ASEAN Journal of Science and Engineering

Journal homepage: http://ejournal.upi.edu/index.php/AJSE/

Scientific Research Trends of Flooding Stress in Plant Science and Agriculture Subject Areas (1962-2021)

Arinal Haq Izzawati Nurrahma[1,], Hana Haruna Putri[2], Ray March Syahadat[3]*

[1] Executive Secretariat, National Research and Innovation Agency, Indonesia
[2] Graduate School of Agriculture, Forestry, and Fisheries, Kagoshima University, Japan
[3] Department of Landscape Architecture, National Institute of Science and Technology, Indonesia
*Correspondence: E-mail: arinal.haq.izzawati.nurrahma@brin.go.id

ABSTRACTS

Data collection was gathered from PubMed, Google Scholar, Semantic Scholar, and Crossref in Harzing"s Publish or Perish software. The keyword used in this study was "Flooding Stress" with the publication year of the 1962-2021 articles. Results showed that PubMed retrieves more relevant manuscripts from journal sources than other databases. The search method by whole years was the most effective and efficient if the total manuscripts are less than 1000. Flooding stress-related manuscripts were published continuously from 1994 to 2021 with Annals of Botany as the most productive journal. A combination of "Flooding Stress" with related keywords, e.g., submergence stress, anaerobic stress, and oxidative stress, improves the relevancy of the manuscript results. VOSviewer keyword analysis found that there were 5 clusters discussing oxidative stress, tolerant mechanism, physiological mechanism, flood occurrence, and molecular mechanism. Based on the density visualizations, the anaerobic metabolism, mRNA expression level, SOD, fv/fm, leaf gas exchange, ABA biosynthesis, and halophyte lead to potential topics of flooding stress research to be studied in the future.

ARTICLE INFO

Article History:
Received 16 Apr 2022
Revised 03 Mei 2022
Accepted 12 Mei 2022
Available online 23 Mei 2022

Keyword:
Agriculture,
Bibliometric analysis,
Flooding stress,
Harzing's Publish or Perish,
Plant science,
VOSviewer.

1. INTRODUCTION

Floods are the most common type of natural disaster. On agricultural land, floods are generally caused by intensive or extensive rainfall over a certain period, but can also be caused by overflowing of water bodies overland (Fukao *et al*., 2019). It was the cause of nearly two-thirds of all crop damages and losses from 2006 to 2016, with a billion-dollar worth. The flooding's negative impacts on crops as a result of low O2 availability, require cross-disciplinary solutions (Pedersen *et al*., 2017). Therefore, it is necessary to map the research related to flooding stress to monitor to date research progress and determine areas that have not been studied much.

The subject area of plant science and agriculture covered resources that focus on the management of plant growth and development from seeds germination to post-harvest (Yuan & Sun, 2021). The research incorporates molecular biology and genetics, biochemistry, cell, hormone, and whole plant physiology (Visser *et al*., 2003). This paper's coverage is only limited to plant science and agriculture subject areas to focus on plant responses to flooding stress including the anatomical, morphological and physiological responses, mechanism of adaptation, to the way of developing new tolerant genotypes.

Bibliometric analysis is a popular and rigorous method of exploring and analyzing large volumes of scientific data. It enables us to unpack the evolutionary nuances of a specific field while shedding light on the emerging areas in the focused field. Recent applications have shown that such analyses can build firm foundations for advancing a field in novel and meaningful ways. It enables and empowers scholars to gain a one-stop overview, identify knowledge gaps, derive novel ideas for investigation, and position their intended contributions to the field (Donthu *et al*., 2021).

The bibliometric analysis required literature databases that differ in terms of coverage, focus, and tool provided (AlRyalat *et al*, 2019). Publish or Perish is a software program that retrieves and analyzes academic citations. It uses a variety of data sources to obtain the raw citations, then analyses these and presents a range of citation metrics, including the number of papers, total citations, and the h-index. For bibliometric research, it is important to understand the strengths and weaknesses of different bibliographic data sources. Because most researchers cannot retrieve large amounts of data from data sources (Harzing, 2019). PubMed, Google Scholar, Semantic Scholar, and Crossref are several databases available in Harzing's Publish or Perish software that can retrieve 1,000 scientific manuscripts in a search time.

This study aims to evaluate the most effective database available in Harzing"s Publish or Perish software, year ranges search methods, and the use of additional keywords to obtain the highest number of manuscripts from journal sources that are relevant to flooding stress in plant sciences and agriculture subject areas. Further, the study also aimed to assess publications of articles and review types on flooding stress research related to plant sciences and agriculture subjects from 1962 to 2021 by bibliometric science mapping and visualization tools. Network visualization of all keywords was done by VOSviewer. The results of this study will provide information on future prospective topics on flooding stress related to the plant science and agriculture subject area.

2. METHODS

In this study, data was retrieved on February 15, 2022, using Harzing's Publish or Perish software and then saved in the form of CSV and RIS files. The CSV dataset was opened to

DOI: http://dx.doi.org/10. 17509/xxxx.xxxx
p- ISSN 2776-6098 e- ISSN 2776-5938

select the article's relevance using Pivot Table of Microsoft Excel, based on the journal name and article title related to the Agriculture and Plant Science subject. The RIS dataset was opened using VOSviewer software to analyze the data into mapping visualization, years range, and keyword density (Mulyawati & Ramadhan, 2021). Then, all data were descriptively analyzed.

2.1. Comparison of article search results using PubMed, Google Scholar, Crossref, and Semantic Scholar Database

The keyword "Flooding stress" is used to search for articles using PubMed, Google Scholar, Crossref, and Semantic Scholar in Harzing's Publish or Perish software; then, the data were selected for relevance using the pivot table function in Microsoft Excel based on the journal name and the title of the article according to the subject Agriculture and Plant Science. The PubMed, Google Scholar, Crossref, and Semantic Scholar databases were chosen because of their ability to retrieve 1,000 manuscripts in a search time.

2.2. The Effectiveness of the search method with the Harzing"S Publish or Perish software by year of search

The search for articles with the keyword "Flooding Stress" was carried out using the 1962-2021 range which is divided into 3 periods of time, i.e., 1) dividing the 1962-2021 range into three searches per 20 years (1962-1981, 1982-2001, and 2002-2021), 2) dividing the 1962-2021 range into six searches per 10 years (1962-1971, 1972-1981, 1982-1991, 1992-2001, 2002-2011, and 2012-2021), and 3) searches with a range per year (1962-1962, 1963-1963, 1964-1964, etc. until 2021-2021). The search results are saved in CSV and RIS format. PubMed search was used because the results were more relevant to the requested keyword than other search facilities.

