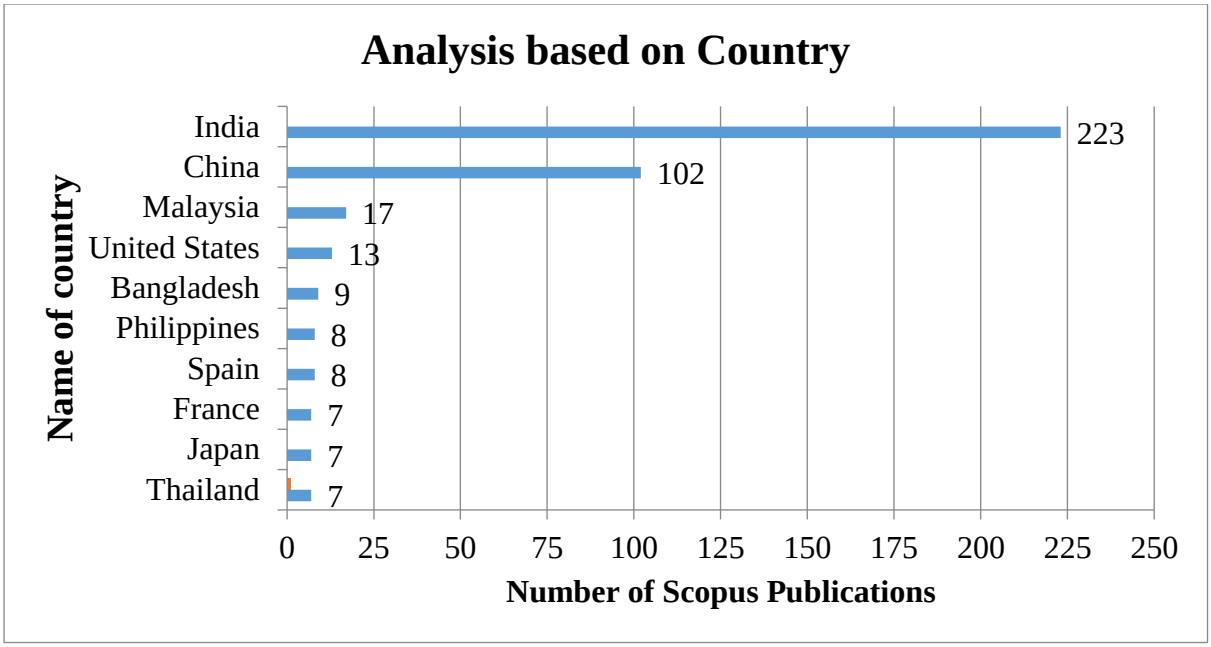

Figure 3: Ten topmost countries publishing papers on plant leaf diseases
Data access information source: http://www.scopus.com (accessed on 18th October 2019)

3.2 Statistical analysis based on keywords

The top ten keywords searched by the Scopus database for plant leaf disease is shown in Table 6. Proper combination of keywords helps to identify the publications in the required research area. It gives an overall view of what the researchers want to search for. The following table clearly insists that majority of the research in plant leaf disease is based on image processing as it is the most widely used keyword in the extracted literature.

Table 6: Top ten keywords for plant disease detection

Keywords	**Number of Publications**
Image Processing	158
Image Segmentation	103
Plants (botany)	88
Feature Extraction	78
Neural Networks	74
Classification (of Information)	72
Plant Disease	71
Crops	67
Support Vector Machines	64
Agriculture	51

Data access information source: http://www.scopus.com (accessed on 18th October 2019)

3.3 Network Analysis

Network analysis is used to represent the association among different computable attributes using graphical formats. Many tools are available fo the same purpose. However in this research paper VOSviewer, Gephi and NodeXL is used for making network analysis graphs. Figure 4-9 shows network analysis diagrams for combination of different computable parameters in plant leaf disease research area based on literature derived from the Scopus database.

VOSviewer is a tool which is freely available. The primary purpose of the tool is to analyze the bibliometric network on the parameters. The .csv extension file from Scopus is given as input to VOSviewer. Three types of visualization analysis is done based on network, overlay and density. Figure 4 is the network visualization map based on combination of keywords and source titles extracted from Scopus. Circles in the map represents the keywords used in the source titles of extracted documents. The bigger the circle higher is the frequency of the occurrence of the keyword. Links between the circles represents the distance between two keywords. If size of the link is smaller, the association among the keywords is higher. Keywords with same colors represent clusters of closely related keywords. The diagram has eight different clusters each cluster represented with different color. Threshold value for minimum number of occurrence of keyword is limited to 3. 83 keywords met the threshold value. Relevance score is calculated for 83 terms. 60% of 43 terms was selected as it is default value kept by the software. So with this value, 50 keywords were selected to draw the relation between keywords and source titles.

