

Trends of Doctoral Theses in Biotechnology – Citation Analysis Perspective

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ABSTRACT

The evolution of biotechnology over the years has been marked by significant scientific breakthroughs, from the development of biopharmaceuticals to genetically modified crops, that address some of the most pressing global challenges. Despite the rich repository of biotechnological research, there remains a lack of comprehensive bibliometric studies that encompass the entire spectrum of biotechnology, particularly in emerging areas such as synthetic biology and bioinformatics. Bibliometric studies provide a meta-analysis of scientific literature, offering insights into the growth, development, and focus areas of research fields. The current analysis ascertains the distribution of these across the timeline: 2004-2023, distribution of theses based on the area of study based on keywords extraction, calculation of doubling time, cumulative trends, and relationship between RGR and DT, submission vs. average citation.

KEYWORDS: Bibliometric Analysis, Biotechnology, Doubling Time, Trends.

1. INTRODUCTION AND CONCEPTUALIZATION

Biotechnology is a rapidly advancing field that integrates biological sciences with engineering technologies to create innovative solutions across various sectors, including healthcare, agriculture, and environmental sustainability [6]. The evolution of biotechnology over the years has been marked by significant scientific breakthroughs, from the development of biopharmaceuticals to genetically modified crops, that address some of the most pressing global challenges. This dynamic progression is mirrored in the exponential growth of academic and industry research, which continuously expands the boundaries of what biotechnological applications can achieve [15]. As a result, there is a critical need to systematically review and synthesize the extensive body of research to understand the trajectory of biotechnology development and its future potential [10]. The study of bibliometric data provides a comprehensive approach to analyse the scientific literature, offering insights into the trends, gaps, and networks within a specific field [17].

In biotechnology, a bibliometric analysis can reveal the most influential studies, prolific authors, and core topics that have shaped the field's development [13]. Furthermore, it can highlight the collaboration patterns between

researchers and institutions, which are pivotal for fostering innovation and advancing the field [19]. Such analyses are crucial for researchers, policymakers, and industry stakeholders who rely on evidence-based insights to make informed decisions and strategize future research directions [1].

Despite the rich repository of biotechnological research, there remains a lack of comprehensive bibliometric studies that encompass the entire spectrum of biotechnology, particularly in emerging areas such as synthetic biology and bioinformatics[4]. These emerging areas are critical for the next generation of biotechnological advancements and require detailed exploration to leverage their full potential [2]. This gap highlights the need for a detailed bibliometric analysis that not only maps the historical landscape but also pinpoints emerging trends and methodologies in biotechnology research [13].

Citation analysis has long been recognized as a significant bibliometric method for assessing scholarly communication, research influence, and academic visibility. It provides insights into how references, citations, and scholarly linkages contribute to the intellectual structure of disciplines and the measurement of research performance [16]. Over time, citation analysis has become an essential tool for libraries, research institutions, and policymakers to evaluate scientific productivity, identify influential works, and trace knowledge diffusion [3];[5]. The rise of bibliometrics and scientometrics has further enhanced its role by introducing measures such as the *h*-index [8], journal impact factor [14], and Google Scholar-based indicators [7]. While citation counts remain the traditional metric of research evaluation, alternative metrics such as altmetrics have emerged to capture digital attention and societal impact [12]. This multidimensional approach makes citation analysis crucial for understanding both academic recognition and the broader influence of research.

Bibliometric studies provide a meta-analytical perspective on scientific literature, offering insights into the growth, development, and thematic focus of research fields. In biotechnology, bibliometric analyses have been instrumental in mapping research trends and identifying influential authors, institutions, and journals [18]. For example, [11] employed citation analysis to highlight the most impactful research in microbial biotechnology, revealing key themes such as enzyme production and waste treatment. Similarly, [12] examined agricultural biotechnology, illustrating significant shifts toward sustainable practices and genetically modified (GMO) crop production. Collectively, these studies underscore the value of bibliometric methods in understanding complex research landscapes and guiding future scientific inquiries.

