

**MAPPING OF PLANT SCIENCE RESEARCH PRODUCTIVITY IN PAKISTAN****SAIMA NASIR<sup>1</sup>, JAMILA AHMED<sup>1,2</sup>, JAVERIA QADIR<sup>3</sup> AND ANWARUL-HASSAN GILANI<sup>1,4\*</sup>**<sup>1</sup>*Pakistan Council for Science and Technology, Islamabad, Pakistan*<sup>2</sup>*ORIC, Allama Iqbal Open University, Islamabad, Pakistan*<sup>3</sup>*Department of Biosciences, COMSATS Institute of Information Technology, Islamabad, Pakistan*<sup>4</sup>*Department of Biological and Biomedical Sciences, Aga Khan University Medical College, Karachi, Pakistan**\*Corresponding author's email address: anwar.gilani@aku.edu***Abstract**

The purpose of this study was to carry out a bibliometric analysis of the articles published from Pakistan during 1975-2017 that were categorized into the Plant Science discipline by ISI. The data were extracted from the Science Citation Index online database of the Web of Science, obtaining a total of 14,504 articles for analysis. The 10 most-cited articles and 10 most frequently used journals were identified. The analysis showed a rising trend in research output within the discipline of plant sciences and the number increased from just 16 publications in 1975 to 1276 in 2017. When compared with other categories of subjects, the plant scientists are the 6<sup>th</sup> most active researchers in Pakistan, chemists being on top, but being an agricultural country, more research is needed to be carried out in this field and scientists should be encouraged to publish their research in peer-reviewed and indexed journals to make it available to the scientific community.

**Key words:** Pakistan, Plant sciences, Research productivity, Bibliometric.

**Introduction**

Bibliometrics has been widely applied for quantitative evaluation of literature (Luukkonen, 1990; Friedberg, 2000). The policy makers and research managers have become ever more concerned in the use of indicators of scientific productivity in the recent years. A number of bibliometric studies have been carried out to measure the quantity and impact of scientific publications for assessing overall research output in different disciplines (Fu *et al.*, 2010; Sainte-Marie, 2010; Han & Ho, 2011; Li *et al.*, 2011; Tanaka & Ho, 2011; Shi *et al.*, 2012; Xingjian *et al.*, 2012; Bilir *et al.*, 2013; Fu *et al.*, 2013; Gopalakrishnan & Kumar, 2013).

A rapid progress has been made globally in all branches of science and technology over the past two decades. Pakistan is also contributing to world scientific knowledge, though the share is weak. But the encouraging fact is the rapid growth in research output in the country during the past decade. Pakistan has become successful in its agenda to improve its international profile in scientific community by persistently increasing the quantity and quality of articles published in peer-reviewed scientific journals primarily as a result of the initiatives and incentives of the Higher Education Commission and the yearly Research Productivity Award of the Pakistan Council for Science and Technology.

Plant sciences are one of the important areas of research not only in Pakistan but also globally. Plants are an indispensable resource for human survival and well-being as they provide oxygen, food, medicine, shelter, and clothing as well as are a source of unrelenting magnificence. Plants are also being looked to as a potential solution to many of the challenges of the 21<sup>st</sup> century including food shortage, climate change issues and growing demand for energy. In this context, plant sciences research has become more important now than ever before. A number of studies have been done to describe patterns of publications within a given field of plant sciences (Anwar, 2006; Krauskopf, 2008; Singh *et*

*al.*, 2008; Al-Qallaf, 2009; Das, 2012; Kumar & Khormi, 2013; Kumar & Singh, 2013; Pereira & Putzke, 2013; Walton and Morris, 2013). But unfortunately no such study is available from Pakistan for mapping of the trends and magnitude of plant science research. The present study analyzes the research productivity of plant scientists of Pakistan. The distribution of plant sciences literature has been analyzed by annual publication outputs, citation impact, document type, name of journal, share of international collaboration papers and contribution to the global science system by comparing the country output to the bigger science producers in plant science research. The study will help researchers understand the characteristics of research output in plant sciences and provide a reference for determining future direction and quantum of research in this regard.