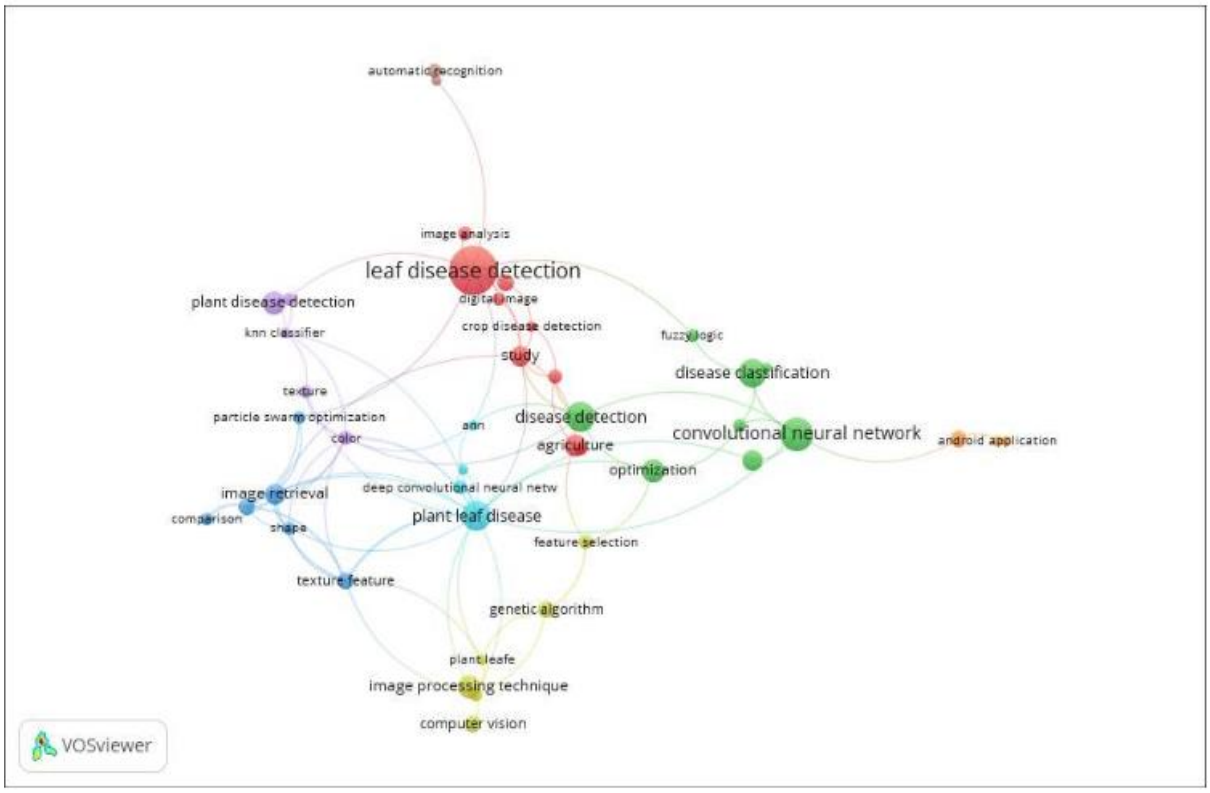

Figure 4 : Network visualization diagram based on keywords and source title.
(Source : https://www.vosviewer.com)

A cluster of publication title and their respective publication year is depicted in Figure 5. This diagram is drawn using NodeXL open source tool for drawing network analysis diagrams. Here nodes are different entities such as publication title and publication year. The connections between these entities are called as edges. Fruchterman-Reingold layout is used to map the publication year and publication title data. The cluster size indicates that majority of the publications in the field of plant leaf disease are publicized in the year 2019 followed by 2018.

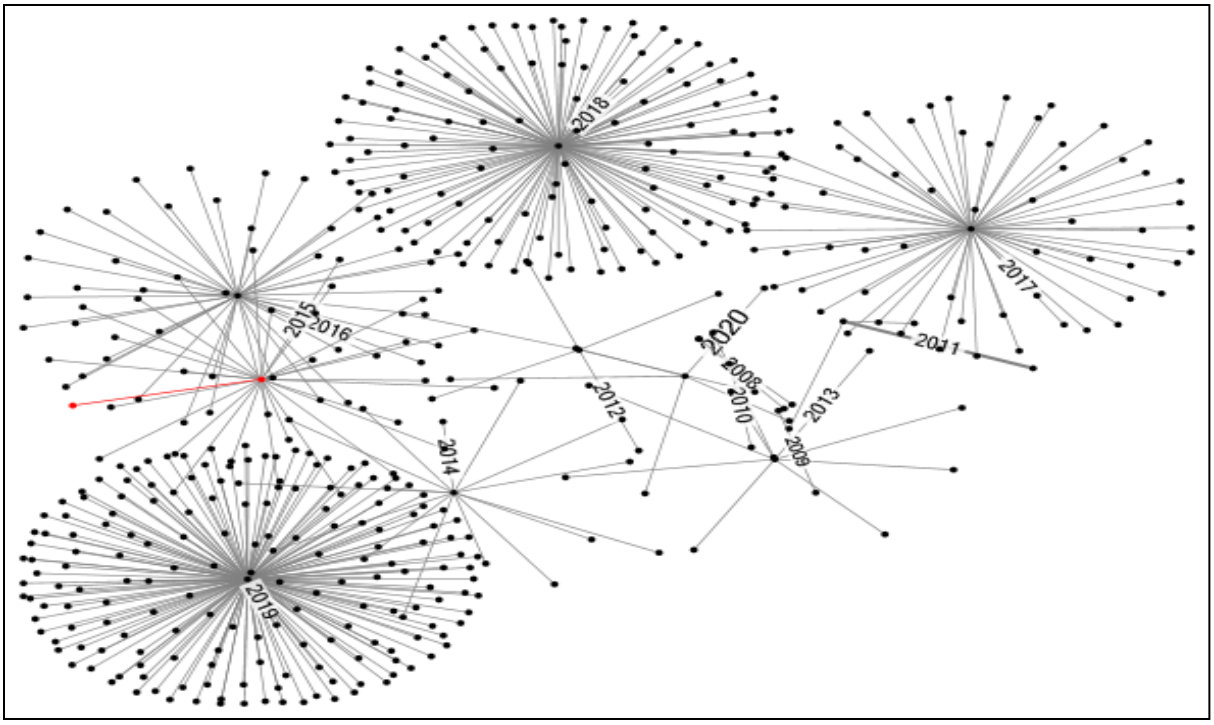

Figure 5. Network analysis diagram depicting cluster of publication year and its title.
(Source : https://nodexl.com/)

Figure 6 represents cluster of co-authors and authors co-appearing among the same papers. The collaborative work is shown among the authors. The link represents collaborative work of authors on the documents published. Threshold value for author having minimum number of documents was set manually to 2 which resulted into 191 authors. The total strength of the co-authorship links with other authors is calculated and displayed in Figure 6.

