CHAPTER 6
FINDINGS, SUGGESTIONS AND CONCLUSIONS

6.1 INTRODUCTION

The major findings, suggestions, and conclusions of this study pertaining to the literature in Rubber Plant Research in International and National levels based on the analysis and interpretation are presented in this chapter. Based on this analysis, discussions and observations have been highlighted further; workable suggestions and recommendations are also listed.

6.2 THE FINDINGS
6.2.1 Growth of Rubber Plant Research Literature
6.2.1.1 Year wise publications output

- The Rubber Plant Research Publications output during the study period 1967 to 2016 consist of 4936 records of publications and the average publication per year is 98.72. Hence, the total publications, 35% of publications was published in first 30 years, i.e. 1967 to 1996. More than 60% of publications was published the years between 2000 and 2016.

- The publication trend noticed from the year 1995 onward. Important fact that, 40% of publications were received from 2007 to 2016, i.e. last 10 years. This explores scientists have shown their interest recently in the field of Rubber Plant research.

- The study period of 50 years has been divided in ten five year block periods. Among the seven blocks, the first seven blocks have an average of 7%, the eighth block has 14%, ninth block has 18% and
final block has 22% publications. The cumulative percentage explains that linear growth occurs in this Rubber Plant Research Literature publications.

6.2.1.2 Growth Ratio output

- The Growth Ratio progress over the previous period has calculated that the growth ratio varies from 0.60 to 4.22. It observes that there exists fluctuations through this study period. During the Growth Ratio of block period publications, the fluctuation varies from 4.68 to 6.63. There exists steep growth of publications in the first block with 6.63 & third 4.68 and the final block slashed with 5.10. However, there is linear growth from first to final blocks.

6.2.1.3 Relative Growth Rate (RGR) & Doubling Time (DT)

- The Year wise RGR has been decreasing from the year 1968 ie is 0.47 and 2016 is 0.04. On the other hand, the DT records as an increasing trend, show from the year 1968 is 1.48 and the final year 2016 is 15.64. The DT values gradually increased from the top to down. The Same way in the blocks, RGR from the second block is 1.17 and the final block shows 0.25, these values gradually decreased from the top to down. The DT from the second block is 0.59 and in the final block shows 2.73, the values increased from the top to down.

- There exists, a decreasing trend in the Relative Growth Rate and correspondingly increasing trend in Doubling Time. It has significantly proved the hypothesis in Rubber Plant Research literature.
6.2.1.4 The Time Series Analysis - Future Growth

- Use of Time Series Analysis technique is to predict the number of publications for the near future that is 2025 and 2030. The results found that the estimated future growth increased as 98.74 (2016), 218.84 (2025) and 237.4 (2030). It clearly explains the progressive trend continued up to estimated year. It is inferred that the rate of growth is positive in relation by the year wise publications of Rubber Plant Research.

6.2.1.5 Growth of Pages Output

- A total page 39069 with an average of 781 pages per year and average page per publication is eight pages. The page count explains, that the minimum is 46 (1968) and the maximum is 2756 (2014). This clearly explains the upward trend in the rubber plant pages output. Relative Growth Rate from the year 1968 is 0.28, and in the final year 2016 is 0.05, The overall value is 5.56, and the values gradually decreased from the top to bottom. On the other hand, the Doubling Time explains an increased trend, from the year, 1968 is 2.50 and the final year 2014 is 12.79. There exists, a declining trend in the Relative Growth Rate and correspondingly increasing trend in Doubling Time. It significantly proved the hypothesis in Rubber Plant Pages output.

6.2.2 Geographical Contributions

6.2.2.1 Continent wise distributions

- In Continent wise contribution, Asian countries lead with 1493 with 26% followed by North America with 1305 (23%), Europe 1227 (22%) publications, Africa with 135 (2%), Australia 105 with (2%), and finally South America with 20 (0.35). Asia and North America
contributed together more than 50% of the publications. Asia played a major role in this Rubber Plant Research.

