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Bradford's law applicability to the Bacterial Blight research: A bibliometric study

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Abstract: The present study tests one of the important bibliometric laws that is Bradford's Law of scattering for the literature related to 'Bacterial Blight' research for the period 1989- 2021 as reflected in the Web of Science Core Collection database (Science Citation Index expanded). A total of 4748 articles related to Bacterial Blight research published and are scattered in 643 journals during the study period are retrieved. It was observed that the Phytopathology ranks first with total 5.22% (248) publications share, followed By Plant Disease ranks 2nd with 4.82% (229) publications, Molecular Plant-Microbe Interactions ranks 3rd with 2.49% (118) publications. In the present study, theoretical aspects of Bradford's Law of Scattering are tested also, graphical formation by drawing the bibliograph and found that the data do not fit to the present sample.

Keywords: Bradford's Law, Bacterial Blight research, Bibliometrics, Bibliometrics Law.

I. INTRODUCTION

Agriculture is backbone of any country as its offers the food needs of the growing population across the world. Farming community is facing many problems mainly diseases in plants cause loss in the crop yield. The main cause of plants diseases are bacteria, viruses and fungi. Diseases with plants harmful to the crop production or yields, the loss in the yield further affects the seed quality and contamination of the grain (Skelsey & Newton, 2015). Farming community facing many problems with plant diseases, scientists across the world involved in the prevent and support such type of plant diseases to overcome and get good crop yield. Blight is a specific symptom affecting plants in response to infection by pathogenic organism. Blight is a rapid and complete chlorosis, browning, this death of plant tissues such as leaves, branches, twigs or floral organs (Agrios, 2005).

'Bibliometrics' has commanded the attention of a number of individuals in Library and information science. The measurement of bibliographic information offers the promise of providing a theory that will resolve many practical problems. It is claimed that patterns of author productivity, literature growth rates and related statistical distributions can be used to evaluate authors, to assess disciplines and to manage collections (Sangam, 2015; Rao, 1998; Keshava et.al., 2010; Sangam, 2010). The core journals ranking studies are usually made to help in the selection of journals and assessing the importance of one or more journals in a particular subject field (Ganjihal & Keshava, 2015). The journals are arranged in their respective descending order of frequency. The journal contributing the largest number of publications is ranked as number one, next is ranked subsequently as two and so on. Bradford's (1934) law states that; documents on a given "subject" is distributed (scattered) according to a certain mathematical function so that a growth in papers on a subject requires a growth in the number of journals/information sources. The number of the groups of journals to produce nearly equal number of articles is roughly in proportion to 1: n: n2 …, where n is called the Bradford multiplier. In the present paper an attempt has been made to study the Bradford's Law.

II. OBJECTIVES

The specific objectives of this study are:

- To identify the core journals in the field of Bacterial Blight research publications.
- To test the appropriateness of verbal and graphical formulation of Bradford's Law of Scattering in the field of Bacterial Blight research publications.
- Application of Leimkuhler's model to the present data

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III. METHODOLOGY

For the present study, the data has been collected from Web of Science, Science Citation Index Expanded database records pertaining to the field Bacterial Blight research publications for the period 1989 to 2021 in the month of February 2022. A total of 4,748 publications were extracted from 643 journals and analyzed to test the Bradford's law.

Bradford's law of scattering:

Samuel Clement Bradford a chemist and chief librarian at the London Science Museum has made a statistical analysis of two geophysics bibliographies, the Current bibliography of applied Geophysics (1992-1931) and the quarterly bibliography of lubrication (1931-1933).

Bradford law of scattering is used as a tool to study the output of journals (Bradford, 1948). Based on the Bradford's observations, Brookes suggested the following linear relation to describe the scattering phenomenon as:

$$F(X)= a + b \log x$$

Where F(X) is the cumulative number of references contained in the first x most productive journals, and a & b are constants.

Further, Vickery (Vickery, 1948) extended the verbal formulation of the Bradford law to show that its application to any number of zones of equal values. Later Leimkuhler (Leimkuhler, 1967) has presented a simple expression of Bradford's distribution, which was named after him:

$$R (r) = a \log (1+ br)$$

Where, R (r) is the cumulative number of articles contributed by journals ranked 1 through r, and a & b are parameters. Similarly, Brooke's derivation for journal productivity takes the form

$$R (r) = a \log(\frac{b}{r})$$

Further, several other mathematicians provided different models but the Brookes expression of the Bradford's distribution has however gained wide acceptance.