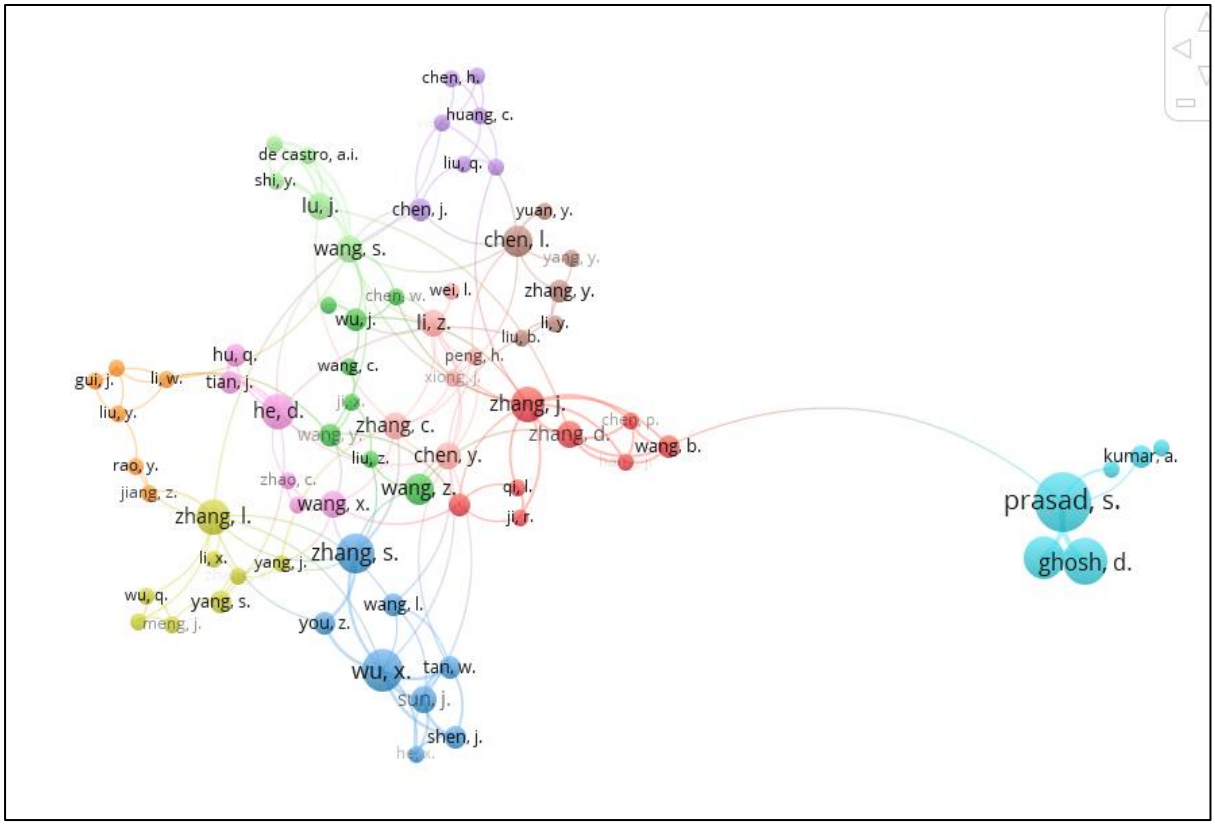

Figure 6: Network analysis diagram of co-authors and authors based on co-appearance among the same papers
(Source : https://www.vosviewer.com)

Figure 7 describes about the network map of publication title and the citations received by publications published in it. Gephi an open software is used to draw this diagram. The Fruchterman-Reingold layout is used to plot diagram. Layout shows 288 number of nodes as publication title is a collaborative work of the authors and 473 edges. The edges were set to in degree property which means that the arrows coming towards a certain node has cited that particular paper. The dark green color dot represents the publication title that received highest number of citations.

