Article

Trends of WRKYs transcription factors based on bibliometric analysis

Mouna Choura

Biotechnology and Plant Improvement Laboratory, Center of Biotechnology of Sfax, University of Sfax, Route Sidi Mansour Km 6, P.O.Box 1177, 3018 Sfax, Tunisia

E-mail: mouna.choura@cbs.rnrt.tn

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Abstract

WRKY transcription factors play important roles in plant growth, development, and stress responses. WRKYs have been intensively studied in plants providing valuable information. However, limited data were for the evaluation of the trend of WRKYs researches. This study aims to investigate the trend of WRKY researches from 2010 to 2021 including the latest findings, major contributors, institutions, and journals. Here, 2302 publications were retrieved for analysis. They have been published in 361 journals. Over 1789 organisations have contributed to WRKY publications, with China and United States of America in the first place. The trend of publications is increasing year by year. Plant Sciences journals ranked top for publishing papers. The Chinese authors and institutions were the most productive in the WRKY research. The WRKYs are most studied in different plants such as Arabidopsis in the context of biotic and abiotic stresses. This study provides a comprehensive overview and valuable references allowing researchers to identify cooperation, find research hotspots, and provide intuitive profile for the contribution in this field.

Keywords bibliomertic; countries; organisations; plant; stress; WRKY.

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1 Introduction

The WRKY transcription factors are widely distributed in plants. They are involved in several biological processes including plant development, signal transduction, regulation and responses to biotic abiotic stress. Also, they play a key role in cross-talk pathway networks such as between plant response and development (Rushton, 2010; Chen and Yin, 2017).

In addition, WRKY genes were considered as potential candidates for functional studies and breeding programs.

Consequently, WRKYs has been an attractive target for the scientific community to understand the ability of WRKYs to cope with various environmental constraints (Phukan et al., 2016; Bai et al., 2018). Moreover,

computational analysis showed that WRKYs in *A. thaliana* and cereals are mainly involved in plant-pathogen interaction pathway (Choura et al., 2015, 2020, 2022).

Currently, there are many publications related to WRKYs around the world. Despite this, no bibliometric analysis has been conducted for WRKY research to demonstrate the evolution in the field and evaluate the contributions and the performance of the institutions, the authors and countries around the world.

Here, this study aimed to report scientific productivity on WRKY research from 2010 to 2021 including the latest findings, major contributors, institutions, and journals.

2 Materials and Methods

2.1 Literature search

Data collection for use was done from the Web of Science, CNUDST, Tunisia. The data search was on "WRKY" as topic published from 2010 to 2021. The contents of full records' downloads included publication year, authorship, abstract, institutions, country, publication type, and journal title.

2.2 Data analysis

The retrieved data were exported to VOSviewer software (version 1.6.11) (https://www.vosviewer.com). VOSviewer is a software tool for constructing and visualizing bibliometric maps (Van Eck and Waltman, 2010). The maps can be constructed based on co-citation or co-occurrence data.

3 Results and Discussion

3.1 General landscape

Web of Science database search showed 2302 publications related to WRKYs from 2010 to 2021. It is noticed that, the number of publications and citations increased continuously over this period (Fig. 1). These articles were predominantly published in English (n=2294, 99.6%). Original articles (n=2137, 92.8%) were more prevalent than the other document types (Table 1).