IV. DATA ANALYSIS AND DISCUSSION

4.1 Ranking of Journals

The compiled ranked list of journals can be utilized by librarians and research workers to select the journals of greater importance and productivity in the particular discipline and thereby overcome the budgetary constraint which is posing serious threat to librarians.

The journals are arranged in terms of h-index (Keshava et.al., 2009; Ganjihal et.al., 2015), number of citations received by each individual journal and hence the highest rank will be occupied by journal with maximum number of publications and citations (Keshava et.al., 2010).

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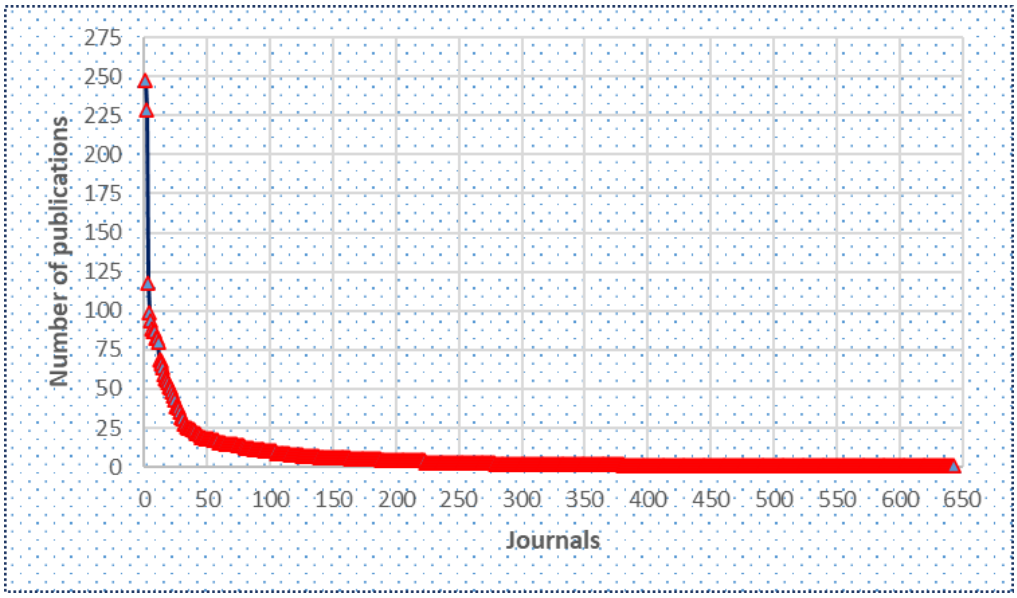

Figure 1: Ranking of Journals in Bacterial Blight research

The table 1 and figure 1 show the ranking of journals which are preferred by scientists to communicate their research output, the Phytopathology ranks first with total 5.22% (248) publications share, followed By Plant Disease ranks 2nd with 4.82% (229) publications, Molecular Plant-Microbe Interactions ranks 3rd with 2.49% (118) publications, European Journal of Plant Pathology ranks 4th with 2.09% (99), and Frontiers in Plant Science ranks 5th with 1.98% (94) of publications share in the field of Bacterial Blight research.

Table 1: Top 20 most preferred Journals in the field of Bacterial Blight research

Rank	Journal Name	TP	%	TCR	ACP	h-index	IF 2021
1	Phytopathology	248	5.22	5978	24.10	45	4.025
2	Plant Disease	229	4.82	3726	16.27	31	4.438
3	Molecular Plant-Microbe Interactions	118	2.49	6209	52.62	48	4.171
4	European Journal of Plant Pathology	99	2.09	1758	17.76	21	1.907
5	Frontiers in Plant Science	94	1.98	1918	20.40	26	5.753
6	Euphytica	89	1.87	2952	33.17	23	1.895
7	Plant Pathology	87	1.83	1550	17.82	22	2.59
7	PLOS One	87	1.83	2288	26.30	26	3.24
8	Journal of Plant Pathology	83	1.75	545	6.57	14	1.729
8	Theoretical and Applied Genetics	83	1.75	4975	59.94	43	5.699
9	Molecular Plant Pathology	80	1.68	3223	40.29	25	5.663
10	Journal of Phytopathology	69	1.45	707	10.25	15	1.789
11	Scientific Reports	68	1.43	1098	16.15	21	4.379
12	Journal of Plant Registrations	66	1.39	289	4.38	8	0.395
13	Crop Science	64	1.35	2349	36.70	26	2.319
14	Applied and Environmental Microbiology	59	1.24	3694	62.61	28	
15	Frontiers in Microbiology	57	1.20	1037	18.19	18	5.64
16	Molecular Breeding	56	1.18	1706	30.46	25	2.589
17	Rice	54	1.14	1197	22.17	18	4.783
18	Plant Pathology Journal	52	1.10	402	7.73	12	1.795
19	Physiological and Molecular Plant Pathology	51	1.07	1329	26.06	19	
20	Biological Control	48	1.01	1157	24.10	20	3.687
	Truncated						