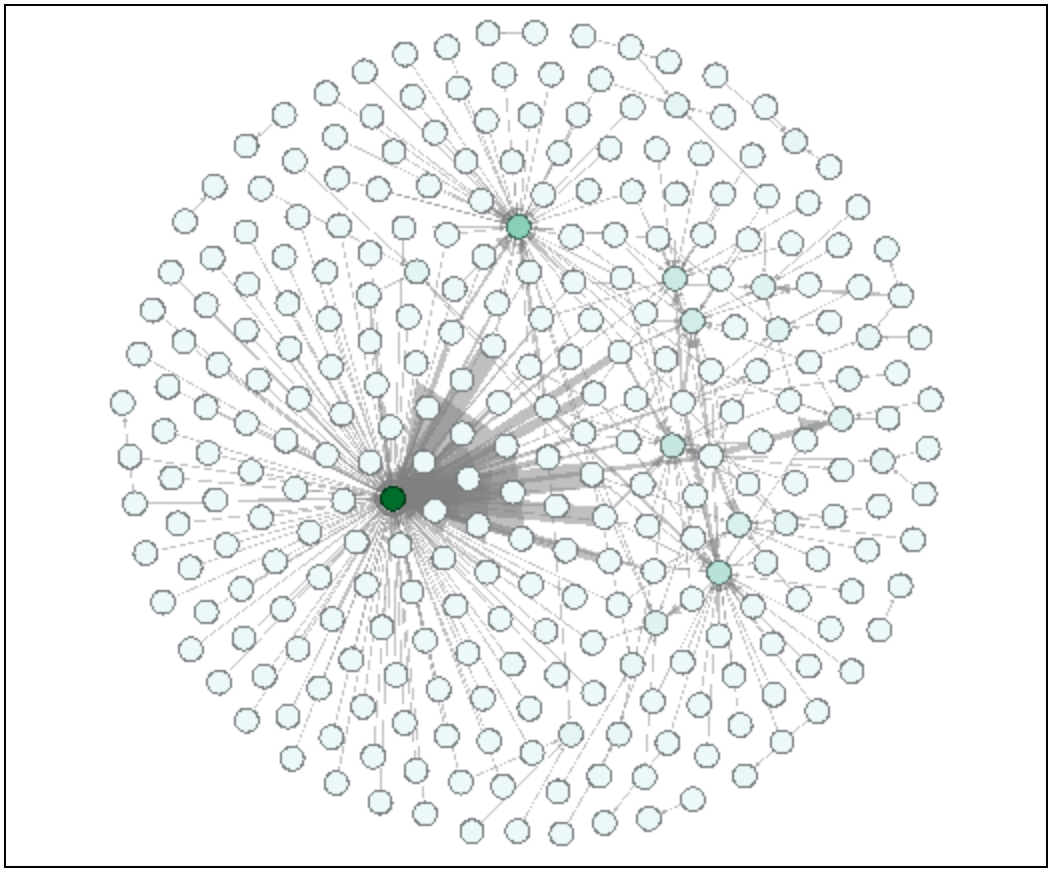

Figure 7 : Network map of publication title and the citations received by publications (Source : https://gephi.org/)

3.4 Statistical analysis based on Subject areas

Figure 8 shows compartmentalization of publications in different disciplines retrieved for plant leaf disease publications. It can be easily concluded from this figure that majority of the research is carried out in Computer Science area followed by engineering and agricultural and biological sciences area. Few research have been carried out in the area of energy.

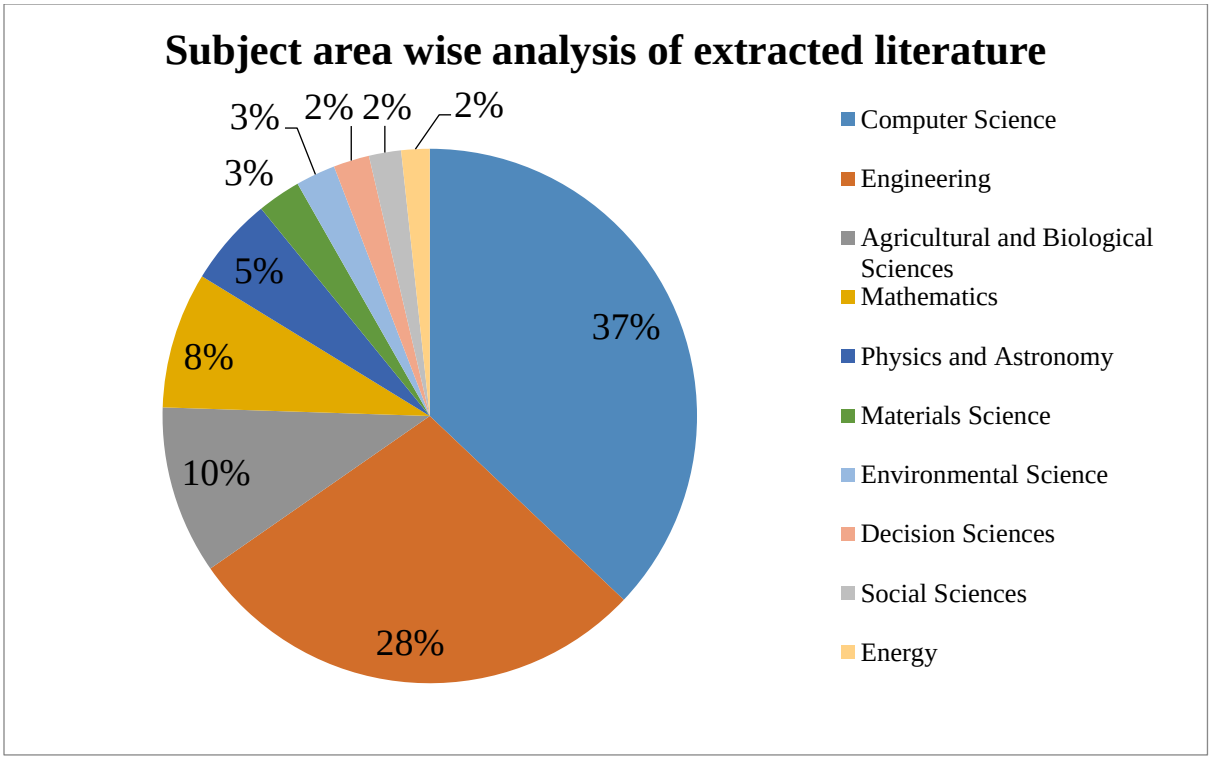

Figure 8: Subject area wise analysis of extracted literature for plant leaf diseases.