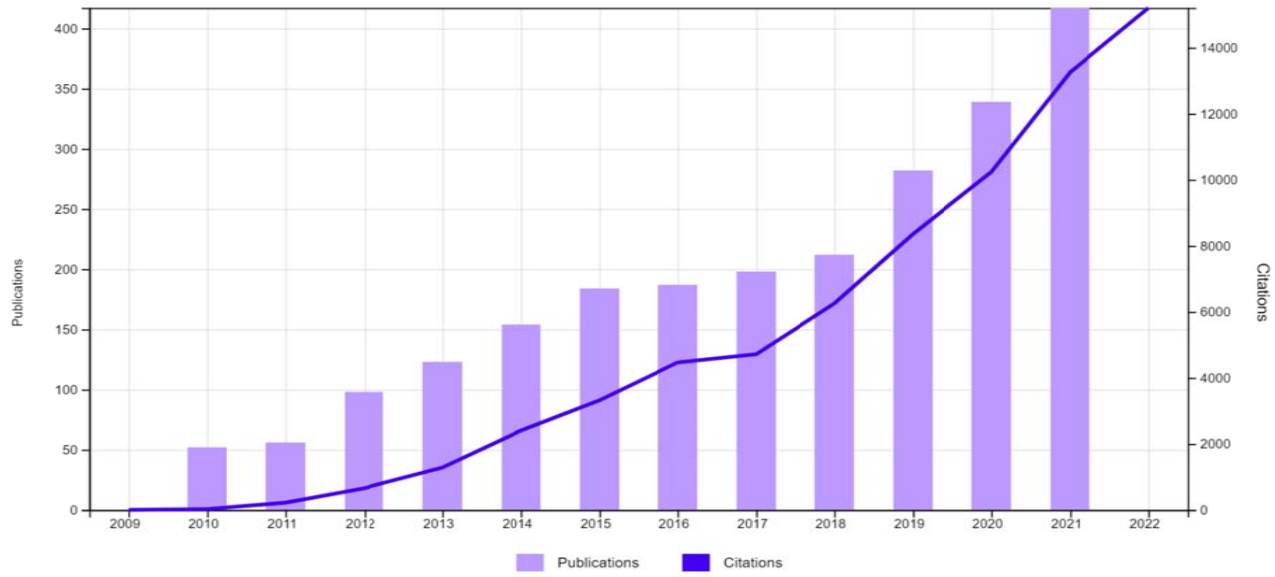

Fig. 1 Times Cited and Publications in WRKY research field from 2010 to 2021.

Table 1 Publication count of different document types.

Types	Count
Article	2137
Review article	131
Proceeding paper	22
Meeting abstract	10
Book chapters	2
Editorial Material	2
Correction	3
Early Access	1
Letter	1
Retracted Publication	1
Retraction	1

Around 5184 authors contributed to WRKY publications. The distribution of the most productive authors is shown in Fig. 2. Relative to 2229 documents, Wang Y have the most publications record (40 papers, 1.74%) followed by Zhang Y (36 papers, 1.56%), Li Y and Zhang J (32, 1.39%) and Li L (30 papers, 1.3%).

These authors are involved in agriculture plant sciences, genetics and heredity biotechnology and applied microbiology virology disciplines.

In addition, Fig. 3 visualized the co-authorship network of 84 authors who published more than five documents. However, only 19 authors linked with the line in the network, which indicates the insufficient cooperation of authors in the WRKY research field.

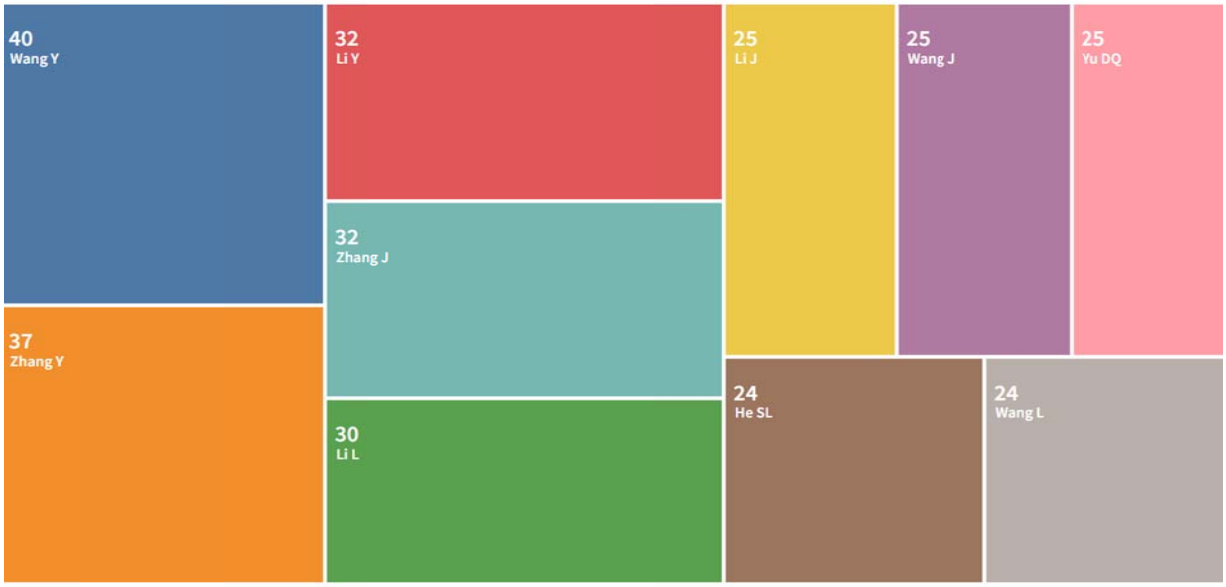

Fig. 2 Tree Map chart of the most productive authors in WRKY field during 2010-2021.