**Material and Methods**

No data are available in the Thomson Reuters Science Citation Index online database of the Web of Science (ISI-WoK) from 1966 to 1974 in the field of plant science from Pakistan; hence, we considered the data from 1975-2017 for analysis. Publications in the field of plant sciences from 1975 to 2017 were retrieved from the Science Citation Index online database of the Web of Science (ISI-WoK). The data were retrieved on February 23<sup>rd</sup>, 2018. The search option was run for country (Address = Pakistan) for time span from 1975-2017. The records obtained were refined in the research domain= Science technology and then all records that were categorized as "Plant Science" among the ISI disciplines were retrieved. The documents were analyzed according to numbers of publications, times cited, cites per document (impact), most frequently cited articles, document type, funding agencies, international collaborations and most frequently used journals. For this study, a comparison of records retrieved is compared with records retrieved from top ten publishing countries in the research field "plant sciences" as well as with other

countries of the region to know the scientific standing of Pakistan in the research domain. A comparison of papers published in “plant sciences” from Pakistan is also collated with other disciplines contributing to Pakistani research output.

**Results and Discussion**

A total of 96,692 research papers were published from Pakistan in different disciplines of science and technology during the period of 1975 to 2017, as extracted from the Web of Science database. About 15% (14,504 papers) of this total share is contributed by papers published in the field of Plant Sciences, which attracted 157,891 citations with an average citation per article of 12.294. The *h*-index for papers published in the field of Plant Sciences from Pakistan is 61. The data retrieved from databases of the Web of Science show that a total of

1,920,852 publications in the research area of Plant Sciences have been published all over the world from 1975-2017 indicating less than 1% global share in the fields of Plant Sciences.

**Year-wise publications from Pakistan:** Year-wise publications from Pakistan show a trend of rapid increase from 2001 onwards (Fig. 1). The major reason could be funding from HEC and some other schemes initiated by the Government of Pakistan from that year such as Research Productivity Award and also the inclusion of some of prominent Pakistani journals in ISI-WoK. The citations for these papers also show a sudden increase in the same period. A uniform pattern for increase in number of publications and citations is observed when four year spans are considered (Fig. 2). The annual growth rate is 41.71 % for publications and 37.70% for citations, which are highly encouraging figures of growth.