2. PURPOSE AND METHODOLOGY:

The very purpose of the current research aims at elucidating the trends in Doctoral Theses submitted to the University of Mysore the citations included in doctoral theses submitted to the University of Mysore serve as the primary data for this research. Each doctoral thesis housed in the University of Mysore Library undergoes thorough examination. The study specifically focuses on doctoral theses related to Biotechnology submitted between 2004 and 2023. The data is restricted only to the Biotechnology department. The researcher found that a total 177 number of theses submitted to the University of Mysore in the area of Biotechnology during the study period. The researcher has collected a total of 57,753 citations were retrieved from 177 Ph.D.

Total number of citations constitute of 56101 citations out which; 55092(98.20%) are Journals, 139 (0.25%) are Datasets, 101 (0.18%) are Reports, 381 (0.68%) are Book Chapters, 138 (0.24%) are Thesis, 133 (0.23%) are Artwork, 114 (0.20%) are Conference Papers. Highest number of literature sources are cited are Journals followed by Book Chapters, Data Set and Thesis. The current analysis ascertains the distribution of the theses across the time line: 2004-2023, distribution of theses based on area of study based on key word extraction, calculation of Doubling time, cumulative trends, relationship between RGR and DT, submission Vs Average citation.

3. DISTRIBUTION OF THESES

The researcher analyzed year wise number of Ph.D theses submitted and awarded in the department of Biotechnology at the University of Mysore from 2004 to 2023 and the same is presented in Table-1. The table also presents year wise cumulative total number of theses and year wise cumulative percentage.

Table-1 Year wise distribution of Theses on Biotechnology During 2004 to 2023

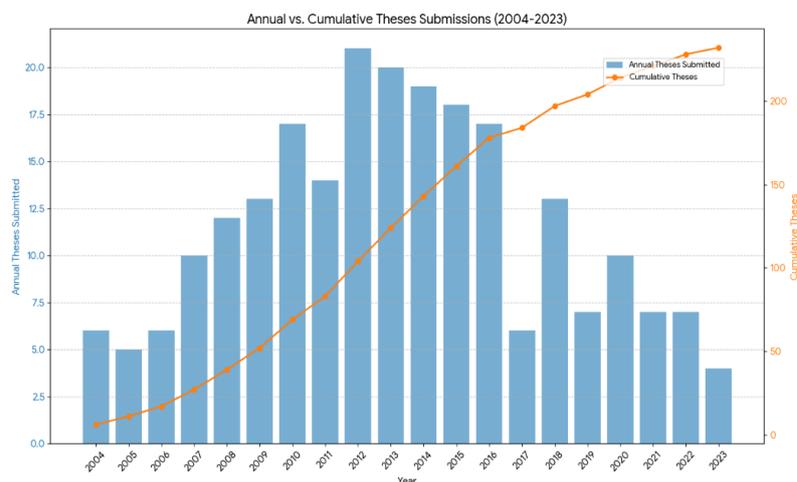
Sl. No.	Year	Number of Theses Submitted	Percentage (%)
1	2004	1	0.56
2	2005	1	0.56
3	2006	1	0.56
4	2007	3	1.69
5	2008	4	2.26
6	2009	3	1.69
7	2010	2	1.13
8	2011	6	3.39
9	2012	15	8.47
10	2013	15	8.47
11	2014	18	10.17
12	2015	24	13.55
13	2016	17	9.60
14	2017	18	10.17
15	2018	13	7.34
16	2019	16	9.04
17	2020	10	5.65
18	2021	3	1.69
19	2022	6	3.39
20	2023	1	0.56
Total		177	100

The above table shows that the total number of theses submitted in year wise in biotechnology during 2004 to 2023. The data presented in table 1 indicates that total 177 theses submitted and awarded in the department of Biotechnology during 2004 to 2023 in the University of Mysore. The highest 14.12% (25) of the total theses