TP-Total publications; TCR-Total Citations Received; ACP-Average Citations per Paper; IF: JCR IF 2021

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4.2 Application of Bradford' law

S.C Bradford (1934) first formulated his law in 1934 while searching for publications in two journals 'Applied Geophysics and Lubrication'. He noticed that the scatter of scientific journal publications follows a common pattern (Ganjihal & Keshava, 2008). He described productivity of publications relevant to a subject field and then they may be divided into 3 zones so that each zone produces 1/3 of the total relevant publications.

In other words, Bradford's law of scattering describes that "If the scientific periodicals are arranged in order of decreasing productivity of publications on a given subject, they may be divided into a nuclear of periodicals more particularly devoted to the subject and several groups or zones containing the same number of publications as the nucleus when the number of periodicals in the nucleus and succeeding zone will be as $1:n:n^2$ in zone" (Ganjihal & Keshava, 2015; Keshava et.al., 2008). The first nucleus zone contains a small number of highly productive journals say n1, the second zone contains a larger number of moderately productive journals, say n2, and the third zone containing a still larger number of journals of low productivity say n3. He enunciated his law as

$1: n : n^2$, where 'n' is a multiplier.

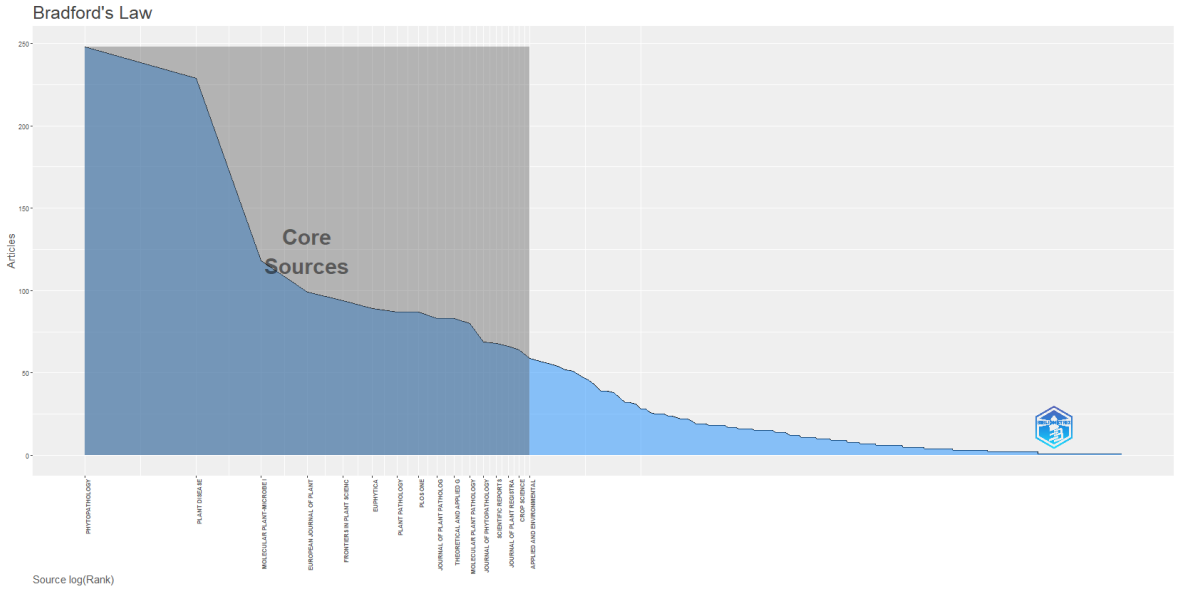

Figure 2: Core journal in Bacterial Blight research according Bradford's law

For testing the law, the Bacterial Blight research publications, the 643 journals are divided into three zones. Core journals are presented in the figure 2. The Bradford's multiplier factor was arrived at by dividing journals of a zone by its. In the present data set it was observed that, 16 journals covered 1623 publications, next 65 journals covered 1560 publications and next 562 journals covered 1565 publications.