2.3. Combination of the search for the keyword "Flooding Stress" with other related keywords

Keywords "Flooding stress", "Anaerobic stress", "Oxidative stress", and "Submergence stress" were used as a single keyword to search the articles. Then the keyword of "Flooding Stress" was combined with "Anaerobic Stress", "Oxidative Stress" and "Submergence Stress" to search the manuscripts in PubMed search with the year range of 1962-2021.

2.4. Research trends on flooding stress from combined results for the keyword "Flooding Stress" in PubMed, Google Scholar, Crossref, and Semantic Scholar

The combined search results for the keyword keyword "Flooding stress" in PubMed, Google Scholar Search, Crossref, and Semantic Scholar were used for trend analysis of research on flooding stress using VOSviewer software. The minimum number of conjunctions in the use of Vosviewer is 10 words. This study occupied 53.505 terms in total, of which only 1.506 meet the threshold. For each of the 1.506 terms, a relevance score will be calculated to select the most relevant terms. The default choice in VOSviewer is to select 60% most relevant terms to be selected for visualization; in this study, 904 terms are selected.

3. RESULTS AND DISCUSSION

3.1. Comparison of article search results using PubMed, Google Scholar, Crossref, and Semantic Scholar database

The results of manuscripts retrieved from four search facilities in Harzing"s Publish or Perish software are shown in Table 1. Crossref and Semantic Scholar found articles with the

DOI: http://dx.doi.org/10.17509/xxxx.xxxx
p- ISSN 2775-6793 e- ISSN 2775-6815

flooding stress keyword according to the maximum number of searches, which is 1000 manuscripts. In terms of the number of manuscript duplications, Crossref and PubMed provide the minimum number of duplicate articles, namely 0 manuscripts. Crossref retrieved more irrelevant manuscripts than Semantic Scholar, PubMed, and Google Scholar (**Table 1**). This information also shows that although the number of manuscripts is quite large, the comparison of the number of relevant manuscripts is generally far less than irrelevant manuscripts.

Table 1. Comparison of manuscripts retrieved from the keyword "Flooding Stress" using different databases in Harzing's Publish or Perish software.

Database	Total Manuscripts	Duplicate Manuscripts	Irrelevant Manuscripts	Relevant Manuscripts
Crossref	1000	0	899	101
Google Scholar	997	6	292	699
PubMed	943	0	537	406
Semantic Scholar	1000	6	605	389

Table 2 shows the total sources of manuscripts and their types from Crossref, Google Scholar, PubMed, and Semantic Scholar in Harzing's Publish or Perish software. The search using Crossref and PubMed found 36 and 105 manuscript sources, respectively, which all came from journals. PubMed offers a quick free search with numerous keywords as well as limited searching with various criteria [i.e., search by authors, journal, date of publication, date of addition to PubMed, or type of article] (Falagas *et al*., 2008). Crossref itself is a registration agency for DOIs. When a scientific publisher works with Crossref to register a DOI for a document, the publisher provides the metadata for this document to Crossref. This metadata is then made openly available by Crossref (with the possible exception of the reference list, for which the publisher determines whether it is made openly available or not) (Visser *et al*., 2021).

Google Scholar provided the highest number of relevant manuscripts compared to other search tools (**Table 1**). This has occurred because the Google Scholar database is part of the worldwide web (www) search engine that crawled the web and indexes any document with a seemingly academic structure (Martín-Martín *et al*., 2018). It, given Google Scholar, has no limits on the language coverage, keywords allowed per search, and list of covered journals (Falagas *et al*., 2008; Gusenbauer, 2019). Manuscripts retrieved from Google Scholar came from 392 sources, which is the largest database compared to others, consisting of 4 online sites, 32 proceedings, 337 journals, and 26 from other sources (**Table 2**).

Table 2. The type of manuscript sources that each database retrieved in Harzing"s Publish or Perish software.

Database	Total Manuscript Sources	Types of Manuscript Sources			
		Online Site	Proceeding	Journal	Others
Crossref	36	0	0	36	0
Google Scholar	392	4	32	337	26
PubMed	105	0	0	105	0
Semantic Scholar	Undefined	Undefined	Undefined	Undefined	Undefined

DOI: http://dx.doi.org/10. 17509/xxxx.xxxx
p- ISSN 2776-6098 e- ISSN 2776-5938

Meanwhile, the Semantic Scholar database in Harzing's Publish or Perish software does not provide facilities to track where the source of the manuscript comes from (**Table 2**). Semantic Scholar is artificial intelligence (AI)-based search engine that saves users time because it removes the long tail of search results, allowing quick up-to-date of one"s disciplines while limiting distraction caused by less relevant research (Fricke, 2018).

PubMed and Semantic Scholar's main reasons for the irrelevant manuscript in Table 1 are because the two databases were the search engine for medical literature, though currently has expanded the coverage to nature and life science (Falagas *et al*., 2008; Fricke, 2018). This manuscript source information is useful for researchers who want to find manuscripts from certain sources, such as only from journal sources.

3.2. The effectiveness of the search method by year of search with the Harzing's Publish or Perish software.

This research was carried out because the search limitation of 1000 articles per search is very possible for elimination by search engines if the search is carried out with a long enough range of years with the number of articles more than 1000. To find out whether the search results with one search will be the same as the search results per year, in terms of number, level of relevance of the articles obtained, number of duplications, and search effectiveness. Referring to the results of **Table 2**, where the PubMed search resulted in the most manuscripts from journal sources only, the effectiveness of this search method with different year ranges only used the PubMed search method.

The results of the search by year are the acquisition of the highest total number of manuscripts compared to other search ranges with the most duplicates and irrelevant manuscripts as well. Searches with a range of 10 years show fewer total numbers of manuscripts than searches per year. Search with a span of 20 years and direct searches for the whole year provide total manuscripts that are not much different, namely 944 and 943 manuscripts without a single manuscript duplicate. However, the direct search for all years was better in terms of the number of relevant manuscripts retrieved (**Table 3**).

Table 3. Comparison of search methods based on a range of years using Harzing's Publish or Perish software.

Search Methods	Total Manuscripts	Duplicate Manuscripts	Irrelevant Manuscript	Relevant Manuscript
By year	1077	17	671	389
By 10 Years	962	9	558	395
By 20 years	944	0	544	400
By whole years	943	0	537	406

3.3. Trend of the manuscript number and the most productive journals related to "Flooding Stress" from 1962-2021.

The search for the number of manuscripts was carried out between the years 1962-2021. However, no manuscripts were published between 1962-1979, so only the data range from 1980 to 2021 is shown in **Figure 1**. Flooding stress-related manuscripts were published continuously from 1994 to 2021 although the number of manuscripts fluctuates every year. The manuscript number achieves the peaks in 2021, which is 59 manuscripts. It can be said that the topic of flood stress is increasingly in demand. This is closely related to the threat of climate change, which is becoming more and more real and has an impact on the

DOI: http://dx.doi.org/10.17509/xxxx.xxxx
p- ISSN 2775-6793 e- ISSN 2775-6815

environment, including agriculture. If seen, this trend emerged in the middle of the decade of the 2000s. As we know, at that time environmental communication on climate change was indeed heavily reported, and this seems to affect research trends related to flood stress to anticipate, or maybe it has already happened in the agricultural world (Heyhoe *et al*., 2007; Jacobsen, 2011; Lin, 2013; Shrestha *et al*., 2019).