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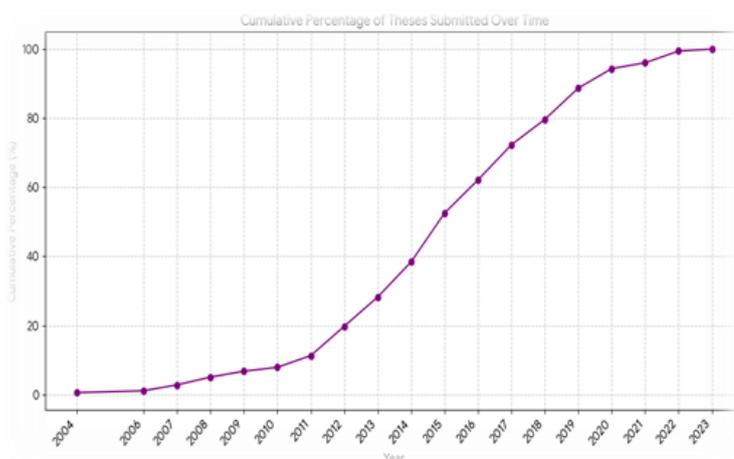
submitted in the year 2015 followed by 18 theses in the years 2014 and 2017, 17 theses in the year 2016, 16 theses in the year 2019, 15 theses in these in the year 2012 and 2013 respectively, 13 and 10 theses submitted in 2018 and 2020 respectively. Sigel digit i.e. 1 to 9 theses submitted in the years from 2004 to 2011 and 2021 to 2023. The study highlighted that the highest i.e 83% (147) of the total submission of theses submitted during 2011 to 2020. After 2020 little bit decreased it might be COVID-19 pandemic.

Figure No. 1: Annual and Cumulative Thesis submission across Timeline



The red dashed line in the chart represents the cumulative number of theses submitted from 2004 to 2023. This line shows a consistent and upward trajectory, which is a key indicator of growth in thesis production over the observed period. The slope of this line is always positive, meaning the total number of theses never decreases. This clearly demonstrates a steady, long-term expansion in academic output. The blue line with circular markers shows the number of theses submitted each year. Unlike the cumulative trend, this line exhibits significant fluctuations. We can see several notable periods:

Figure-2: Cumulative Percentage of Submitted Theses



This combined view is prevailing because it allows researcher to distinguish between the short-term fluctuations in yearly output and the long-term, continuous growth of the overall thesis count. It shows that even with periods of fewer submissions, the total number of theses continues to grow.

- Initial Slow Growth (2004-2010): The line is relatively flat during this period, indicating that it took many years to accumulate even a small percentage of the total theses.
- Period of Exponential Growth (2011-2019): The curve becomes significantly steeper in this phase. This rapid rise shows that the number of theses submitted per year increased dramatically, quickly adding to the cumulative total. Over **85%** of the total theses were submitted during this period.
- Maturity Phase (2020-2023): The curve begins to flatten out again towards the end of the period, indicating that the rate of cumulative growth has slowed considerably.

4. RELATIVE GROWTH RATE AND DOUBLING TIME

The word ‘**Growth**’ represents an increase in actual size. Implying a ‘change of state’, change in size of literature over a specific period of time is termed ‘growth of literature’. Relative Growth Rate (RGR) is growth rate which is related to size. Based on the speed of growth it is also called as exponential growth rate or the continuous growth rate. RGR is increase in the number of publications per unit of time. The RGR has been calculated by the following formula.

$$R = \frac{\log(W_2) - \log(W_1)}{T_1 - T_2}$$

Where,

R= Mean relative growth rate over the specific period of intervals

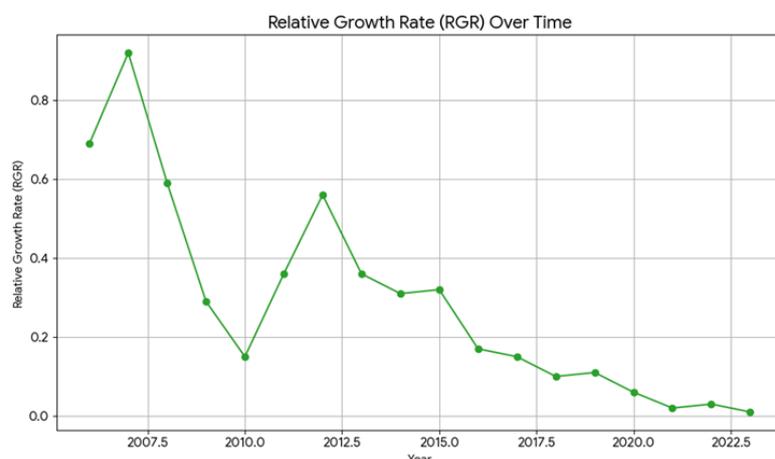
W₁ = Log W1 (Natural log of initial number of publications)

W₂ = Log W2 (Natural log of final number of publications)