In other words, one third of the total in the present study is 1 : 4.062 : 8.646. By this, it is found that the relationship of each zone in the present study for Bacterial Blight publications does not fit into the Bradford's distribution (Vickery, 1948; Sudhir, 2010; Ganjihal, Keshava, & Sangam, 2017).

Therefore, the Bradford's formulation may be modified in the following way to suit the journal distribution pattern:
$16:16*6.354 : 16*6.354^2 :: 1:n:n^2$
16: 101.664 : 645.973 which is 763.637
The percentage of error = $\frac{763.637-643}{643}$X100 = 18.76 %

Here, the percentage of error is higher and the present dataset will not confirm the Bradford's law.

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Table 2: Distribution of Bacterial Blight publications and journals according to zones

Zones	No. of Journals	% of Journals	No. of publications	% of Publications	Bradford Multiplier
1st	16	2.49	1623	34.18	-
2nd	65	10.11	1560	32.86	4.062
3rd	562	87.40	1565	32.96	8.646
All zones	643	100	4748	100	6.354*
* Mean value of the Bradford multiplier					

Application of Leimkuhler model:

For testing the Bradford's law, the 643 journals are divided in to three zones, since Bradford assumes that there should be minimum three zones i.e. p=3, then the value of k can calculated using the formula $k= (e^y y_m)^{1/p}$ where y is Euler's number (e^y = 1.781), y_m is the number of items in the most productivity sources (Leimkuhler, 1967; Brookes, 1969).

k= $(e^y y_m)^{1/p}$ = $(1.781 * 248)^{1/3}$ = **7.61**
Y_o= A/P = 4748/3 = **1,582.67**
r_0 = $\frac{T(k-1)}{k^p-1}$ = 643(7.61-1) / (7.61^3-1) = **9.66**
r_1 = r_0 * k = 9.66*7.61 = **73.51**
r_2 = r_0 * k^2 = 9.66 * $(7.61)^2$ = **559.43**
a= $\frac{Y0}{\log k}$ = 1582.67/0.881 = **1,796.48**
b = $\frac{k-1}{r0}$ = 6.61/9.66 = **0.68**

the findings of the calculation are shown in table 3, the number of journals in nucleus is found to be 9.66 and k=7.61is a multiplier. therefore, the Bradford distribution is

9.66 : 9.66*7.61 : $9.66*7.61^2$ ⁼⁼⁼ 1:n:n^2
9.66: 73.51 : 559.43 = 642.6

The percentage of error = $\frac{642.6-643}{643}$X100 = -0.062%

Here, the percentage of error of distribution is -0.062% and it is also observed that, the number of journals contributing the publications to each zone increases by a multiplier of 7.61. Specifically, first zone, containing 10 journals contributes 1217 publications, the 2nd zone consisting 2002 publications and the 3rd zone accounting for 1529 publications.

Table 3: Distribution of Bacterial Blight publications and journals according to zones

Zones	No. of Journals	% of Journals	No. of publications	% of Publications	Bradford Multiplier
1st	10	1.56	1217	25.63	-
2nd	74	11.51	2002	42.17	7.4
3rd	559	86.94	1529	32.20	7.55
All zones	643	100	4748	100	7.48

The Bradford's algebraic interpretation of the law, 1:n:n^2 is followed in this case. But the number of publications in each zone does not follow one third of the total citations.

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Graphical Formulation:

The graphical formulation approach was developed by Brookes, which tries to verity the Verbal formulation of Bradford's law (Bookes, 1969).