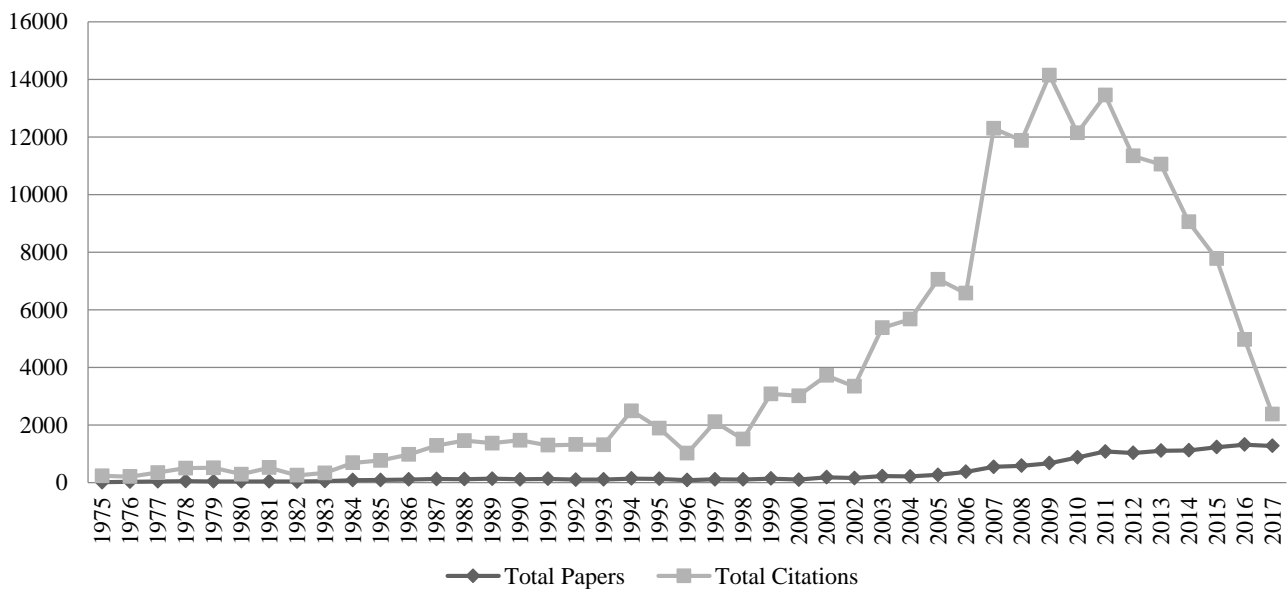


Fig. 1. Year-wise publications and citations from Pakistan in the field of Plant Sciences from 1975-2017.

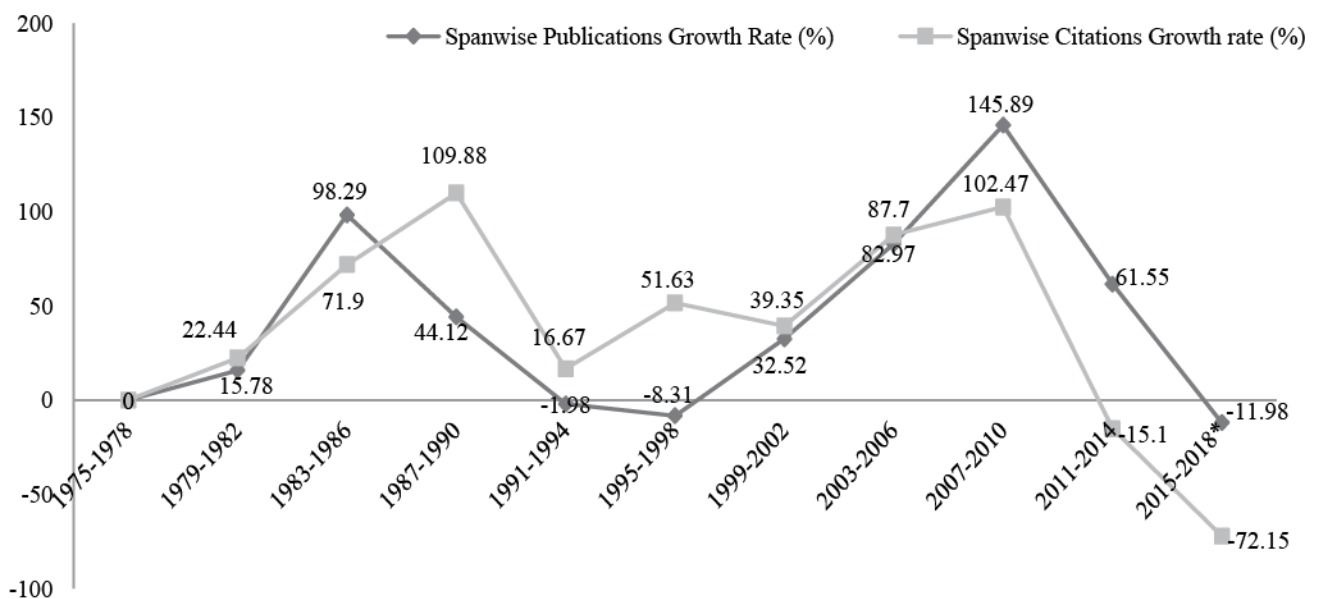


Fig. 2. Span-wise percent average growth rate of publications and citations per article for papers published in plant sciences from Pakistan during 1975-2017.