T₁-T₂ = The unit difference between the initial and final time

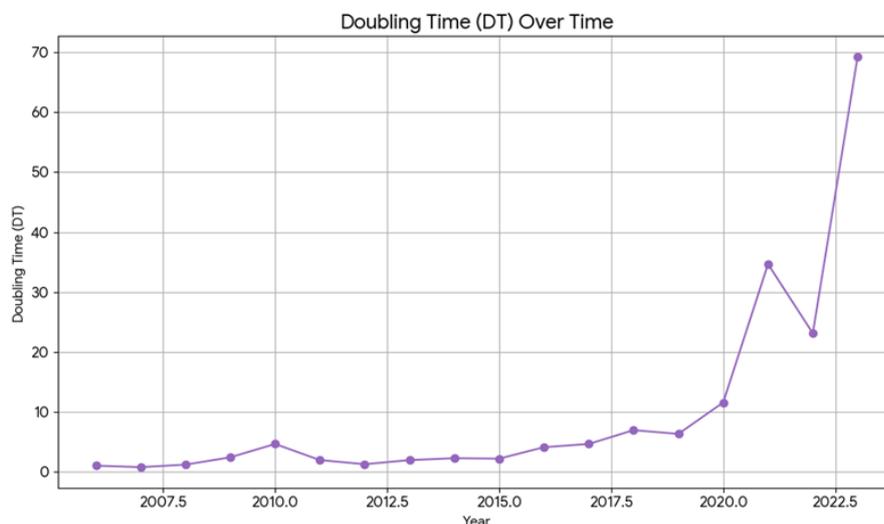
Relative Growth Rate (RGR): The RGR chart shows a high rate of growth in the initial years (e.g., 2006 and 2007) when the research output was small. As the total number of theses grew, the RGR generally declined. This is a common pattern in scientific growth where the initial rate of expansion is high, and then it stabilizes or slows down as the field matures. The low RGR in recent years indicates that the total body of work is growing, but at a much slower rate compared to the early years (Figure-3).

Figure-3: Relative Growth Rate



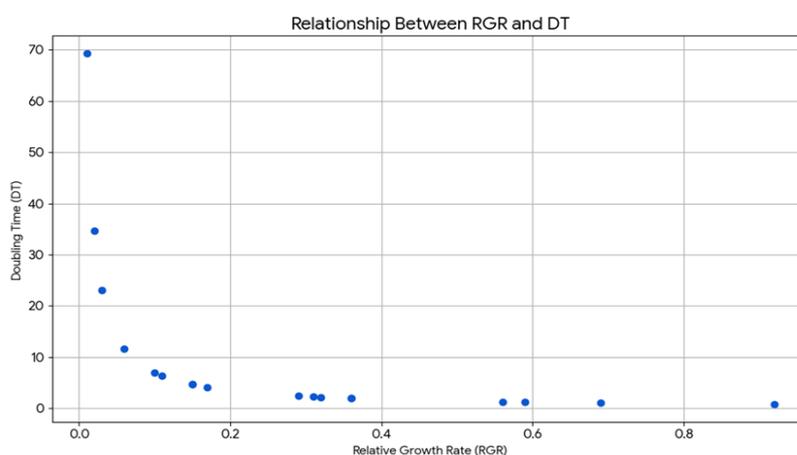
Doubling Time (DT): The DT chart is a mirror image of the RGR chart. It shows that in the initial years, the doubling time was very short (as low as 0.75 years in 2007), meaning the number of theses was doubling rapidly. As the RGR decreased, the DT dramatically increased, reaching over 69 years in 2023. This implies that while the field is still expanding, it will take a much longer time for the current body of work to double in size (Figure-4).

Figure-4: Doubling Time



The scatter plot of RGR vs. DT visually confirms the **inverse relationship** between these two metrics; RGR and DT. The data points form a clear curve, showing that a high RGR is always associated with a low DT, and a low RGR with a high DT. The chart provides empirical evidence of this fundamental principle of exponential growth and decay in the context of academic output (Figure-5).