6.2.2.2 Country wise Contributions

- The Scopus database explores that 103 countries participated in this study. USA participated with 909 (18%) publications, followed by China 388 (8%), Germany 270 (5%), Brazil 240 (5%), Japan 240 (4%) and India contributed with 209 publications. It has been registered as the sixth spot among the countries.

6.2.2.3 Asian Countries and Vs Year distributions

- Among 26 Asian countries participated in this study, China ranked first with 26% publications, followed by Japan with 14.13%, and India with 14% with third place, respectively.

6.2.3 The Authorship Pattern Analysis

- Total 16,222 authors participated and contributed with 4936 publications in the Rubber Plant Research literature Output. The single authors 1097 (22%), followed by two authors 913 (19%), three authors with 784 (16%), four authors with 652 (13%), five authors with 431 (9%), more than five authors contributed 791 (16%) and an anonymous authors 268 (5%). The Degree of collaboration (DC) is 0.78, which clearly indicates the dominance of multiple authors in this research; while multiple authors published 88%, (3839) and Single authors published 22%, (1097).
6.2.3.1 The Authorship Pattern Vs DC, CC & CI

- The Degree of Collaboration (DC) of Rubber Plant Research literature ranges between 0.36 (1970) and 0.96 (2016), but the average is 0.78. This reflects that the collaborative is more in chance in this research.

- During the collaborative Index (CI) between the years 2.24 (1979) and 5.50 (2016), the average is 3.94. Joint authored papers imply the research team falls between 3 to 5 in the field of Rubber Plant Research literature.

- The Collaborative Coefficient (CC) ranges between 00.15(1970) and 0.29 (2012) with an average 0.25. According to Ajifuruke, the fewer rates (0.50 to 0.67) are better than the collaboration among authors.

6.2.3.2 The Co-Authorship Index (CAI)

- Authorship values are categorized single, two, three and more than three authors. It is found that co-authorship index is high in more than four papers. Three author’s papers are higher than two authors’ papers where as two authors’ papers have lower CAI.

6.2.3.3 The Single and Joint Authorship - Time Series Analysis

- The estimated future growth of single authorship has been increasing from 21.94 (2016), 23.26 (2025) and 23.46 (2030). The estimated future growth of joint authorship has been increasing from 76.78 (2016), 213.58 (2030) and 627.86 (2025). The trend continued up to the estimated year. Hence, it is inferred that the rate of growth is positive in relation by the year wise publications. Again, the multiple Authors collaboration dominates in this field of rubber plant research literature.
6.2.3.4 The Author Productivity

- Single-authored papers produced 1097, 2-authored 913, 3-authored 784, and 4-authored 652 and up to the maximum 48-authored papers are contributed in this research. Over all, single-authored paper 22% and multiple authored papers 88% are contributed. Multiple-authored papers are leading the Rubber Plant Research literature.

6.2.3.5 The Prolific Authors contributions

- For the Author wise contribution of Rubber Plant Research Output in the world level, the analysis explains that Cornish, K published 54 (3%) publications followed by Raulf-Heimsoth, M. with 34 (2%), Montoro, P. with (1%).

6.2.4 Document Type Contributions

- For the Document Type contributions in the International level, only three document types produced more than 200 publications. Among the Document Type, Journal Articles play the major role, which produces 3846 (78%) publications, Secondly Conference Paper 559 (11%), and Review 221 (4%), respectively.

6.2.5 Source Title Wise Distribution

- Among the contributed Source Titles, only five Source Titles have more than 50 publications. The Industrial Crops and Products records the highest 88 (2%) publications, followed by Chemical And Engineering News with 71 (1.4%), and Rubber World with 51 (1%), respectively.
6.2.6 Keyword Analysis contributions

• Totally 19035 keywords combinations has been identified in this research. Only four keywords contributed more than 500 publications combination. The keyword “Rubber” leads the research and covers 1572 publications, followed by “Article” with 1089 nd “Hevea Brasiliensis” with 689, respectively.

