Bradford's Law of Scattering and its Application to the Analysis of Plant Breeding Research Publications in India.

Abstract

This article deals with the application of Bradford's law of scattering for Plant breeding research in India from 2021 to 2025, for this study the data has extracted from Web of Science. 7842 total publications are related to Plant Breeding research was published in 849 journals during 2021-2025. The study reveals Plant breeding with special emphasis on Indian researchers who accomplished unexpected milestones by contributing significant advances to the field and increasing their visibility in the global scientific community. It was determined that Plant Science Today ranked 1st with a total of 447 (5.70%) publications, followed by Frontiers in Plant Science, ranked 2nd with 439 (5.60%) publications, and Indian Journal of Genetics and Plant breeding, ranked 3rd with 333 (4.25%) publications. The result shows that verbal formulation 1: n: n2 has not fits with the data on Plant Breeding' and verification of Bradford's law and it fits with 13:65:771 geometric series with 23.25% of error. Furthermore, the Bradford law is examined using a graphical formulation, which indicates that all three characteristics are viable.

Keywords: Bradford's Law, Plant Breeding, AGR, ARoG, India

1. Introduction

Plant Breeding is the significant branch of Agricultural Science that focuses on intended to enhance plants' genetic composition to make them more useful for humankind. Producing desirable crop varieties with enhanced yield, quality, disease resistance, and environmental adaptability requires the intentional manipulation of plant species (Briggs & Knowles 1967). To enhance qualities such as production, quality, disease resistance, tolerance to environmental challenges, and nutritional value, it combines insights on genetics, botany, and agriculture. Farmers have been using simple selection since ancient times, determining the best-performing plants to propagate (Allard, 1999). Modern plant breeding currently utilizes systematic methods such as hybridization and mutant breeding, and biotechnological tools such as genetic engineering and molecular markers, driven by scientific advancements (Stoskopf et al. 2019). To ensure food security, promote sustainable agriculture, and adapt crops to a changing climate, plant breeding is essential. It helps meet the expanding demands

of the world's population while preserving environmental balance by continuously developing crop varieties.

The exponential evolution of scientific literature has made a specific field increasingly challenging for researchers due to the exponential growth of scientific publications. Bibliometric specifications provide methodical methods to evaluate trends in standard academic communication in the area of information and library science. One of the most important tools for interpreting the distribution of scientific publications across journals is Bradford's Law of Scattering, proposed by Samuel C. Bradford in 1934. Bradford's Law states that if scientific journals are arranged in order of decreasing productivity on a given subject. They can be divided into various consecutive zones, each with an increasing number of journals but a equivalent number of articles, and a nucleus (core journals). This occurrence emphasises the uneven distribution of knowledge: many journals publish only a few papers on the same subject, while a small number of publications account for a significant share of relevant research. The Law is frequently used in information retrieval techniques, journal selection, and collection development. Therefore, aims to apply Bradford's Law of Scattering to the domain of plant breeding research in India, evaluating how research outputs are distributed across journals, find out the core sources of information, and assessing the law's applicability in an agricultural research context. The findings are expected to contribute to both bibliometric research and the effective dissemination of agricultural knowledge in India. The study analyses the application of Bradford’s law to the plant breeding research in India for the period of 2021 to 2025.

2. Objectives of the Study:

The most important objectives of the study are as follows:

1. To analyse the growth and trends of plant breeding research in India;
2. To formulate the rank list of journals and study the phenomenon for the scattering of journals in India Plant Breeding publications and
3. To test the relevance of verbal and graphical formulation of Scatter of the law in Plant Breeding research publications.

3. Methodology

The current study focused on the verification of Bradford’s law of scattering in the Plant Breeding research in India. The data was obtained from the Web of Science database.

The databank has been searched for the keyword 'Plant Breeding' in the 'Title' AND 'CU=India' for the period 2021 to 2025. A total of 7842 articles published in 849 journals were included in the study. The following are the tests of Bradford's law and indicators used to analyse and evaluate data on Plant Breeding. The data collection period was specified for 2021 and 2025, encompassing over five years of Plant Breeding research results.