Data access information source: http://www.scopus.com (accessed on 18th October 2019)

3.5 Statistical analysis based on Affiliations

The topmost ten universities and organizational affiliations contributing towards the field of plant leaf disease are represented in Figure 9. The Indian Institute of Technology, Roorkee shows maximum contribution towards the research in the field of plant leaf disease diagnosis followed by China Agricultural University. It can be clearly observed that Indian universities are captivating this field of research as seven out of the top ten universities or organizations are from India.

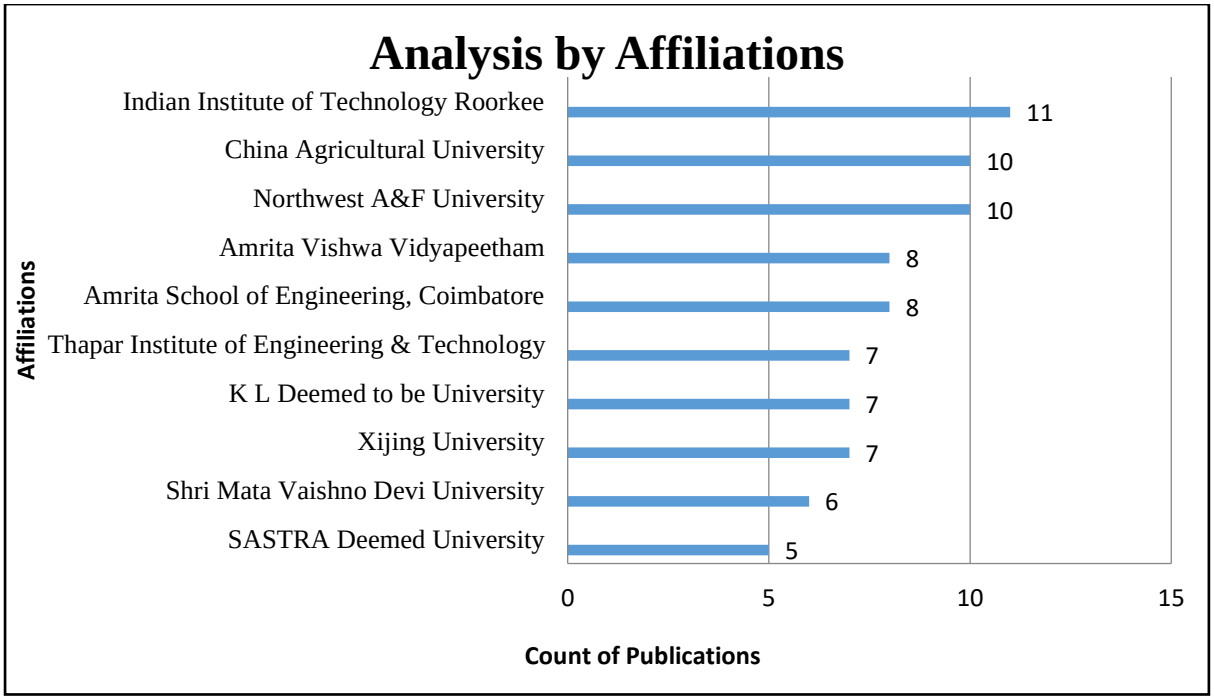

Figure 9: Affiliation statistics for plant leaf diseases

Data access information source: http://www.scopus.com (accessed on 18th October 2019)

3.6 Statistical analysis based on Authors

Figure 10 depicts the top ten authors contributing in the area of plant leaf diseases in order to understand the impact of a particular author. Majority of the top ten authors are from India.

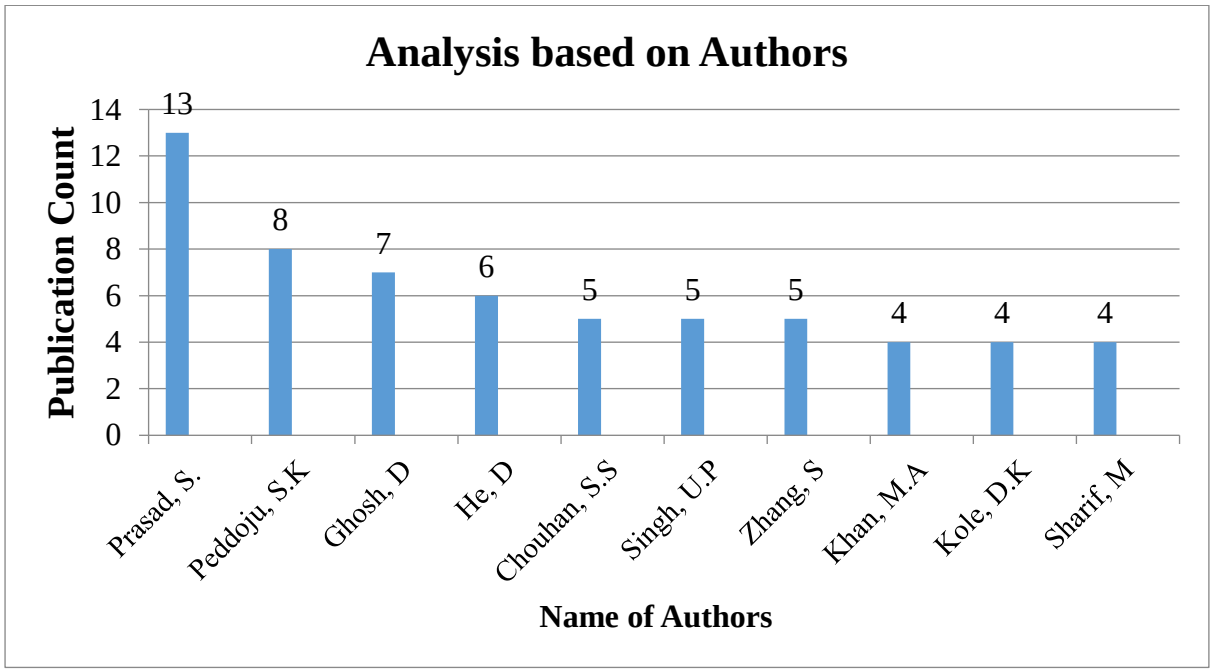

Figure 10: Top ten authors contributing to research area of plant leaf disease

Data access information source: http://www.scopus.com (accessed on 18th October 2019)