6.2.7 Institute Wise contributions

• Among the top 20 participated Institutions, The Institutions from USA occupied 05 places; China 04, Brazil 04, Thailand 02, India, France, Malaysia, German and Srilanka occupied each one place among top 20 institutes. The Institute wise distribution of world level rubber plant research literature expressed that Chinese Academy of Tropical Agricultural Sciences of China contributed with 106 (4.5%) publications followed by Prince of Songkla University, Thailand 76 (3.23%) and CIRAD Centre de Recherche de Montpellier from France 69 (3%), respectively.

• Indian institute, Rubber Research Institute of India, Kottayam, Kerala contributed 40 publications with 11th place among the institutes in this research.

6.2.8 The Research Areas contributions

• Among the 27 sub-fields, a total number of 7752 research area combinations has been contributed in this rubber plant research. Engineering produces maximum number of publications i.e. 1408 (18%), Agricultural and Biological Sciences 1200 (15%), Medicine 774 (10%), Material Science 673 (9%), Biochemistry, Genetics and Molecular Biology 662 (9%) and Chemical Engineering with 623 publications.
6.2.9 The Language Wise contributions

- English language dominated in this research! It covers 4122 (84%) publications where as other languages only 10% of publications. The German language has 231 (5%), Chinese got 96 (2%) Japanese has 120 (1%) and French got 111 (1%) publications. Scopus database explores that 22 languages cover 11, 050 publications and others have 129 publications.

6.2.10 Citation Analysis

- During this study period 1967-2016, 51600 citations have been received among the 4936 publications. The minimum citation was 20 in the year 1968, the maximum 3440 received in the year 1996 and the average citations 1032 per year. An average citation per paper is 10.5. The minimum citations are 83 (1980) and the maximum citations are 4304 (2008). The highest average per paper is 09.80 (2003) and very low in 0.46 (2014). Citations growth reflects in this analysis. The progressive trend occurred between the starting year and the ending year.

- The top 10 cited articles gained minimum 230 and the maximum 1348 citations received. Agarwal, A.K. from the IIT Kanpur, India got the first position; In the year, 2007 published the article received maximum 1348 citations followed by Godfrey, NH published in the year 1969 and total 868 citations received. Among the top 10 articles, the document type Articles occupied 5 places followed by Review got 3 places, Conference Paper and Book got each one place.
6.2.11 Indian Contributions in Rubber Plant Research

6.2.11.1 The Growth of literature

- The Indian Rubber Plant Publications research output during the study period 1967 to 2016 i.e. 50 years, India contributed a total of 209 publications. There were no articles in three years i.e. 1980, 1985 and 1989. The maximum output 18 (2016) followed by 17 (2014), 14 (2011) and so on. More than 50% of the Indian publications have been received only last 10 years. The cumulative percentage is 5% (1967) and finally, it 91% (2015). This reflects the progressive Indian contributions in Rubber Plant Research output.

6.2.11.2 The Growth Ratio of Indian contributions

- The Growth ratio varies from 0.33 to 6.00; From the table, it is observed that there exists fluctuation through the study period of Indian Rubber plant Research literature. In block period publications, Fluctuation varies from 0.83 to two. There exists steep growth of publications over the Sixth block topped with 1.83 and very low in the third, blockwas 0.38. From seventh to tenth block, values got increased double time of publications.

6.2.11.3 RGR & DT for Indian Publications

- In the Publications, In the year, 1969, it is 0.69 and in the final year, 2014 it is 0.09. The overall value is 5.34. The RGR values gradually decreased from the top. On the other hand, the DT shows an increasing trend. In the year, 1968, it is one and the final year (2016) it is 7.69. Relative Growth Rate has shown a decreased trend, which means the rate of is low in terms of proportion, and this has highlighted by Doubling Time for publications, It is more than the
relative growth rate. It is significantly proved by the first hypothesis in Indian Rubber Plant Research Publications.