Figure-5: Relationship between RGR and DT

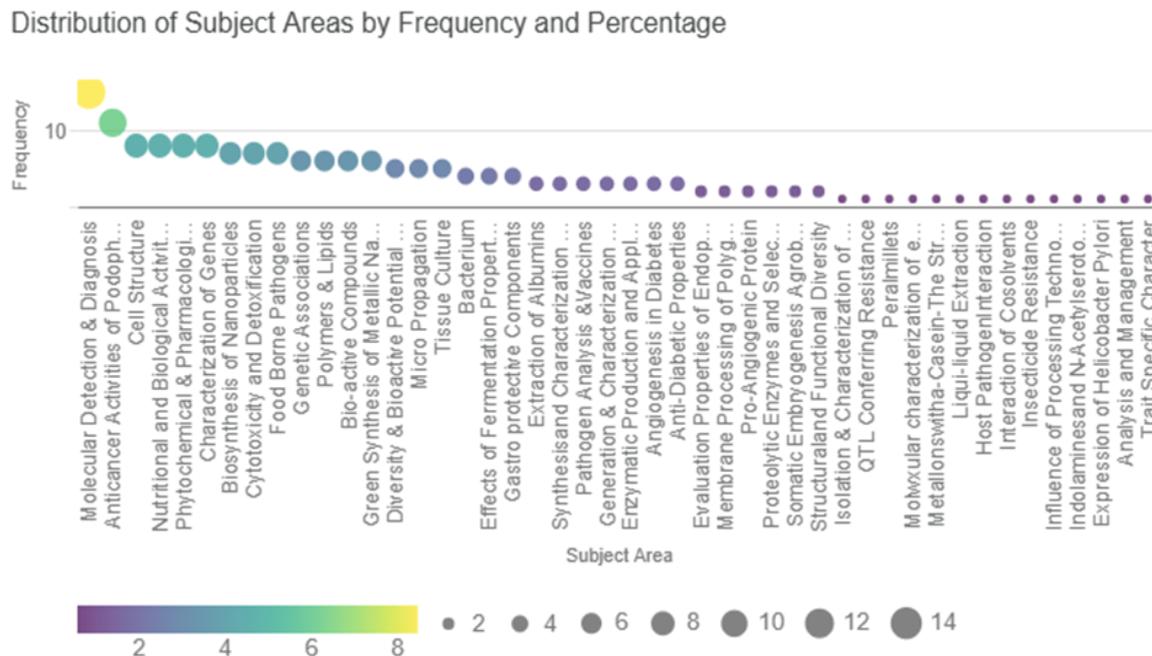


5. Distribution of Subject Areas

The study indicated that, out 177 doctoral research study in the department of Biotechnology at the University of Mysore, most of the research of doctoral research study on Molecular (15, 8.47%), anticancer activities (11, 6.21%). Four subject area i.e. Cell Biology, Genes, Nutritional & Biological activities, Phytochemical & Pharmacological areas accounted 8 each covered in 4 theses. Biosynthesis, Cytotoxicity and Detoxification, Food Borne these three subjects are accounted 7 each covered in 3 doctoral theses. Bio-Active, Genetics, Green Synthesis and Polymers