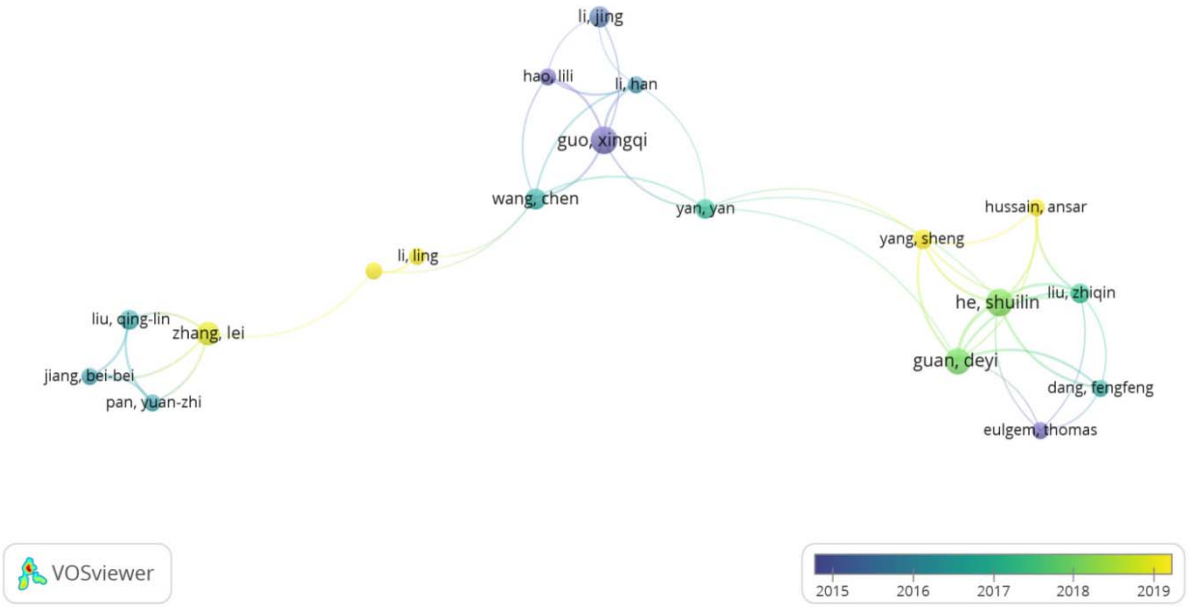

Fig. 3 Co-authorship analysis of authors performed by Vosviewer.

For instance, guoxing qi and colleagues demonstrated a novel disease defence mechanism through which the WRKY-MAPK pathway promotes flavonoid biosynthesis to defend against pathogen infection (Wang et al., 2022).

The citation of an article in another article is important for scientific publications and is representative of its quality (Table 2). Rushton's article is the most cited paper (Rushton et al., 2010). They revealed that WRKY transcription factor might be involved in regulating several processes and exhibit extensive regulation. Also, they illustrated the progress in WRKY transcription factor research.

Table 2 The top 5 author's relationships.

Author	Documents	Citations	Total linkstrength
guo, xingqi	12	754	20
he, shuilin	12	394	32
guan, deyi	11	378	30
rushton, paul j.	10	2251	17
yu, diqiu	10	1592	8

3.2 Institutions and countries

Over 1789 organisations from 57 countries have contributed to WRKY publications. China had published the majority papers (1350 documents), followed by USA (304 documents) during 2010 to 2021 (Fig. 4). Papers from China received the highest number of citations (21786), accounting for 45.37% of total numbers. The

USA ranked second with 9545 citations (19.9%). Most of the publications were originated from institutions from China with the ministry of agriculture rural affairs producing the highest number of publications on WRKY (167) followed by Chinese Academy of Sciences (154) (Table 3). Besides, the important role of funding agencies such as National Natural Science Foundation Of China Nsfc, National Key Research And Development Program Of China, Fundamental Research Funds For The Central Universities, National Science Foundation Nsfand National Basic Research Program Of China. Although the majority of cooperations are between Chinese institutions, some are between China and USA institutions (Yang et al., 2017)

This is consistent with the most productive authors cited above, which are mainly affiliated with the Chinese institutions.