**Article types:** A major share of publications in plant sciences (98.96%) in the form of original research articles as shown in Table 1. Number of review papers is relatively insignificant (3.411%). Most of the scientists tend to publish their original research executed during doctoral or post-doctoral studies or during supervision of research based degrees. Review articles are essence of deep thoughts and evaluation process and also attract distinctly high citations (Table 1). Thus, senior scientists need to be encouraged for publishing review articles in addition to original research articles.

**Funding agencies:** The Higher Education Commission (HEC) is the major contributor of grants not only for plant science research but also for other fields. These funds are released by the HEC either as doctoral scholarships or for the research projects. It is obligatory for scholarship holders to publish their research outcomes, which is the main reason that 1,761 papers are acknowledged under HEC as shown in Fig. 3. Surprisingly, the National Science Foundation (NSF) China stands second with 375 articles acknowledging funding, while Pakistan Science Foundation has only 117 projects acknowledged as part of funding research, which needs explanation. Pakistan Science Foundation (PSF) has distinctly less budget for funding research compared to HEC, despite the fact, it has a wider mandate (funding opportunity open to scientists both from Academia and Research & Development organizations). It is expected that the share of PSF in terms of number of publications arising from projects funded by PSF will increase as a result of enhanced funding in recent years. Regarding a large number of papers with the funding source from NSF (China) compared to PSF, it appears as if a large number of Pakistani scientists/students have been working in Chinese Universities as a part of their PhD or post-doctoral training in addition to increasing research collaboration between scientists of two neighboring countries. It may be noted that the highest number of scholarships for PhD in China under TWAS Scholarship programs, are won by Pakistani students compared to any other country from the developing world. It has been observed that a significant number of overseas scholarships (PhD or Post-doc) are awarded by the HEC mostly to young faculty members holding faculty position in Pakistani universities, who write usually dual affiliation (Chinese University and parent Pakistani University) in their publications. HEC also has option for working in overseas labs for 6 months as a part of Indigenous PhD program, and it is possible that majority of students opt working in China being a neighbor country where there is high emphasis on science and technology.

Interestingly, two other sources of funding research from China include: 1) National High Technology Research and Development Program of China, 2) Fundamental Research Funds of the Central Universities (Fig. 3), which occupy 4<sup>th</sup> and 5<sup>th</sup> positions with number of papers 95 and 47, respectively, while Pakistan Agricultural Research Council is the last in the list with 40 papers only. Further analysis of the Chinese source of funding for Pakistanis scientists is warranted.

**International collaboration:** International collaboration is very important for quality publications. Pakistan has collaborated mostly with plant scientists from China and

USA. These papers are also the most cited papers and have the highest average citations per item as shown in Table 2. Saudi Arabia and England/UK are the 3<sup>rd</sup> and 4<sup>th</sup> most collaborated countries followed by Australia and Germany. These papers are mainly ascribed to the HEC's scholarship scheme where students are sent to these countries to complete a part of their research in their laboratories. Some senior scientists also work in international projects resulting in high number of quality papers.

**Top journals:** Pakistan Journal of Botany is the most reputed journal in the field of plant sciences in Pakistan and consequently is at the top of this ranking with 4,261 papers published in it (Table 3). Number of citations per article is the highest for *Journal of Ethnopharmacology* followed by *Phytochemistry*. A list of ten most frequently used journals is given in Table 3.

**Top 10 research article from Pakistan:** Interestingly, the top 05 out of top10 papers were the research output of a single group, either as a solo author or with a group of authors (Table 4). The most cited paper has a total of 1515 citations with an average citation of 168.33 per year. The data revealed that 8 out of top 10 papers were co-authored by foreign author(s). This finding clearly demonstrates the significance of international collaborations, thus, highlighting the need for more such collaborations to improve the quality of research.

**Comparison of plant sciences with other related research areas:** Figure 4 presents a comparative picture of papers published from Pakistan in other related disciplines of plant science research. It is evident from the data that maximum research articles are published in "Agriculture". Although the number of publications in plant sciences is more, average citations per item for papers published in biochemistry/molecular biology, environmental sciences/ecology, genetics/heredity, pharmacy, pharmacology, and toxicology are higher as compared to those of pure plant sciences.