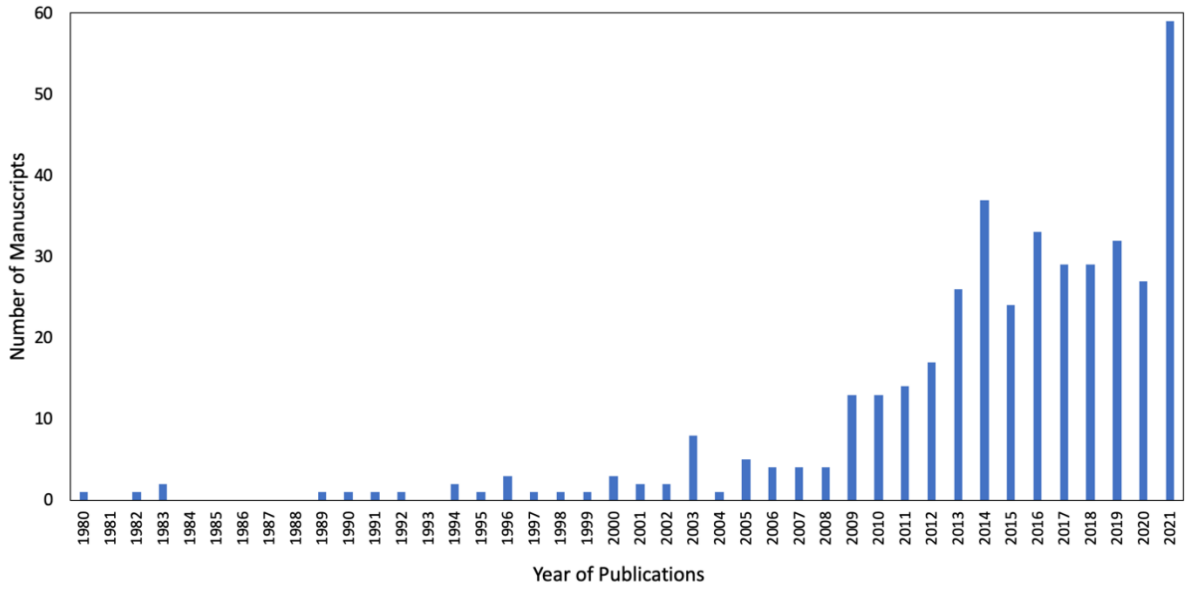

Figure 1. The trend of Flooding Stress-related manuscripts published between 1980-2021.

Figure 2 shows the top ten journals with the highest accumulated number of manuscripts related to "Flooding Stress" from 1962 to 2021. Sequentially from the largest number of manuscripts are Annals of botany; Frontiers in plant science; Journal of proteomics; Journal of proteome research; Plant, cell & environment; Plant physiology; International journal of molecular sciences; Plant physiology and biochemistry: PPB, Plants (Basel, Switzerland); and Scientific reports. Of the ten journals, we specifically investigated when the journal started publishing manuscripts and how the number of manuscripts has progressed periodically in **Table 4** and **Figure 3**.

Table 4 provides information on the ranking of the journals based on the number of manuscripts related to "Flooding Stress" every 10 years. There is no journal publishing the manuscript between 1962-1971. Plant physiology and Planta began publishing manuscripts in 1972-1981. From 1982-to 1991, Plant physiology still ranked first, followed by two new journals, namely Evolution: International Journal of Organic Evolution and The Journal of Biochemistry. In the next 10 years (1992-2001), the Annals of botany replaced Plant physiology in the first place. Starting in 2002, new journals have been introduced changing the lead of top ranks. Journal of proteome research leading in 2002-2011 followed by Journal of proteomics. Frontiers in plant science are in 7th place in 2002-2011, then lead as the top ranks in 2012-2021.

The question rises about the publication continuity of journals that have existed since early 1972. To do this, we study the consistency of the number of manuscripts related to "Flooding Stress" published specifically in the journals Plant physiology, Planta, Evolution; international journal of organic evolution; The journal of biological chemistry; and Annals of Botany as the leading journals in **Figure 3**.

DOI: http://dx.doi.org/10. 17509/xxxx.xxxx
p- ISSN 2776-6098 e- ISSN 2776-5938

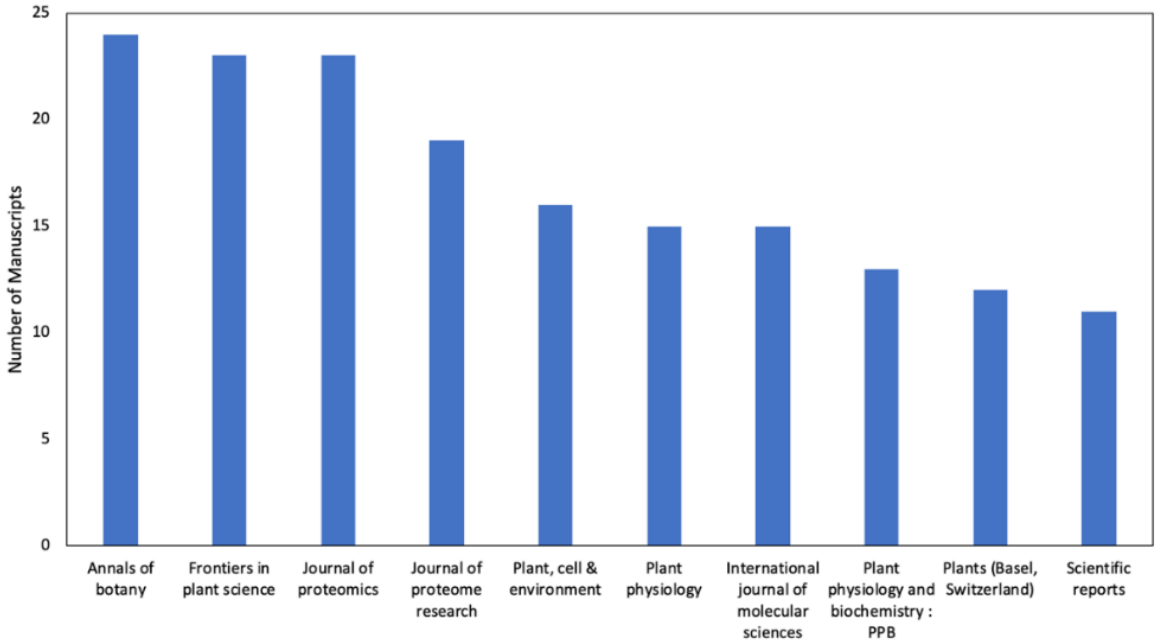

Figure 2. Journal with the highest number of manuscripts related to "Flooding Stress" since 1962-2021.