4. Result and Discussion

4.1.Growth Ratios of Plant Breeding

Table 1 analyse the Annual Ratio of Annual Growth Rate (AGR) and Growth (ARoG) of plant breeding during 2021 to 2025.

a. Annual Growth Rate (AGR) provides the average growth in the number of publications over a period, calculated using the current and previous publications. This formula can be applied to calculate the following:

$$\text{AGR} = \frac{\text{End Value} - \text{First Value}}{\text{First Value}} \text{X100}$$

b. Annual Ratio of Growth (ARoG) states the ratio between the number of present year publications and the number of previous year publications. This formula can be applied to calculate the following:

$$ARoG = \frac{\text{No. of Publications of Present Year}}{\text{No. of Publications of Prior Year}}$$

However, Table 1 depicts the annual growth rate (AGR) and Annual Ratio of Growth (ARoG) of plant breeding research in India for the period of 2021 to 2025. The data indicate that the highest annual growth rate, i.e., 0.233, was recorded in 2024, and the minimum annual growth rate in 2023 (0.094). The mean of AGR for the period of study is 0.168. The highest ARoG was in 2024 (1.233), and the lowest was in 2023 (1.094). The mean of ARoG for the period of study is 1.168.

Table 1. Annual Growth Rate (AGR) and Annual Ratio of Growth (AROG) of Plant Breeding Research in India

Year	TP	TP %	Cum.Pub.	Cum.Pub.%	AGR	ARoG
2021	1142	14.56	1142	14.56		
2022	1329	16.95	2471	31.51	0.164	1.164
2023	1454	18.54	3925	50.05	0.094	1.094
2024	1793	22.86	5718	72.92	0.233	1.233

2025	2124	27.08	7842	100	0.185	1.185
Total	**7842**	**100**		**Mean Value**	**0.168**	**1.168**

TP=Total Publications, Cum.Pub.= Cumulative publications, AGR= Annual Growth Rate, ARoG= Annual Ratio of Growth

The (table 1) data indicate a consistent and sustained increase in research publications during 2021 and 2025, signifying a substantial and progressive growth in productivity. The period of elevated growth is illustrated by the significant growth in 2024, while the highest contribution in 2025 illustrates the climax of this upward trend. Consistently high AGR values and moderate average growth indices indicate that the overall growth pattern remains positive and stable despite slight fluctuations, particularly the slowdown in 2023. A growing annual share of publications further highlights a positive research trajectory. Overall, the pattern suggests a dependable, evolving, and increasingly productive research environment throughout the study.

4.2. Ranking of Journals

The table 2 presents the top 25 ranking of journals preferred by scientists in the field of Plant Breeding research. Plant Science Today ranked 1st with 447 (5.70%) publications share, followed by Frontiers in Plant Science ranked 2nd with 439 (5.60%) publications, Indian Journal of Genetics and Plant Breeding ranked 3rd with 333 (4.25%) publications, Legume Research 281 (3.58%) publications and Genetic Resources and Crop Evolution 196 (2.50%) ranked 4th and 5th respectively. The highest impact factor received by the preferred journal is Frontiers in Plant Science (8.8), followed by Plant Physiology and Biochemistry (5.7), BMC Plant Biology (4.8) and others.

Table 2: Top 25 Most Preferred sources for Plant breeding research in India

Rank	Source Title	Publications	% of 7842	Impact Factor	Publisher Name	Country
1	Plant Science Today	447	5.70	0.8	Horizon e-Publishing Group (HePG)	India
2	Frontiers in Plant Science	439	5.60	8.8	Frontiers Media S.A. Lausanne	Switzerland
3	Indian Journal of Genetics and Plant Breeding	333	4.25	0.9	Indian Society of Genetics and Plant Breeding (ISGPB)	
4	Legume Research	281	3.58	0.84	Agricultural Research Communication	India