3.7 Statistical analysis based on Source Types

Source types of the scholarly articles means where the original research work is published. From the Scopus extracted literature of plant leaf disease, it can be clearly stated that 55% of the publications are from Journals followed by 35% publications in Conference proceedings. It has been observed that review publications for the plant leaf disease are not retrieved. Therefore this becomes one of the motivations to write this bibliometric review on plant leaf disease.

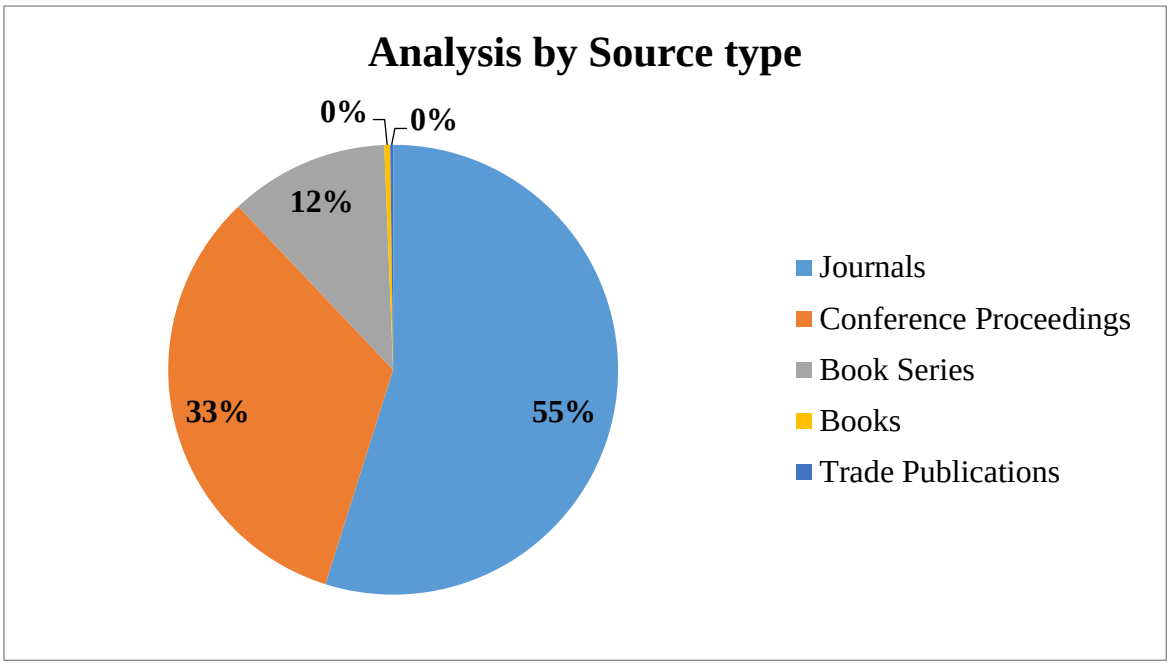

Figure 11: Source types for publications in plant leaf diseases
Source: http://www.scopus.com (accessed on 18th October 2019)

3.8 Analysis based on publication citations

Table 7 depicts citations count on yearly basis derived through publications extracted in the area of plant leaf disease. Till date the total citation count of 472 publications is 1862. Very few documents are cited from the years 2010 to 2012 summing up to eight citations while maximum number of citations are seen in the year 2019 followed by 2018.

Table 7: Analysis based on citations for publications in plant leaf disease

Year	<2012	2012	2013	2014	2015	2016	2017	2018	2019	Total
No. of Citations	8	23	37	44	63	92	216	509	870	1862

Data access information source: http://www.scopus.com (accessed on 18th October 2019)

The top ten publication titles extracted from Scopus database that received maximum number of citations till date are represented in Table 8. It can be inferred that the research work with the title ‘Detection of unhealthy region of plant leaves and classification of plant leaf diseases using texture features’ gains maximum number of citations in this field of research.

Table 8 : An analysis of top ten publication based on citations in plant leaf diseases

Publication Title	Citations received by the Publications yearly									
	<2012	2012	2013	2014	2015	2016	2017	2018	2019	Total
Detection of unhealthy region of plant leaves and classification of plant leaf diseases using texture features.	-	-	2	3	12	7	17	22	31	94
Detection of plant leaf diseases using image segmentation and soft computing techniques	-	-	-	-	-	-	5	28	50	83
A survey of image processing techniques for plant extraction and segmentation in the field	-	-	-	-	-	-	14	39	32	85
Detection and classification of leaf diseases using K-means-based segmentation and neural-networks-based classification	1	5	7	6	11	4	10	11	13	68
Grape leaf disease detection from color imagery using hybrid intelligent system	1	5	6	5	8	5	5	14	12	61