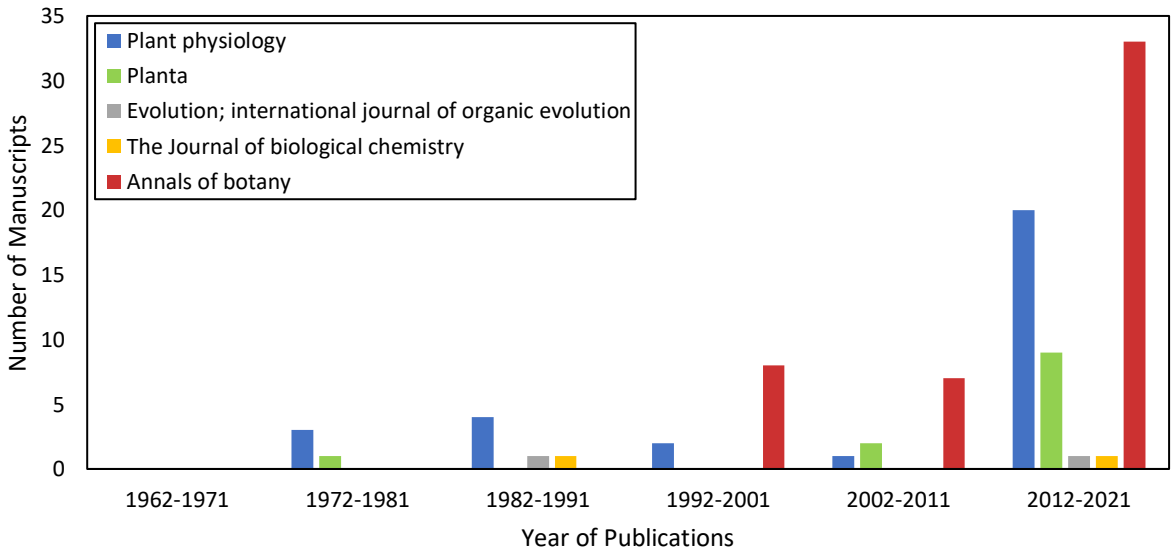

Figure 3. Trend the number of manuscripts related to “Flooding Stress” in the eldest journals between 1962 and 2021.

Plant physiology is the oldest and most productive journal that published manuscripts related to “Flooding Stress” although the number of manuscripts is periodically surpassed by Annals of Botany from 1992 to 2001 (**Figure 3**). Other new emerging journals also surpass plant physiology in the following years, that is, the Journal of the proteome in 2002-2011 and Journal of proteomics in 2002-2021, and Frontiers in plant science in 2012-2021 (**Table 4**). The new emerging journals started publishing later but accumulated more publications than the earlier published journals. This is most likely because these new emerging journals have more publication capacity per year than previous journals.

DOI: http://dx.doi.org/10.17509/xxxx.xxxx
p- ISSN 2775-6793 e- ISSN 2775-6815

Table 4. Journal rankings are based on the highest number of manuscripts related to "Flooding Stress" by 10 years between 1962 and 2021.

Journal Ranks	Year of Publications					
	1962-1971	1972-1981	1982-1991	1992-2001	2002-2011	2012-2021
1		Plant physiology	Plant Physiology	Annals of Botany	Journal of proteome research	Frontiers in plant science
2		Planta	Evolution; International Journal of Organic Evolution	Plant Physiology	Journal of proteomics	Journal of proteomics
3			The Journal of Biochemical Chemistry	Journal of Experimental Botany	Plant, cell & environment	Annals of Botany
4				Oecologia	PloS one	International Journal of Molecular Sciences
5				Tree Physiology	Annals of Botany	Journal of proteome research
6				Biochimica et Biophysica Acta	AoB PLANTS	Plant, cell & environment
7				Die Naturwissenschaften	Frontiers in plant science	Plants (Basel, Switzerland)
8				Functional plant biology: FPB	Journal of Plant Physiology	Scientific reports
9				Nature	Plant biology (Stuttgart, Germany)	Plant physiology and biochemistry: PPB
10				Plant & cell physiology	Plant physiology and biochemistry: PPB	Plant Physiology

3.4. The combination of "Flooding Stress" with other related keywords.

Searching with a single keyword will get a total number of manuscripts with a large number of irrelevant manuscripts as well. This is because single keywords are multi-interpreted by search engines to get articles from various scientific backgrounds. Adding other keywords related to "Flooding Stress" such as "Submergence Stress", "Anaerobic Stress", and "Flooding Stress" is expected to increase the relevance of the manuscript obtained from the search.

DOI: http://dx.doi.org/10. 17509/xxxx.xxxx
p- ISSN 2776-6098 e- ISSN 2776-5938

The single keyword of "Anaerobic Stress" and "Oxidative Stress" obtained more than 96% of irrelevant manuscripts. A combination of "Flooding Stress" and "Submergence Stress" as well as "Flooding Stress" and "Anaerobic Stress" obtained 100% relevant manuscripts. Although the combination of "Flooding Stress" and "Oxidative Stress" only obtained 62.3% of the relevant manuscripts (**Table 5**).

Table 5. Comparison of search methods based on a range of years using Harzing's Publish or Perish software.

Keywords	Number of manuscripts	Irrelevant Manuscripts	Relevant Manuscripts
Flooding Stress	943	537	406
Submergence Stress	342	109	233
Anaerobic stress	968	932	36
Oxidative stress	168	165	3
Flooding Stress, Submergence Stress	128	0	128
Flooding Stress, Anaerobic Stress	61	0	61
Flooding Stress, Oxidative Stress	85	32	53

The word anaerobic indicates a condition that occurs without oxygen, which occurs in many things, i.e., anaerobic respiration (Lovley *et al*., 1999), anaerobic exercise (Patel *et al*., 2017), anaerobic bacteria (Thauer *et al*., 1977), etc. The wide meaning of anaerobic stress is the main reason for the ineffectiveness of a manuscript related to the subject area of plant science and agriculture when anaerobic stress is used as a single keyword. Despite this, it also describes the main problem of flooding stress (Vartapetian & Jackson, 1997). Oxidative stress is defined as a disturbance in the balance between the production of reactive oxygen species (free radicals) and antioxidant defenses (Betteridge, 2000). Oxidative stress occurs in living body cells, that is, humans (Betteridge, 2000; Pizzino *et al*., 2017), plants (Chaki *et al*., 2020), and animal cells (Puppel *et al*., 2015). Then submergence is defined by the depths of water that covered the entire surface of the plant for a long period. When anaerobic, submergence, and oxidative keywords are combined with flooding stress, the results of relevant manuscripts improved.