					Centre (ARCC).	
5	Genetic Resources and Crop Evolution	196	2.50	1.6	Springer Nature	Netherlands
6	Scientific Reports	181	2.31	3.9	Nature Portfolio	United Kingdom
7	Plants Basel	130	1.66	4.1	Multidisciplinary Digital Publishing Institute (MDPI)	Switzerland
8	Cereal Research Communications	126	1.61	1.9	Springer Nature / Springer-Verlag	Hungary
9	South African Journal of Botany	105	1.34	2.7	Elsevier	Netherlands
10	BMC Plant Biology	102	1.30	4.8	BioMed Central	United Kingdom
11	Plant Breeding	102	1.30	1.8	Wiley-VCH GmbH	Germany
12	EUPHYTICA	96	1.22	1.7	Springer Science+Business Media	Germany
13	Plant Genetic Resources Characterization and Utilization	96	1.22	0.7	Cambridge University Press (CUP)	United Kingdom
14	Frontiers in Genetics	95	1.21	2.8	Frontiers Media S.A	Switzerland
15	Molecular Biology Reports	95	1.21	2.316	Springer Science+Business Media	Germany
16	Plant Physiology Reports	89	1.13	2.0	Oxford University Press	USA
17	Physiological and Molecular Plant Pathology	83	1.06	3.3	Elsevier	Netherlands
18	Plant Physiology and Biochemistry	75	0.96	5.7	Elsevier	Netherlands
19	Indian Journal of Agricultural Sciences	74	0.94	0.7	Indian Council of Agricultural Research (ICAR)	India
20	3 Biotech	69	0.88	2.9	Springer Nature	Netherlands
21	Agronomy Basel	67	0.85	3.4	Multidisciplinary Digital Publishing Institute (MDPI)	Switzerland
22	Journal of Environmental Biology	67	0.85	0.7	Triveni Enterprises	India

23	Physiology And Molecular Biology of Plants	67	0.85	3.3	Springer India Private Ltd.	India
24	Journal of Plant Biochemistry and Biotechnology	66	0.84	1.9	Springer India Private Ltd.	India
25	Planta	64	0.82	4.4	Springer Science+Business Media	Germany

The (table 2) majority of journals contributed between 0.8% to 4%, indicating that research output is dispersed rather than emphasised in a small number of sources. The research determines the most of publishers from Switzerland, Netherlands, Germany, UK, USA, and India highlight the global nature of plant science research. Furthermore, despite an array of major journals and high-impact foreign publications influencing plant science research, the dataset depicts a globally dispersed yet India-centric research landscape.

4.3. Bradford's Law of Scattering

'Bradford's Law of Scattering' is a fundamental bibliometric principle widely applied in scientometric studies to identify core journals within a specific discipline. Originally proposed by Bradford in 1934, based on his study of applied geophysics literature, the law describes the distribution pattern of scholarly articles across journals. It establishes a quantitative relationship between journals and the number of articles they publish on a given subject.

According to Bradford's formulation, journals arranged in decreasing order of productivity can be divided into a nucleus (core) and successive zones, each containing an approximately equal number of articles. However, the number of journals in each zone increases geometrically, following the ratio 1: n: n^2, where 'n' represents a constant multiplier. The nucleus comprises a small number of highly productive journals, followed by zones with progressively larger numbers of journals exhibiting moderate and low productivity.

In the present study, Bradford's Law was applied to analyze journal articles in Plant Breeding research published during the period 2021–2025. A total of 7,842 publications distributed across 849 journals were examined. The journals were arranged in descending order of productivity and divided into three zones, each contributing nearly one-third of the

total publications. The results indicate that a limited number of core journals account for a significant proportion of the literature, while a larger number of journals contribute fewer articles. This distribution confirms the applicability of Bradford's Law in identifying core journals in the field of Plant Breeding, as illustrated in Table 3.

Table 3: Parameter value for the Bradford's distribution in Plant Breeding Journals

Rank	Number of Journals	Cumulative number of Journals	Number of Publications	Cumulative number of Publications	Log(n)
1	1	1	447	447	0.00
2	1	2	439	886	0.69
3	1	3	333	1219	1.10
4	1	4	281	1500	1.39
5	1	5	196	1696	1.61
6	1	6	181	1877	1.79
7	1	7	130	2007	1.95
8	1	8	126	2133	2.08
9	1	9	105	2238	2.20
10	2	11	204	2442	2.40
11	2	13	192	2634	2.56
12	2	15	190	2824	2.71
13	1	16	89	2913	2.77
14	1	17	83	2996	2.83
15	1	18	75	3071	2.89
16	1	19	74	3145	2.94
17	1	20	69	3214	3.00
18	3	23	201	3415	3.14
19	1	24	66	3481	3.18
20	1	25	64	3545	3.22
21	1	26	60	3605	3.26
22	3	29	171	3776	3.37
23	2	31	106	3882	3.43
24	1	32	47	3929	3.47
25	1	33	46	3975	3.50
26	1	34	45	4020	3.53
27	1	35	43	4063	3.56
28	1	36	42	4105	3.58
29	2	38	78	4183	3.64
30	2	40	76	4259	3.69
31	2	42	74	4333	3.74
32	3	45	108	4441	3.81