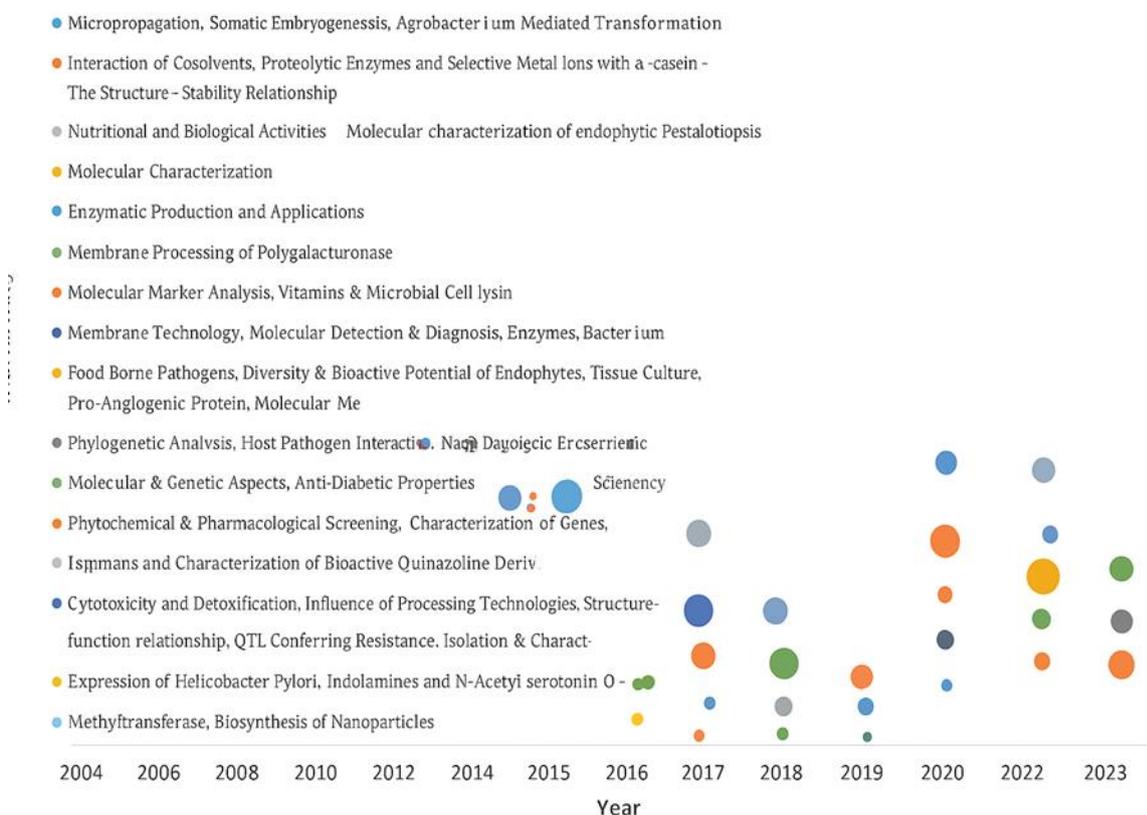
have accounted 6 keywords covered in 4 doctoral research theses. Total 14 doctoral research area of study is very low rate i.e. one each thesis at the University of Mysore in the department of Biotechnology.

Figure-6: Distribution of Theses based on Subject Area



- ❖ Molecular & Genetic Studies is the most frequent theme, appearing 9 times. This includes topics like molecular characterization, genetic aspects, and phylogenetic analysis. This category reflects a strong focus on the fundamental biological and genetic underpinnings of various subjects.
- ❖ Disease & Anti-Disease Research is the second most common area, with 7 instances. This category includes work on anticancer activities, anti-diabetic properties, and pathogen analysis, showing a significant emphasis on health-related research.
- ❖ Biotechnology & Microbiology are also prominent, appearing 6 times. This covers a broad range of topics from enzyme production and fermentation to the study of bacteria and fungi.
- ❖ Nanotechnology is a notable emerging theme, with 3 studies focusing on the synthesis and application of nanoparticles.
- ❖ Food Science & Agriculture is a consistent topic, with 3 entries related to food packaging, formulations, and agricultural applications.

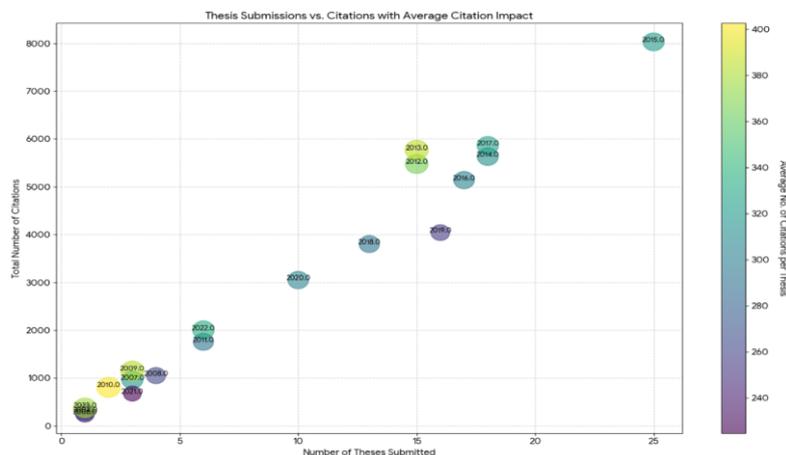
Figure-7: Distribution of Theses based on key words across Timeline 2004-2023



6. CITATIONS PER THESIS AND IMPACT

Citations are a fundamental component of academic and research work. A **citation** is a formal reference to a source used to support facts, arguments, or ideas presented in a piece of writing. It acknowledges the original creator of the content and provides the necessary information for readers to locate the source themselves. So, the researchers are mandatory to mention the references in their research work. In this study the researcher highlighted number of theses submitted and how many citations listed in their thesis in year wise.