3.5. Bibliometric and Visualized Analysis of Scientific Publications on Flooding Stress

Keyword co-occurrence is one of the content analysis methods to discover directions and popular topics in research. Keywords are very useful in interpreting the scope of the research scope and the main themes of each study (Mubaroq *et al*., 2020). VOSviewer provides three different mapping visualizations, namely network visualization, overlay visualization, and density visualization. Keywords are labeled with a colored circle. The size of the circles shows a positive relationship between the occurrence of keywords in the title and the abstract. Therefore, the size of letters and circles is determined by the frequency with which they appear. The more often a keyword appears, the larger the font and circle size will be (Hamidah *et al*., 2021; Nandiyanto & Al Husaeni, 2021).

The results of the VOSviewer keyword analysis are shown in **Figures 4, 5, 6**. After being analyzed using VOSviewer, there are 5 clusters (red, green, blue, yellow, and purple) that show the relationship between one topic and another (Hamidah *et al*., 2021). The analysis of the clusters formed by keywords allows the classification of the different groups into which research trends are grouped (**Table 6**).

DOI: http://dx.doi.org/10.17509/xxxx.xxxx
p- ISSN 2775-6793 e- ISSN 2775-6815

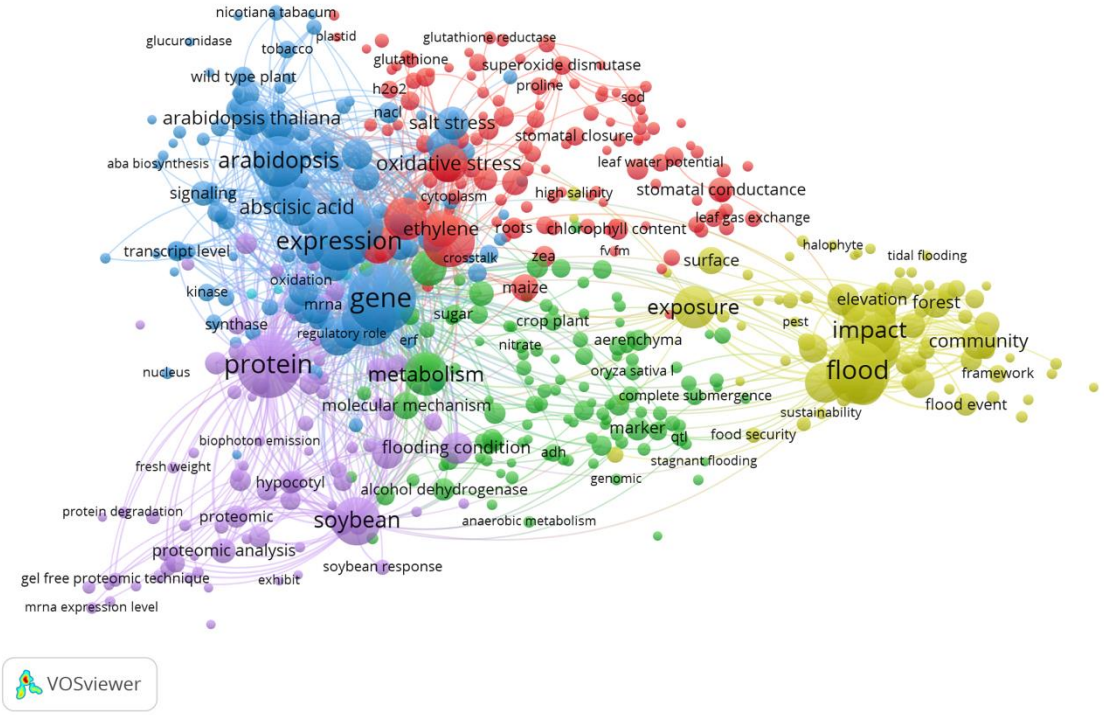

Figure 4. Network visualization of scientific research on flooding stress related to plant science and agriculture subject area.

The first of these groups, shown in red, is related to oxidative stress. This is reflected in the main keywords associated with this cluster: Oxidative stress, superoxide dismutase, antioxidant, chlorophyll, and peroxidase. Reactive Oxygen Species (ROS) (e.g., superoxide, superoxide, and hydrogen peroxide) are normally products of oxygen metabolism from the processes of respiration and photosynthesis in mitochondria, peroxisomes, and chloroplasts (Singh *et al*., 2016). Superoxide dismutases (SOD) are a class of enzymes that catalyzes the dismutation of superoxide into oxygen and hydrogen peroxide (Alscher *et al*., 2002). ROS can play positive roles in cell signaling and homeostasis or act as harmful in causing irreversible damage to DNA depending on the balance between ROS production and the disposal by antioxidant systems (Blokhina *et al*., 2001). Excess ROS production can be triggered by environmental stress (e.g., flooding stress) that causes significant damage to the cell structure known as oxidative stress (Das & Roychoudhury, 2014).

The second cluster, in green, is focused on the tolerant mechanism in flooding stress, as shown by keywords such as metabolism, submergence tolerant, marker, tolerant mechanism, and QTL. Plant adaptations to complete submergence have recently been classified into two main strategies: Low-oxygen-quiescence syndrome (LOQS) and low-oxygen-expiration syndrome (LEOS). Plants with the LOQS characterized by a lack of a shoot extension to conserve substrates for enhancement of survival until waters recede have fitness advantages in environments with short-duration floods (Bailey-Serres & Voesenek, 2008). This trait has been demonstrated for rice elongation response in lowland rain-fed which is controlled by one polygenic locus (Sub1) on chromosome 9 (Fukao *et al*., 2006). LOES has been studied in detail in *Rumex palustris* and deepwater rice in response to shooting extension. Shoot emergence is highly beneficial to the improved exchange of gases and the re-start of aerial photosynthesis (Bailey-Serres & Voesenek, 2008).