6.2.11.4 Research Areas Output - Indian publications

- Over all performance, Energy Agricultural and Biological Sciences produced 26%, which dominated in the Rubber Plant research areas output. Followed by Biochemistry, Genetics and Molecular Biology with 31 (9%), Engineering 30 (9%), Chemistry 29 (8%) and Environmental Science with 29 (8%), respectively.

6.2.11.5 Document Type contributions – Indian publications

- Among the Document Type contributions of Indian Rubber Plant Research literature, article plays the vital role in this research ie 169 publications with 81%. Second one Conference Paper 13 with 6% and Review got 13 with 6%. The Book chapter has six (3%); Book has 3 (1%), and Business Article has 01 (0.5%). Figure 5.29 clearly shows the Indian document type publications output.

6.2.11.6 Institutions contribution – Indian publications

- The total 293 Indian institutes participated in this research. The Rubber Research Institute of India, Kottayam contributed with 40 (14%) publications followed by Bhabha Atomic Research Centre (BARC), Mumbai with 7 (2%) and so on. Below the Table 5.40 and Figure 5.30 clearly presents the remaining institutes contribution of Indian publications.
6.2.11.7 Source Title distribution – India publications

- The Source Title wise Indian contributions, Journals contributed 176 (84%), Conference Proceedings records 14 (7%) publications followed by Books with nine (4%), Trade Publications with nine (4%) and Book Series with 01 (0.5%).

6.2.11.8 Prolific Authors - Indian Publications

- Form the part of top 10 Indian prolific authors of India, the analysis reveals that Thulaseedharan, A. published 16 (5%) publications followed by Venkatachalam, P. 10 (3%), Priya, P. 8 (2%), Jayashree, R. 6 (1.8%), Rekha, K. 6 (1.8%), Sethuraj, M. R. 6 (1.8%) and so on. Table 5.42 and Figure 5.32 present the top 10 contributed authors in the field of Indian Rubber Research literature.

6.2.11.9 Author Productivity- Indian Publications

- In the Indian Rubber Plant Research literature, multiple authors produced 137 (75%) publications and single authors with 45 (25%). It clearly expresses the trend that multiple authors dominated in this field. Totally, 721 authors have produced 209 publications with an average of 3.45 authors contributed per paper. In this analysis, Single-authored papers contributed 23 (11%), 02-authored 55(26%), 03-authored 52 (25%), and 04-authored 39 (19%) and up to the maximum 14-authored papers contributed in this research. Single and two authors produced 37% of Indian contributions. Hence, multiple authored papers contributed 89% to the Indian Rubber Plant Research literature.
• The degree of collaboration in the field of Rubber Plant Research literature is 0.89, which clearly indicates the dominance of multiple authors’ contributions.

6.2.11.10 Citation Analysis- Indian Publications

• A total 3465 citations received from 209 publications. Table 5.45 and Figure 5.34 clearly reveal the Indian rubber publication citation trend. The minimum single citation from 1974 and the maximum 1438 received in 2007 with an average 69.3 citations per year and 16.6 citations per paper. For 16 years, there was no single citation. From the year 1970 to 2005 there was steady growth and the year 2007 topped with 1438 citation.

6.2.11.11 Highly Cited Papers - Indian Publications

• The top 10 cited articles gained minimum 45 and the maximum 1348 citations received. Agarwal A. K. got the first position! This review has been published in Progress in Energy and Combustion Science, followed by Thakur V.K., and other 3 authors published in Industrial Crops and Products journal in 2014 Totally, 214 citations were received. Banapurmath N.R. and two others published in Renewable Energy in 2008 and received 195 citations.
6.3 FINDINGS IN RELATION TO HYPOTHESES

- There exists linear growth of literature in the field of Rubber Plant Research.

- There is a declining trend in the Relative Growth Rate (RGR) and Doubling Time (DT) reflects an increasing trend. This is significantly proved by the hypothesis in Rubber Plant Research Literature.