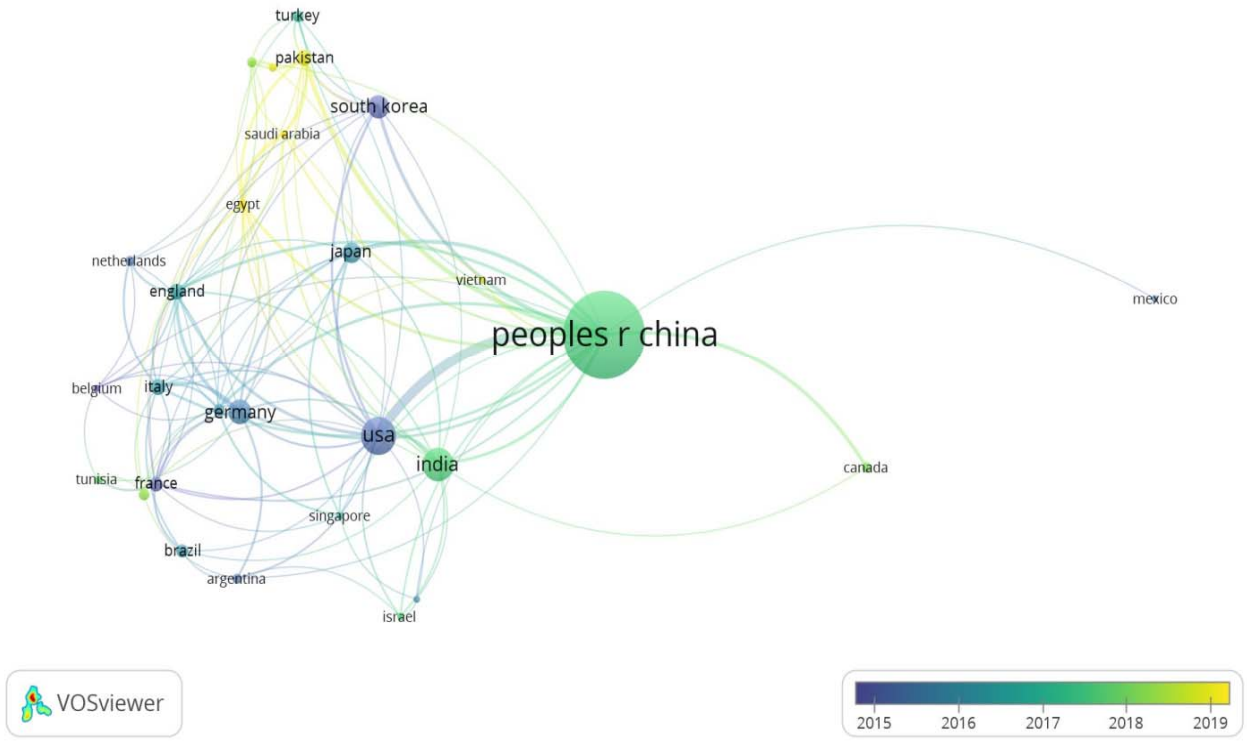

Fig. 4 Co-authorship analysis of countries performed by Vosviewer.

Table 3 The top 5 most productive organizations in the WRKY field from 2010 to 2021.

Organization	Publication count
Ministry of agriculture rural affairs	167
Chinese Academy of Sciences	154
Chinese Academy of Agricultural Sciences	153
Northwest AF University China	90
Nanjing Agricultural university	81

3.3 Active journals

In total, 361 journals have published WRKY papers. The top 5 journals in terms of the number of publications are shown in Table 4. This indicates that most papers were published in the field of plant sciences, biochemistry, molecular biology, genetics heredity, multidisciplinary sciences, biotechnology, applied microbiology and agronomy.

Table 4 The top 5 most productive journals in the WRKY field from 2010 to 2021.

Journal	Impact Factor	Publication count
FRONTIERS IN PLANT SCIENCE	6.6	164
PLOS ONE	3.7	130
SCIENTIFIC REPORTS	5	104
INTERNATIONAL JOURNAL OF MOLECULAR SCIENCES	6.2	103
BMC PLANT BIOLOGY	5.2	84