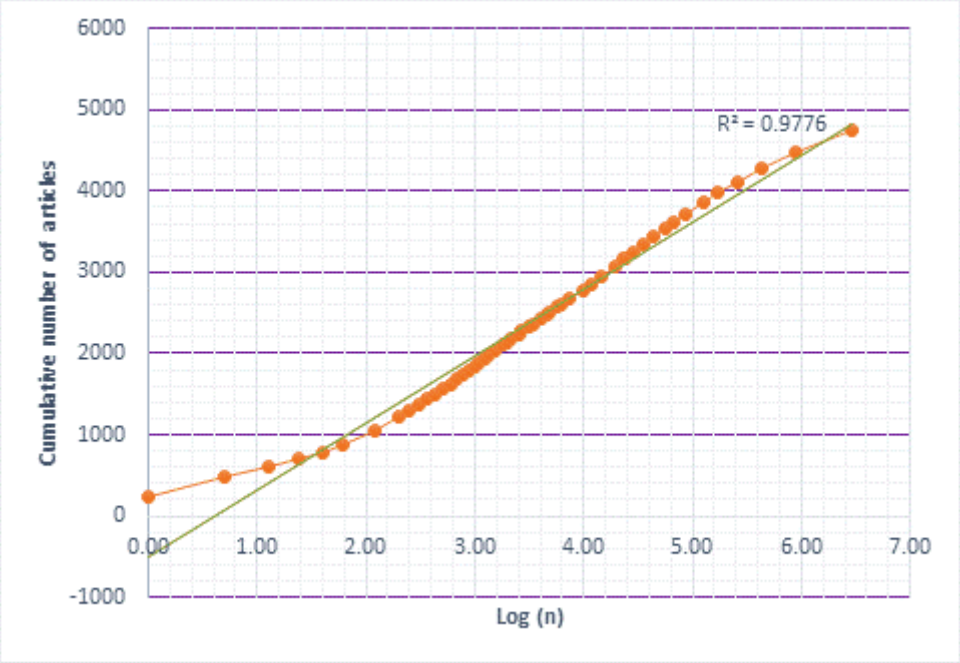

Figure 3: Bradfords Bibliograph for Bacterial Blight research publications

Table 4: Rank List of journals for plotting the graph for Bacterial Blight research publications

Rank	No. of Journals	Cumulative total of journal	No. of articles	Cumulative Number of articles	log (n)
1	1	1	248	248	0.00
2	1	2	229	477	0.69
3	1	3	118	595	1.10
4	1	4	99	694	1.39
5	1	5	94	788	1.61
6	1	6	89	877	1.79
7	2	8	174	1051	1.95
8	2	10	166	1217	2.08
9	1	11	80	1297	2.20
10	1	12	69	1366	2.30
11	1	13	68	1434	2.40
12	1	14	66	1500	2.48
13	1	15	64	1564	2.56
14	1	16	59	1623	2.64
15	1	17	57	1680	2.71
16	1	18	56	1736	2.77
17	1	19	54	1790	2.83
18	1	20	52	1842	2.89

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19	1	21	51	1893	2.94
20	1	22	48	1941	3.00
21	1	23	46	1987	3.04
22	1	24	43	2030	3.09
23	2	26	78	2108	3.14
24	1	27	38	2146	3.18
25	1	28	35	2181	3.22
26	2	30	64	2245	3.26
27	1	31	31	2276	3.30
28	2	33	56	2332	3.33
29	1	34	26	2358	3.37
30	3	37	75	2433	3.40
31	2	39	48	2481	3.43
32	1	40	23	2504	3.47
33	3	43	66	2570	3.50
34	1	44	21	2591	3.53
35	4	48	76	2667	3.56
36	6	54	108	2775	3.58
37	4	58	68	2843	3.61
38	6	64	96	2939	3.64
39	9	73	135	3074	3.66
40	6	79	84	3158	3.69
41	1	80	13	3171	3.71
42	6	86	72	3243	3.74
43	9	95	99	3342	3.76
44	9	104	90	3432	3.78
45	11	115	99	3531	3.81
46	10	125	80	3611	3.83
47	13	138	91	3702	3.85
48	25	163	150	3852	3.87
49	24	187	120	3972	3.89
50	36	223	144	4116	3.91
51	55	278	165	4281	3.93
52	102	380	204	4485	3.95
53	263	643	263	4748	3.97

Accordingly, the natural log of cumulative number of the journals and cumulative number of publications (table 4) is plotted on semi log graph shown in Figure 3, which is similar to Bradford's hyperbolic '**s**' shaped curve and curve with a Groos droop, where the journals are plotted against their productivity.

V. CONCLUSION

Bibliometrics has much to offer to the library and information field. The work of the past-by Lotka, Bradford and Zipf-is valuable in helping librarians assess patterns of authorship, identifying core collections (for collection management), and designing better retrieval systems (for authority control). Bradford's Law of Scattering is one such bibliometric law, which is helpful in selecting core journals in a research field. In this study, theoretical aspects of Bradford's Law of Scattering are tested and found that the data do not fit to the present sample in the field of Bacterial Blight research publications.

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When the Leimkuhler model is employed for the verification of Badford's law, it is found that the law find valid for the present data. The percentage of error is found to be the most negligible (-0.0622%). But the number of publications in each zone does not follow the one third of the total publications.

Conflict-of-interest statement

The authors have no conflicts of interest to declare. All co-authors have seen and agree with the contents of the manuscript and there is no financial interest to report. We certify that the submission is original work and is not under review at any other publication.

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