- The collaboration research dominates and there is an increasing trend in the research during the study period. The degree of collaboration (DC) is 0.78. In addition, in the Time Series Analysis (TSA), the joint authors growth is increasing in double the time while comparing the single authorship, which clearly illustrates the dominance of multiple authors contribution.

- The Journal Articles play a major role in the source publications on Rubber Plant Research and there is a significant difference in the form of publication in publishing research. It has got a predominant place in comparison with other type of publications.

- There is a strong positive correlation among the publication count and the number of journals, number of conference articles and number of conference proceedings.

- The Research area covers the considerable level of variation in subfields of Rubber Plant Research productivity. Engineering and Agricultural & Biological Sciences Engineering produced nearly 35% of publications, and others produced 65% of publications.

- The geographical region wise, the developed countries, USA, Germany and China produced more than 75% of publications in this research.
6.4 DIRECTIONS FOR FURTHER RESEARCH

The present study of research productivity on Rubber Plant Research offers avenues for future research in the following areas:

1. Providing a review of existing knowledge of the Rubber Plant Research sub-sector and increasing understanding the implications.

2. A comparative study of Web of Science, Compendex, Scopus and bibliographic databases and their coverage on Rubber Plant Research can be carried out.

3. Special focus on Citation Analysis research journals can be covered in the field of Rubber Plant Research.

4. Scientometric analysis of Rubber Plant Research among the South Asian Countries can be carried out.

5. The Research can be carried out on subject dispersion. This analysis of the present study further reveals the applications of statistical techniques and tools that facilitate future researchers to test.

6. The Growing Rubber Plant industry that ensure, the sustainable safety, security, stable live hood systems and environmental integrity of the concern.

7. The global policy developments ensure the future directions that can support increasing Rubber Plant Research contribution to the greatest possible extent.
6.5 CONCLUSIONS

The present study has revealed various facts of publishing pattern and with the trend in Rubber Plant Research. During 50 years study period, 1967 to 2016 consist of 4936 records and the average publication per year is 98.72. The estimated future growth trend will be 218.84 (2025) and 237.04 (2030). This indicates the Rubber Plant Research literature has bright future. Paradigm shift over the period is a gradual increase in the study period but good response has been observed in the year 2013, 2014 and 2016. However, USA has the highest (18%) of publications, China with 8% and India contributed 4% publication. Asian Countries play major roles in this research. The Degree of collaboration is 0.78, which clearly indicates the dominance of multiple authors dominated in this research. Among the document type publications, Journal Articles contributed 78% of publications in this research. Industrial Crops & Products Journal contributed 2% publications in this rubber plant research. India contributed 4% publications with sixth position in the world. Indian Scientists gave much more importance for the rubber research, i.e. The Rubber Research Institute of India; Kottayam contributed 14% of publications.

The climate change is considered one of the most serious threats to the global environment. Increasing concentrations in the atmosphere of green houses gases (GHGs) such as methane, nitrous oxide, hydro fluorocarbons, per-fluorocarbons, sulphur hexafluoride and most importantly, carbon dioxide have been implicated to be the primary reason for global climate change which affects the rubber industry. India is world’s fifth largest natural rubber producer and fourth largest consumer behind China, the US and Japan. The development of alternative sources of natural rubber appears essential in the mid- to long-term to both secure our access to this essential polymer
and decrease our dependence on fossil carbon for the production of synthetic equivalents. Although alternative sources for natural rubber were investigated in the past, recent progress in plant molecular sciences has provided powerful tools.

The Rubber is a fascinating material that has given the world much improvements. To ensure a stable supply of natural rubber and to decrease our dependence on petroleum-based synthetic rubber, both development of alternative sources of natural rubber and improvement of the Hevea tree for higher productivity would be necessary. The fruition of international cooperation will open up a plethora of opportunities in the export of rubber goods, equipment and services. The Indian Rubber plant sector and industry need to evolve faster to meet the associated challenges.