Plant disease detection using image processing	-	-	-	-	-	2	7	25	22	56
Applications of smartphone-based sensors in agriculture: A systematic review of research	-	-	-	-	-	5	8	11	18	42
Leaf image based cucumber disease recognition using sparse representation classification	-	-	-	-	-	-	6	10	18	34
Identification of apple leaf diseases based on deep convolutional neural networks	-	-	-	-	-	-	-	9	23	32
Deep Learning for Tomato Diseases: Classification and Symptoms Visualization	-	-	-	-	-	-	1	11	16	28

Data access information source: http://www.scopus.com (accessed on 18th October 2019)

3.9 Statistical analysis based on source titles

Statistics based on top ten source titles from retrieved literature are represented in Figure 12 for publications in plant leaf disease, it is clearly observed that maximum numbers of publications are done in source title Computer and Electronics in Agriculture. However IEEE Access, ACM International Conference Proceedings are less used by the researchers to publish their scientific documents.

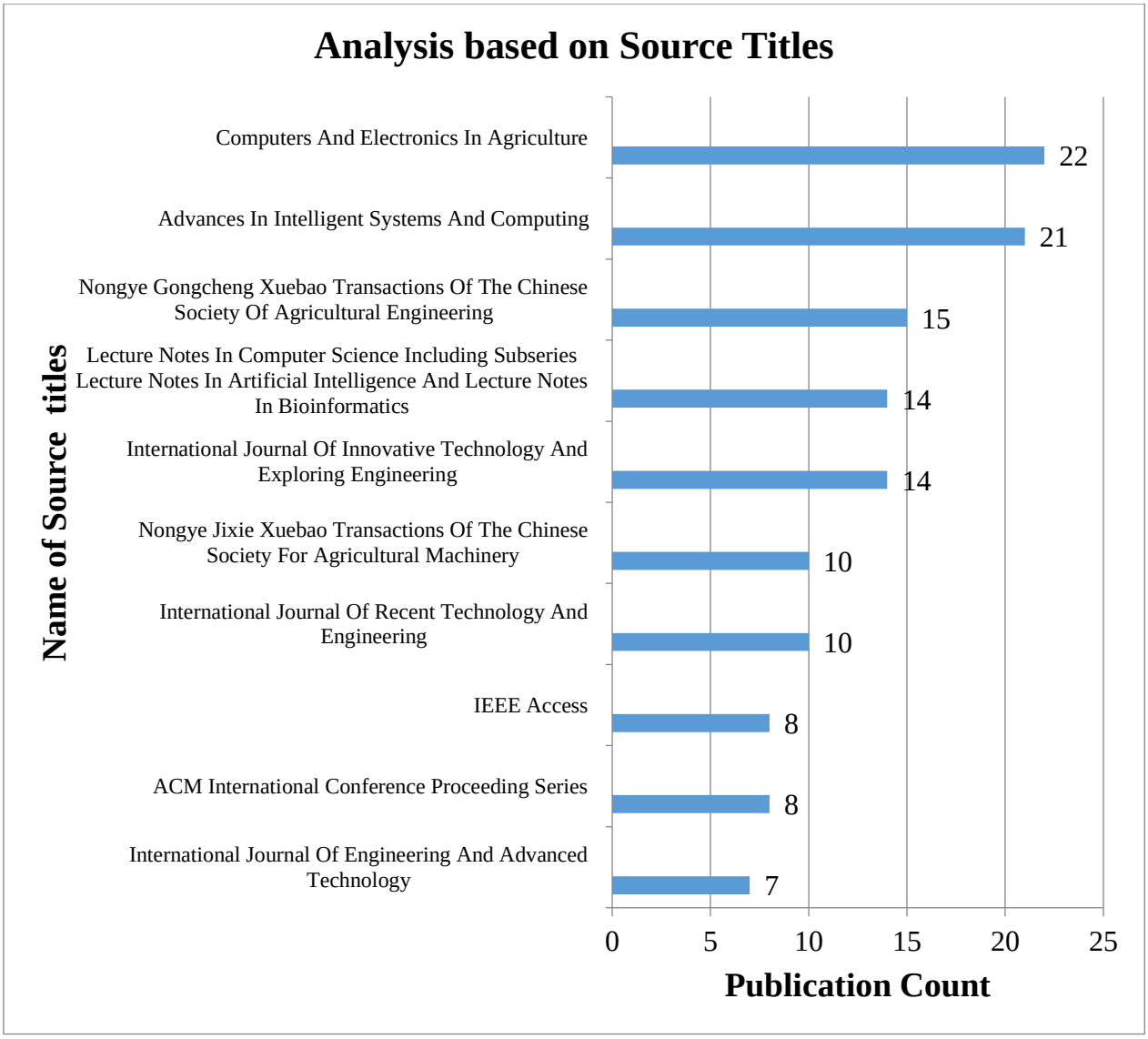

Figure 12: Source statistics for publications in plant leaf diseases
Data access information source: http://www.scopus.com (accessed on 18th October 2019)

3.10 Analysis based on Funding Sponsors

Statistical analysis based on Funding sponsors in the plant leaf diseases diagnosis research area is shown in Figure 13. The top 10 funding sponsors are considered and can based on the statistics it can be clearly inferred that National Natural Science Foundation of China is the highest funding foundation also seven out of ten funding sponsors are from China followed by India.