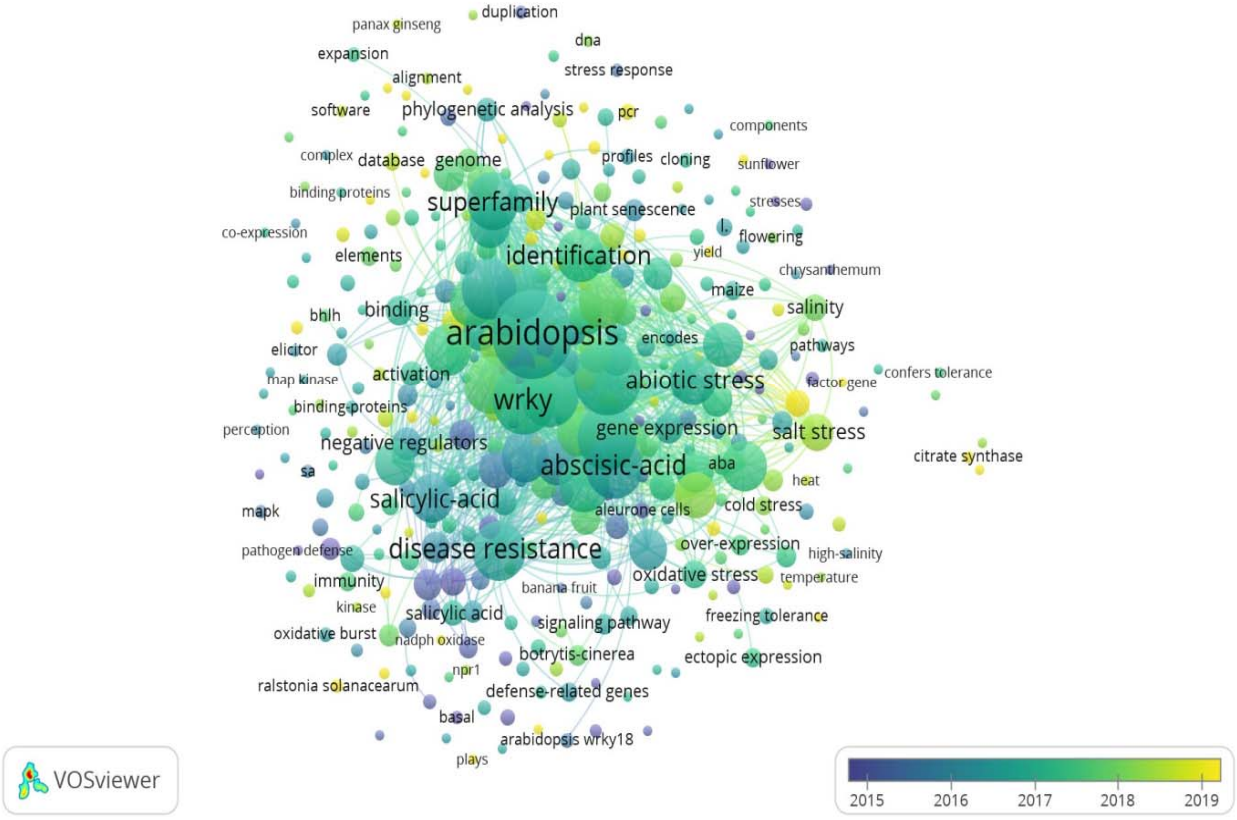

Fig. 5 Term map of WRKY publications performed by Vosviewer.

3.4 Term map

The term map shows the keyword co-occurrence network (Fig. 5). The circle size reflects the term frequency. The most frequent terms are Arabidopsis, WRKY, rice, abiotic stress, gene expression, negative regulators, disease resistance, salt stress, salinity.

In fact, WRKY proteins have been extensively studied in the model plant *Arabidopsis thaliana* with 72 genes. Then, it has expanded greatly in other plants (Rinerson et al., 2015; Mohanta et al., 2016). WRKY proteins are known in the regulation of different abiotic and biotic stresses such as salinity, drought, cold, nutrient starvation, light conditions and disease resistance (Chen et al., 2012; Jiang et al., 2015; Wei et al., 2022).

WRKYs in different plants have been genetically engineered in *Arabidopsis*, Nicotiana, and Gossypium successfully, which enhance plant tolerance against stresses. For example, *TaWRKY2* overexpression has significantly enhanced grain yield and drought tolerance in transgenic wheat (Gao et al., 2018)

4 Conclusions

We conducted a bibliometric analysis of the WRKY research literature from 2010 to 2021 from Web of Science. We identified countries, institutions, authors, keywords, references and journals in WRKY research. This study reveals that the trend of publications is increasing year by year. China has made the largest contribution in the WRKY research field.

These findings may provide researchers and contributors in the field with useful information, such as potential collaborators and institutions, research hotspots, and key references.

Acknowledgements

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