**Comparison of Pakistan with top 10 publishing countries in plant sciences:** Scientists are contributing to synthesis of knowledge across the borders in different fields of science and technology. The global contribution of plant scientists is only 4.104%, which is too little when compared with chemistry (15.346%), engineering (14.127%), and physics (13.026%). The global share of Pakistan in the publications in the fields of plant sciences is only 0.75%. Table 5 shows the top 10 countries contributing to plant science discipline. USA is at the top of the list having 517,461 publications in the study period, while the People's Republic of China stands 2<sup>nd</sup> and Japan 3<sup>rd</sup> in the list. India and Germany are also in the list of top 10 countries occupying 4<sup>th</sup> and 5<sup>th</sup> position with 110,865 and 101,308 publications, respectively. Our analysis revealed a positive trend in Pakistan from 2001 onwards. Out of top 100 publishing countries in the field of Plant Sciences, 25 are Asian countries. Pakistan is ranked at 10<sup>th</sup> position among these 25 Asian countries, which is rather satisfying (Table 6).

**Table 1. Publications, their citations and average citations per item for different article types in the field of Plant Sciences published from Pakistan during 1975-2017.**

Document type	Total papers	Total citations	Average citations per item	% Age
Article	14418	157462	10.92	98.964
Other	1911	39617	20.73	13.117
Review	497	19334	38.9	3.411
Meeting	187	1938	10.36	1.284
Abstract	96	23	0.24	0.659
News	96	865	9.01	0.659
Clinical trial	77	1583	20.56	0.529
Editorial	77	369	4.79	0.529
Letter	58	328	5.66	0.398

**Table 2. Data on number of publications and citations from Pakistan as a result of international collaborations in Plant Sciences during 1975-2017.**

Countries	Total publications	Total citations	Average citations per item
China	1092	14577	13.35
USA	976	20138	20.63
Saudi Arabia	510	5237	10.27
UK	446	10952	24.56
Australia	369	7349	19.92
Germany	358	6376	17.81
South Korea	313	5376	17.18
Japan	261	3639	13.94
Turkey	208	2264	10.88
Canada	202	3798	18.8

**Table 3. List of 10 most frequently used journals by Pakistani plant scientists for publishing their research output showing number of total papers published, total citations and average citations per item for these papers.**

Rank	Journal	Total publications	Total citations	Average citations per item
1.	Pakistan Journal of Botany	4261	23228	5.45
2.	JAPS - Journal of Animal and Plant Sciences	465	1185	2.55
3.	Pakistan Journal of Pharmaceutical Sciences	305	1158	3.8
4.	Phytochemistry	280	4445	15.88
5.	Natural Product Research	209	1451	6.88
6.	Phytochemistry Oxford	193	3195	16.55
7.	Journal of Plant Nutrition	183	1243	6.79
8.	International Journal of Agriculture and Biology	172	1142	6.64
9.	Pakistan Journal of Agricultural Sciences	170	383	2.25
10.	Journal of Ethnopharmacology	167	4813	28.82

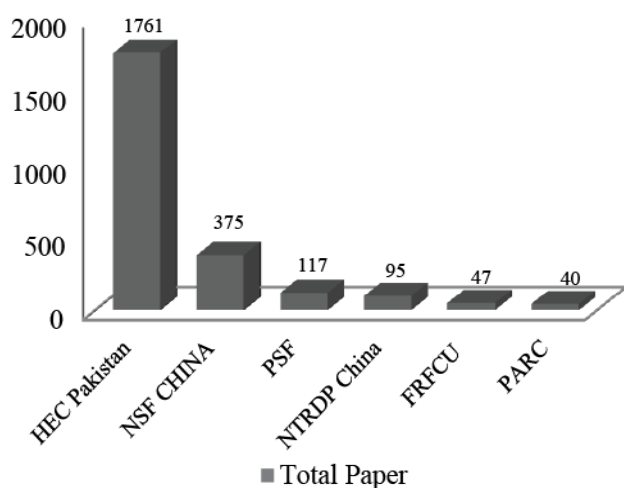


Fig. 3. Articles produced under funding of different agencies; HEC: Higher Education Commission; NSF: National Science Foundation, China; PSF: Pakistan Science Foundation; NTRDP: National High Technology Research and Development Program of China; FRFCU: Fundamental Research Funds of the Central Universities; PARC : Pakistan Agricultural Research Council