The third cluster, in blue, appears to be the central cluster and is related to the physiological mechanism. The main keywords are gene, expression, signaling, transcription

DOI: http://dx.doi.org/10. 17509/xxxx.xxxx
p- ISSN 2776-6098 e- ISSN 2776-5938

factor, and plant hormone. The elongation responses are initiated by the accumulation of the volatile hormone ethylene inside submerged plant tissues (Jackson 2008). Subsequently, the interplay of various other plant hormones such as gibberellic acid (GA) and abscisic acid (ABA) and more downstream targets at the cell wall level, such as cell wall acidification and expansion results in the elongation of shoot organs (Bailey-Serres & Voesenek, 2008; Jackson, 2008). The availability of the *Sub1A* gene in rice submergence cultivars restricts further ethylene production and dampens GA responsiveness, causing shoot tissue to dampen carbohydrate consumption, chlorophyll breakdown, amino acid accumulation, and elongation growth (Fukao, Yeung, & Bailey-Serres, 2012).

The fourth cluster, in yellow, is engaged in the search for flood occurrence. The main keywords are flood, exposure, impact, habitat, flood event, and tidal flooding. Based on the duration and depth of water, there are three types of floods often occurring on rice plants: flash flooding, stagnant flooding, and deep-water flooding (Panda & Barik, 2021).

The fifth cluster, in purple, is focused on the molecular mechanism. The main keywords are protein, proteomic analysis, secondary metabolism, molecular mechanism, and protein degradation. The molecular mechanism includes the process that occurs in DNA, RNA, and protein synthesis (Poole *et al.*, 1998). Many researchers have elucidated molecular mechanisms and identified genetic factors involved in flood tolerance, in particular identification of the SUB1A, OsTPP7, SK1/2, and SD1-DW (Kuroha & Ashikari, 2020; Kuroha & Ashikari, 2020).

Table 6. Keywords used by communities detected on the topic of flooding stress.

Cluster	Color	Keywords	Topic
1	Red	Oxidative stress, superoxide dismutase, antioxidant, chlorophyll, peroxidase.	Oxidative stress
2	Green	Metabolism, submergence tolerant, marker, tolerant mechanism, QTL.	Tolerant mechanism
3	Blue	Gene, expression, signaling, transcription factor, plant hormone.	Physiological mechanism
4	Yellow	Flood, exposure, impact, habitat, flood event, tidal flooding.	Flood occurrence
5	Purple	Protein, proteomic analysis, secondary metabolism, molecular mechanism, protein degradation.	Molecular mechanism

Overlay visualizations can be used to show the developments of research topics over time. The study of topics related to flooding stress over time is presented in Figure 5. In early 2006, the topics studied included flood events, salt stress, stomata closure, flooding in *Arabidopsis thaliana* and *Nicotiana tabacum*, and the effects of flooding on chlorophyll and plant roots. Study of plant physiology (i.e. plant metabolism, gene expression, protein) and flood occurrence (i.e. exposure, impact, community, event) were massively conducted between 2008 to 2012. Advanced study of flooding stress-related topics after 2014 mainly exploring the molecular mechanism, which includes mRNA expression, marker, and proteomic analysis.

Density visualizations show the topic based on massive discussions. The topic of a flood, impact, gene, expression, protein, Arabidopsis, and oxidative stress is the most discussed in research on flooding stress. Anaerobic metabolism, mRNA expression level, SOD, fv/fm, leaf gas exchange, ABA biosynthesis, halophyte, etc. are less discussed, which leads to potential topics to be studied in the future of flooding stress research (**Figure 6**).

DOI: http://dx.doi.org/10.17509/xxxx.xxxx
p- ISSN 2775-6793 e- ISSN 2775-6815

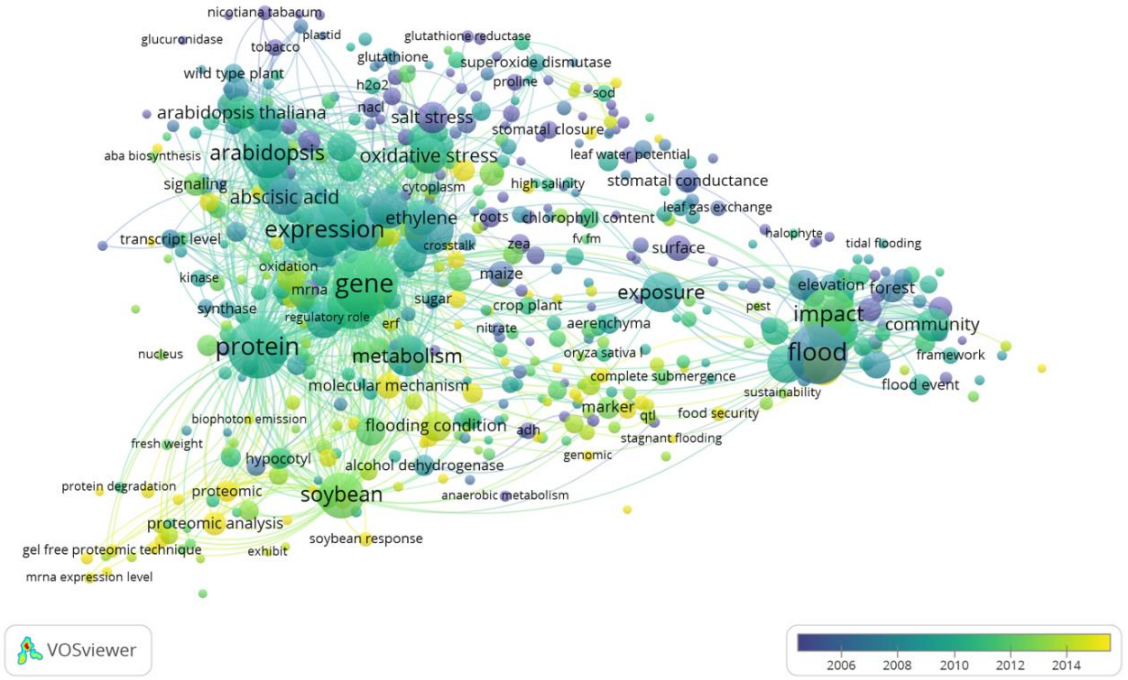

Figure 5. Overlay visualization of scientific research on flooding stress related to plant science and agriculture subject area.