Figure-8: Average Citation Impact



The bubble chart, figure-8 reveals insights into both the quantity and impact of the research:

- High Volume, High Total Citations: As expected, years with a higher number of theses, like 2015 (25 theses), generally correspond to a higher total number of citations.

- Impactful Years: Years like 2010 (2 theses, 402.5 average citations) and 2013 (15 theses, 384.67 average citations) stand out with larger, yellowish bubbles. This indicates that even with a lower number of theses, the average citation impact of the research was exceptionally high, suggesting high-quality or highly influential work.
- Contrasting Periods: Conversely, some years like 2019 (16 theses, 252.56 average citations) and 2021 (3 theses, 224.67 average citations) have smaller bubbles despite a varying number of submissions. This shows that the average citation impact for these years was relatively lower compared to other periods.

7. OUTCOMES OF THE STUDY

This analysis, based on 177 doctoral theses submitted between 2004 and 2023, reveals several key trends regarding submission volume, growth rate, research focus, and citation impact.

7.1 Research Output and Growth

A significant portion of the theses—83%, or 147 out of 177—were submitted in the decade from 2011 to 2020. This indicates a period of high research activity. Following 2020, there was a decline in submissions, which may be linked to the COVID-19 pandemic.

The study also highlights a clear trend in the Relative Growth Rate (RGR) and Doubling Time (DT). Initially, the RGR was very high and the DT was very short (as little as 0.75 years in 2007), reflecting rapid growth when the total number of theses was small. However, as the overall body of work grew, the RGR declined and the DT increased, indicating that the pace of growth has slowed down in recent years. This is a common pattern in the growth of academic fields.

7.2 Dominant Research Areas

The research in the Biotechnology department shows a concentration in a few key areas, while a large number of topics are covered less frequently.

1. Leading Subjects: The most common areas of study were Molecular and Genetic research (15 theses), followed by anticancer activities (11 theses).
2. Other Prominent Areas: Several other topics were also quite popular, each accounting for a notable number of these:
 - ❖ Cell Biology, Genes, Nutritional & Biological activities, and Phytochemical & Pharmacological research each contributed 8 theses.
 - ❖ Biosynthesis, Cytotoxicity and Detoxification, and Foodborne subjects each accounted for 7 theses.
3. Diverse but Infrequent Topics: A significant number of topics (14 in total) were covered in only one thesis each, indicating a broad but low-frequency exploration of various subjects within the department.

7.3 Citation Impact

The analysis of citations reveals a strong connection between the volume of theses and their total impact, with some notable exceptions.

- 1) High Volume, High Impact: There is a clear correlation between the number of theses submitted in a year and the total citations they receive. For example, 2015 saw the highest number of theses (25) and also the highest total number of citations.

- 2) Highly Influential Years: Some years, despite having a lower number of theses, produced highly impactful research. For instance, 2010 and 2013 had a high average number of citations per thesis (402.50 and 384.67, respectively), suggesting that the work from these years was of particularly high quality or influence.
- 3) Years of Lower Impact: In contrast, some years like 2019 and 2021 saw a lower average citation rate per thesis, regardless of the number of submissions, indicating a period of lower collective research impact.

CONCLUSION

The analysis of 177 doctoral theses submitted between 2004 and 2023 reveals a clear and dynamic picture of research trends in the department. Initially, the department experienced a period of slow output, followed by a phase of rapid, sustained growth from 2011 to 2020. This growth is evidenced by an exceptionally high number of submissions during this decade, accounting for 83% of the total. However, the data also shows that this growth rate has slowed significantly in recent years, a trend that may be linked to the COVID-19 pandemic.

In terms of research focus, the research work is concentrated in a few core areas, primarily molecular and genetic studies as well as anticancer activities. While a handful of topics dominate the field, there is also a wide diversity of research, with many subjects being explored on a smaller scale.

Finally, the study of citation impact shows a strong correlation between the volume of theses and their total citations. However, it also highlights that certain years had an exceptionally high average citation rate, suggesting that high-impact research is not solely dependent on the number of theses produced. This indicates that while volume is a factor in collective impact, the quality and influence of individual research also play a crucial role.

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