The distribution of research output of top 10 countries and Pakistan in 10 blocks of 08 years each (Fig. 5) indicates that only 48,529 papers were produced in the first block (1975–1978) as compared to 216,282 papers produced in the last block (2015–2018\*). The main contributors among these countries were the USA, the People’s Republic of China and Japan. The Transformative Activity Index (TAI) was developed to compare the relative change in the output of these 10 blocks following Guan & Ma (2004). Mathematically,  $TAI = [(Ci/Co) / (Wi/Wo)] \times 100$

where  $C_i$  is the number of publications of a country in the  $i^{th}$  block,  $C_o$  is the total number of publications of a country during the period of study,  $W_i$  is the number of publications of all countries in the  $i^{th}$  block and  $W_o$  is the number of publications of all the countries during the period of study.

The values of TAI for different countries (Fig. 5) suggest that the publication activity was the highest during 1983-1990 for all countries under study after which it declined considerably in 1995-2002, but gradually improved in the last two decades.

Table 4. Top 10 most cited papers published from Pakistan in the field of Plant Sciences from 1975-2017.

S.No.	Paper	Total citations	Average citations per year
1.	The <i>Sorghum bicolor</i> genome and the diversification of grasses Paterson, Andrew H.; ur-Rahman, M., <i>et al.</i> , <i>Nature</i> Volume: 457 Issue: 7229 Pages:551-556 Published: 2009	1515	168.3333
2.	Roles of glycine betaine and proline in improving plant abiotic stress resistance Ashraf, M.; Foolad, M. R. <i>Environmental and Experimental Botany</i> Volume: 59 Issue:2 Pages:206-216 Published:2007	1424	129.4545
3.	Heat tolerance in plants: An overview Wahid, A.; Gelani, S.; Ashraf, M.; Foolad, M.R. <i>Environmental and Experimental Botany</i> Volume:61 Issue: 3 Pages:199-223 Published:2007	983	89.3636
4.	Priority actions for the non-communicable disease crisis Beaglehole, Robert; Ibrahim, Shah <i>et al.</i> , <i>Lancet</i> Volume:377 Issue: 9775 Pages:1438-1447 Published:2011	711	101.571
5.	Plant drought stress: Effects, mechanisms and management Farooq, M.; Wahid, A. <i>et al.</i> , <i>Agronomy for Sustainable Development</i> Volume:29 Issue: 1 Pages:185-212 Published: 2009	663	73.6666
6.	Health risks of heavy metals in contaminated soils and food crops irrigated with wastewater in Beijing, China Khan, S. <i>et al.</i> , <i>Environmental Pollution</i> Volume:152 Issue: 3 Pages:686-692 Published:2008	609	60.9
7.	Phytoremediation of heavy metals-Concepts and applications Ali, Hazrat; Khan, Ezzat; Sajad, Muhammad Anwar <i>Chemosphere</i> Volume:91 Issue: 7 Pages:869-881 Published:2013	547	109.4
8.	Geminivirus strain demarcation and nomenclature Fauquet, C.M.; Briddon, R.W.; Brown, J.K. <i>et al.</i> , <i>Archives of Virology</i> Volume:153 Issue: 4 Pages:783-821 Published:2008	455	45.5
9.	Repeated polyploidization of Gossypium genomes and the evolution of spinnable cotton fibres Paterson, Andrew H.; Mansoor, S.; ur-Rahman, M. <i>et al.</i> , <i>Nature</i> Volume:492 Issue: 7429 Pages:423 Published:2012	449	74.8333
10.	Biotechnological approach of improving plant salt tolerance using antioxidants as markers Ashraf, M. <i>Biotechnology Advances</i> Volume:27 Issue: 1 Pages:84-93 Published: 2009	436	48.4444