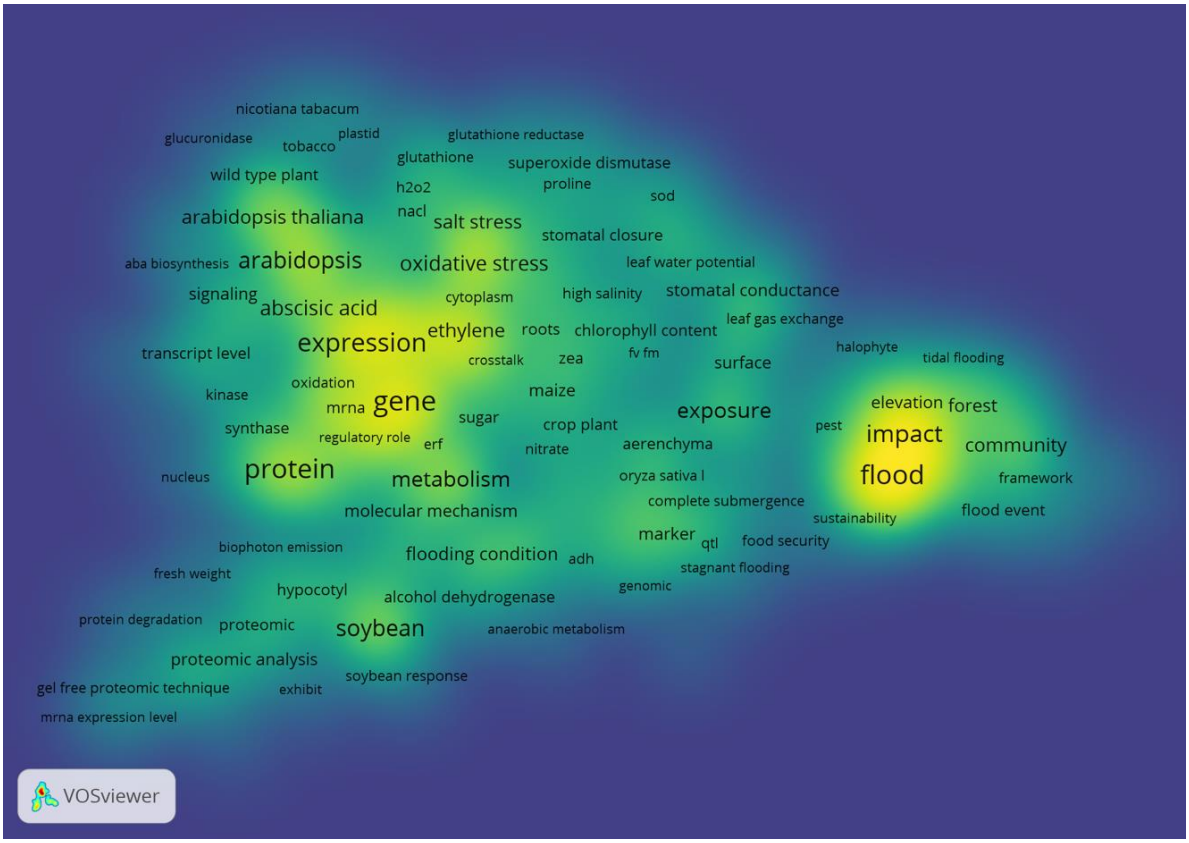

Figure 6. Density visualization of scientific research on flooding stress related to plant science and agriculture subject area.

DOI: http://dx.doi.org/10. 17509/xxxx.xxxx
p- ISSN 2776-6098 e- ISSN 2776-5938

4. CONCLUSION

In the Harzing's Publish or Perish software, PubMed retrieves more relevant manuscripts from journal sources than Crossref, Google Scholar, and Semantic Scholar databases. The search method by whole years is the most effective and efficient if the total manuscripts are less than 1000. The flooding stress-related manuscripts were published continuously from 1994 to 2021 with Annals of Botany as the most productive journal. The combination of "Flooding Stress" with related keywords, eg submergence stress, anaerobic stress, and oxidative stress, improved the relevance of the manuscript results.

The analysis of the VOSviewer keyword found that 5 groups are discussing oxidative stress, the tolerant mechanism, the physiological mechanism, the occurrence of floods, floods, and the molecular mechanism. Advanced study of flooding stress-related topics after 2014 mainly exploring the molecular mechanism, which includes mRNA expression, marker, and proteomic analysis. Based on the density visualizations, the anaerobic metabolism, mRNA expression level, SOD, fv/fm, leaf gas exchange, ABA biosynthesis, and halophyte are less discussed which leads to potential topics to be studied in the future of flooding stress research.

5. AUTHORS' NOTE

The authors declare that there is no conflict of interest regarding the publication of this article. The authors confirmed that the paper was free of plagiarism.

6. REFERENCES

AlRyalat, S. A. S., Malkawi, L. W., and Momani, S. M. (2019). Comparing bibliometric analysis using PubMed, Scopus, and Web of Science databases. *Journal of Visualized Experiments, 152*, e58494.

Alscher, R. G., Erturk, N., and Heath, L. S. (2002). Role of superoxide dismutases (SODs) in controlling oxidative stress in plants. *Journal of Experimental Botany, 53*(372), 1331-1341.

Bailey-Serres, J., and Voesenek, L. (2008). Flooding stress: acclimations and genetic diversity. Annu. *Review of Plant Biology, 59*, 313-339.

Betteridge, D. J. (2000). What is oxidative stress? *Metabolism, 49*(2 Suppl 1), 3-8.

Blokhina, O. B., Chirkova, T. V., and Fagerstedt, K. V. (2001). Anoxic stress leads to hydrogen peroxide formation in plant cells. *Journal of Experimental Botany, 52*(359), 1179-1190.

Chaki, M., Begara-Morales, J. C., and Barroso, J. B. (2020). Oxidative Stress in Plants. *Antioxidants (Basel, Switzerland), 9*(6), 481.

Das, K., and Roychoudhury, A. (2014). Reactive oxygen species (ROS) and response of antioxidants as ROS-scavengers during environmental stress in plants. *Frontiers in Environmental Science, 2*, 53

Donthu, N., Kumar, S., Mukherjee, D., Pandey, N., and Lim, W. M. (2021). How to conduct a bibliometric analysis: An overview and guidelines. *Journal of Business Research, 133*, 285-296.

DOI: http://dx.doi.org/10.17509/xxxx.xxxx
p- ISSN 2775-6793 e- ISSN 2775-6815

Falagas, M. E., Pitsouni, E. I., Malietzis, G. A., and Pappas, G. (2008). Comparison of PubMed, Scopus, Web of Science, and Google Scholar: strengths and weaknesses. *FASEB Journal*, *22*(2), 338-342.

Fricke, S. (2018). Semantic Scholar. *Journal of the Medical Library Association: JMLA, 106*(1), 145-147.

Fukao, T., Barrera-Figueroa, B. E., Juntawong, P., and Peña-Castro, J. M. (2019). Submergence and Waterlogging Stress in Plants: A Review Highlighting Research Opportunities and Understudied Aspects*. Frontiers in Plant Science, 10*, 340.

Fukao, T., Xu, K., Ronald, P. C., and Bailey-Serres, J. (2006). A variable cluster of ethylene response factor–like genes regulates metabolic and developmental acclimation responses to submergence in rice. *The Plant Cell, 18*(8), 2021-2034.