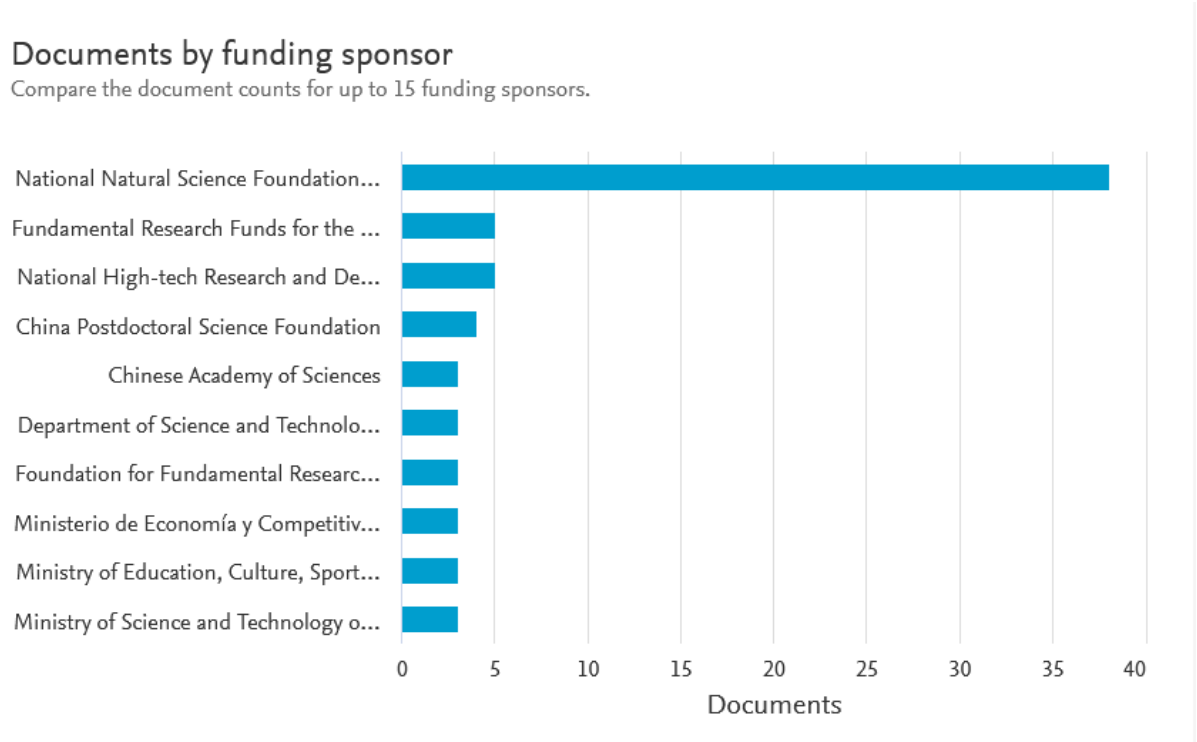

Figure 13: Funding Sponsors statistics in plant leaf disease diagnosis research area
Data access information source: http://www.scopus.com (accessed on 18th October 2019)

4. INFERENCES DRAWN FROM THE RESEARCH STUDY

Research in the area of plant leaf diseases diagnosis is spanning its boundaries throughout the world and it is extending tremendously. This study will put light on the prominence of contribution towards diagnosis of plant leaf diseases using Artificial Intelligence research area.

The types of publications in the respective field of research are majorly Articles followed by Conference papers. These are the effective channels to brainstorm about the research idea and based on the feedback given by the scholars refine the research questions. English language is used by majority of the researchers to publish the documents. It is observed that very less contribution was made towards publishing the documents in the initial years of 2008 to 2011. However the graph is growing every year and thus making 2019 and 2018 to publish maximum number of documents respectively in this research domain.

Countries like India and China are contributing more towards the research in this area. It can be very well inferred that Journals are the major source types used by the researchers to publish their scientific documents. Based on the extracted literature, it is observed that out of 472 papers only thirteen are review papers. The keywords in table 6 of a bibliometric analysis of plant leaf disease are Image Processing, Image Segmentation, Plants (botany), Feature Extraction, Neural Networks, and Classification (of Information). It can be thus inferred that keywords are the more targeted domains in the field of plant leaf diseases and should be explored more.

From the statistics it can be clearly stated that Indian universities along with Indian authors are at the top in contribution towards this research field. It can be concluded that maximum number of citations are seen in the year 2019 while very few citations are seen from year 2008 to 2010. With the arising need to explore the field of diagnosis of plant leaf diseases, researchers can investigate this area which was overlooked in the past.

5. LIMITATIONS OF THE PRESENT STUDY

The publications that are available only in Scopus database are considered for the present study. There may be scientific documents from other research databases such as Web of Science, Google Scholar that are not considered for the current research analysis. The keywords used for querying the Scopus database were selected by the authors. The combination of keywords used of the purpose of analysis can be re-arranged, modified and updated as per the researcher's perspective. The articles from publication year 2010 to 2019 are considered for analyzing the results. The documents in English language are considered for this research study. The secondary documents available in the Scopus is not the part of research study. Those documents can be incorporated for further study purpose as well.

6. CONCLUSION

The bibliometric study is used to evaluate the research documents and to produce the information that can be used by the researchers in the particular research field. It will help to write the literature survey. This study can also help to find the gap in the literature and shall also help to map the gap. This study helps to find out the recent trends in the field of research. The amount of collaborative work of authors represents a trend that shows inclination of authors towards collaborative work. Compared to organizations, universities lead the contribution. India leads the plant leaf disease research with 47.2 % contribution for the time period 2010 to 2019. Out of the top ten universities contributing to the research area around the world, seven universities are from India. The findings of the study reveal that research must be oriented towards those subject areas that benefit the people those who are working in the field and can gain more profit from plants as it play major role in the life of mankind.

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