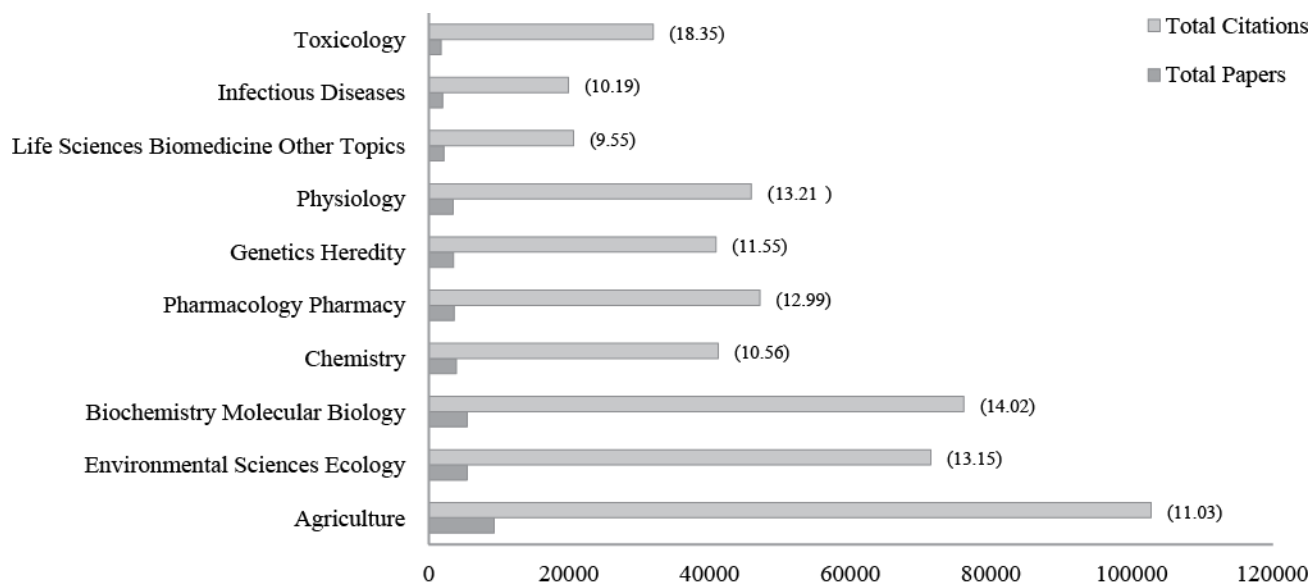


Fig. 4. Comparison of number of papers and citations published from Pakistan in different disciplines of plant science research. Average citations per item are given in parenthesis.