Fukao, T., Yeung, E., and Bailey-Serres, J. (2012). The submergence tolerance gene SUB1A delays leaf senescence under prolonged darkness through hormonal regulation in rice. *Plant Physiology, 160*(4), 1795-1807.

Gusenbauer, M. (2019). Google Scholar to overshadow them all? Comparing the sizes of 12 academic search engines and bibliographic databases. *Scientometrics, 118*(1), 177-214.

Hamidah, I., Pawinanto, R. E., Mulyanti, B., and Yunas, J. (2021). A bibliometric analysis of micro electro mechanical system energy harvester research. *Heliyon, 7*(3), e06406.

Harzing, A. W. (2019). Two new kids on the block: How do Crossref and Dimensions compare with Google Scholar, Microsoft Academic, Scopus and the Web of Science? *Scientometrics, 120*(1), 341–349.

Heyhoe, E., Kim, Y., Kokic, P., Levantis, C., Ahammad, H., Schneider, K., Crimp, S., Nelson, R., Flood, N., and Carter, J. (2007). Adapting to climate change-issues and challenges in the agriculture sector. *Australian Commodities: Forecasts and Issues, 14*(1), 167-178.

Jackson, M. B. (2008). Ethylene-promoted elongation: an adaptation to submergence stress. *Annals of Botany, 101*(2), 229-248.

Jacobsen, G. D. (2011). The Al Gore effect: an inconvenient truth and voluntary carbon offsets. *Journal of Environmental Economics and Management, 61*(1), 67-78.

Kuroha, T., and Ashikari, M. (2020). Molecular mechanisms and future improvement of submergence tolerance in rice. *Molecular Breeding, 40*(4), 41.

Kuroha, T., and Ashikari, M. (2020). Molecular mechanisms and future improvement of submergence tolerance in rice. *Molecular Breeding, 40*(4), 1-14.

Lin, S. J. (2013). Perceived impact of a documentary film: An investigation of the first-person effect and its implications for environmental issues. *Science Communication, 35*(6), 708-733.

Lovley, D. R., Fraga, J. L., Coates, J. D., and Blunt-Harris, E. L. (1999). Humics as an electron donor for anaerobic respiration. *Environmental Microbiology, 1*(1), 89-98.

Martín-Martín, A., Orduna-Malea, E., Thelwall, M., and Delgado López-Cózar, E. (2018). Google Scholar, Web of Science, and Scopus: A systematic comparison of citations in 252 subject categories. *Journal of Informetrics, 12*(4), 1160-1177.

DOI: http://dx.doi.org/10. 17509/xxxx.xxxx
p- ISSN 2776-6098 e- ISSN 2776-5938

Mubaroq, S. R., Abdullah, A. G., and Setiawan, A. G. U. S. (2020). The evolution of smart working and sustainability in socio-technical perspective: A scientometrics technology analysis. *Journal of Engineering Science and Technology, 15*(3), 1868-1882.

Mulyawati, I. B., and Ramadhan, D. F. (2021). Bibliometric and Visualized Analysis of Scientific Publications on Geotechnics Fields. *ASEAN Journal of Science and Engineering Education, 1*(1), 37-46.

Nandiyanto, A. B. D., and Al Husaeni, D. F. (2021). A bibliometric analysis of materials research in Indonesian journal using VOSviewer. *Journal of Engineering Research*, (Special Issue), 1-16.

Panda, D., and Barik, J. (2021). Flooding Tolerance in Rice: Focus on Mechanisms and Approaches. *Rice Science, 28*(1), 43-57.

Patel, H., Alkhawam, H., Madanieh, R., Shah, N., Kosmas, C. E., and Vittorio, T. J. (2017). Aerobic vs anaerobic exercise training effects on the cardiovascular system. *World Journal of Cardiology, 9*(2), 134-138.

Pedersen, O., Perata, P., and Voesenek, L. (2017). Flooding and low oxygen responses in plants. *Functional Plant Biology, 44*(9), 3-4.

Pizzino, G., Irrera, N., Cucinotta, M., Pallio, G., Mannino, F., Arcoraci, V., Sqadrito, F., Altavilla, D., and Bitto, A. (2017). Oxidative Stress: Harms and Benefits for Human Health. *Oxidative Medicine and Cellular Longevity, 2017*, 8416763-8416763.

Poole, A. M., Jeffares, D. C., and Penny, D. (1998). The path from the RNA world. *Journal of Molecular Evolution, 46*(1), 1-17.

Puppel, K., Kapusta, A., and Kuczyńska, B. (2015). The etiology of oxidative stress in the various species of animals, a review. *Journal of the Science of Food and Agriculture, 95*(11), 2179-2184.

Shrestha, B. B., Perera, E. D. P., Kudo, S., Miyamoto, M., Yamazaki, Y., Kuribayashi, D., Sawano, H., Sayama, T., Magome, J., Hasegawa, A., and Hasegawa, A. (2019). Assessing flood disaster impacts in agriculture under climate change in the river basins of Southeast Asia. *Natural Hazards, 97*(1), 157-192.

Singh, R., Singh, S., Parihar, P., Mishra, R. K., Tripathi, D. K., Singh, V. P., Chauhan, D. K., and Prasad, S. M. (2016). Reactive oxygen species (ROS): beneficial companions of plants' developmental processes. *Frontiers in Plant Science, 7*, 1299.

Thauer, R. K., Jungermann, K., and Decker, K. (1977). Energy conservation in chemotrophic anaerobic bacteria. *Bacteriological Reviews, 41*(1), 100-180.

Vartapetian, B. B., and Jackson, M. B. (1997). Plant adaptations to anaerobic stress. *Annals of Botany, 79*(suppl_1), 3-20.

Visser, E. J. W., Voesenek, L. A. C. J., Vartapetian, B. B., and Jackson, M. B. (2003). Flooding and plant growth. *Annals of Botany, 91*(2), 107-109.

Visser, M., van Eck, N. J., and Waltman, L. (2021). Large-scale comparison of bibliographic data sources: Scopus, Web of Science, Dimensions, Crossref, and Microsoft Academic. *Quantitative Science Studies, 2*(1), 20-41.

DOI: http://dx.doi.org/10.17509/xxxx.xxxx
p- ISSN 2775-6793 e- ISSN 2775-6815

Yuan, B. Z., and Sun, J. (2021). Bibliometric analysis of potato research publications from Agronomy Category based on Web of Science from 2000 to 2021. *Potato Research*, *65*, 1-21.

DOI: http://dx.doi.org/10. 17509/xxxx.xxxx
p- ISSN 2776-6098 e- ISSN 2776-5938