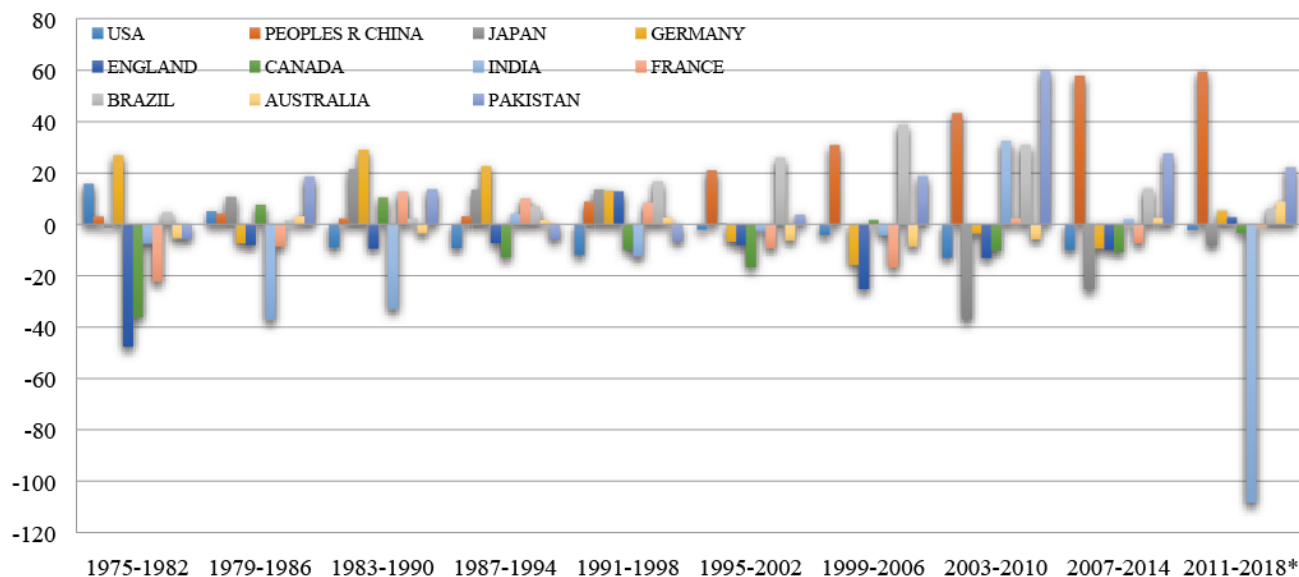


Fig. 5. Change in the values of Transformative Activity Index (TAI) for different countries

**Table 5. Ranking of Pakistan compared to Top 10 Publishing Countries in Plant Sciences on the basis of percent share of total number of papers published from 1975-2017.**

Countries	Total publications	Global share (%)	Rank
USA	517461	26.939	1
China	166584	8.672	2
Japan	120575	6.277	3
India	110865	5.772	4
Germany	101308	5.274	5
Canada	99561	5.183	6
Uk	98680	5.137	7
France	87672	4.564	8
Brazil	83833	4.364	9
Australia	79584	4.143	10
<b>Pakistan</b>	<b>14504</b>	<b>0.75%</b>	<b>36</b>

**Table 6. Comparative ranking of Pakistan with top Asian countries in Plant Science research from 1975 to 2017**

Countries	Total publications	World global share (%)	World rank	Rank among Asian countries
Peoples r China	166584	8.672	2	1
Japan	120575	6.277	3	2
India	110865	5.772	4	3
South Korea	38565	2.008	15	4
Turkey	22394	1.166	23	5
Israel	20666	1.076	26	6
Iran	18753	0.976	30	7
Russia	17950	0.934	31	8
Taiwan	17873	0.93	32	9
<b>Pakistan</b>	<b>14504</b>	<b>0.752</b>	<b>36</b>	<b>10</b>
Thailand	11615	0.605	40	11
Malaysia	9047	0.471	47	12
Saudi Arabia	6252	0.325	50	13
Philippines	5670	0.295	51	14
Bangladesh	4210	0.219	58	15
Indonesia	4134	0.215	59	16
Singapore	3634	0.189	63	17
Vietnam	2625	0.137	73	18
Sri Lanka	2074	0.108	79	19
Syria	1662	0.087	85	20
Jordan	1595	0.083	87	21
Nepal	1198	0.062	94	22
Hong Kong	964	0.05	97	23
Lebanon	918	0.048	100	24
Oman	832	0.043	102	25

## Conclusion

Plant science is one of the most important research fields in Pakistan. This study reveals a rising trend in scientific production within the discipline of plant science occupying 10<sup>th</sup> rank in Asia and the number increased from just 16 publications in 1975 to 1276 in 2017. Plant sciences research is contributing towards the research productivity of Pakistan, but the total share contributed is only 15%. As Pakistan is an agrarian country, more research is needed to be done in this field and scientists should be encouraged to publish their research in peer-reviewed journals.

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