33	1	46	35	4476	3.83
34	1	47	33	4509	3.85
35	1	48	32	4541	3.87
36	1	49	30	4571	3.89
37	2	51	58	4629	3.93
38	4	55	112	4741	4.01
39	1	56	27	4768	4.03
40	2	58	52	4820	4.06
41	3	61	75	4895	4.11
42	5	66	120	5015	4.19
43	2	68	46	5061	4.22
44	1	69	21	5082	4.23
45	6	75	120	5202	4.32
46	3	78	57	5259	4.36
47	8	86	144	5403	4.45
48	7	93	119	5522	4.53
49	5	98	80	5602	4.58
50	9	107	135	5737	4.67
51	5	112	70	5807	4.72
52	11	123	143	5950	4.81
53	6	129	72	6022	4.86
54	4	133	44	6066	4.89
55	10	143	100	6166	4.96
56	12	155	108	6274	5.04
57	15	170	120	6394	5.14
58	26	196	182	6576	5.28
59	18	214	108	6684	5.37
60	25	239	125	6809	5.48
61	29	268	116	6925	5.59
62	81	349	243	7168	5.86
63	174	523	348	7516	6.26
64	326	849	326	7842	6.74
	849		**7842**		

Table No 4: Scattering of Journals and Publication's over Bradford's zones

Zones	Journals	%	Publications	%	Bradford Multiplier (k)
1	13	1.53	2634	33.59	0
2	65	7.66	2625	33.47	5.00
3	771	90.81	2583	32.94	11.86
Total	849	100	7842	100	8.43*

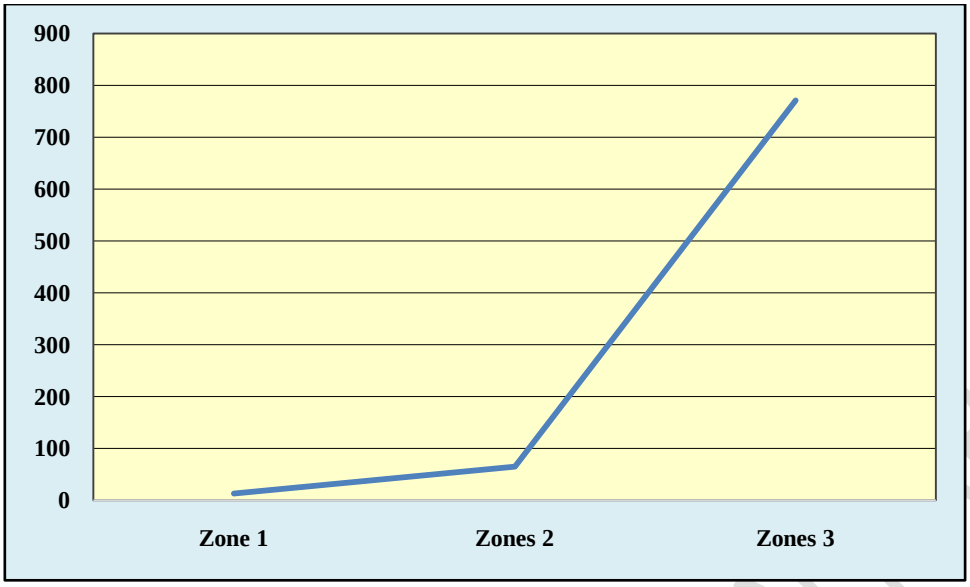

Fig. No.2: Scattering of Journals and Publications over Bradford's zones

For testing of Bradford's law, the Plant Breeding research articles, the 849 journals are divided into three zones. The spreading of journals and a corresponding number of articles in the three zones along with the value of Bradford multiplier are shown in table 4 & figure 2. The present data set, first zone 13 journals covered 2634 articles, second zone 65 journals cover 2625 articles and zone three shows 771 journals having 2583 articles. It means one-third of the total articles have been covered by each group.

According to Bradford's Law, the zone-wise distribution of journals is expected to follow an approximate geometric progression in the ratio 1 : n : n^2. However, in the present study, the observed distribution of journals across the three zones is 13 : 65 : 771, which deviates from the ideal geometric pattern. Despite this variation, it is noteworthy that each zone contributes nearly one-third of the total articles, consistent with Bradford's original proposition.

Furthermore, the Bradford multiplier calculated between Zone 1 and Zone 2 is 5.00, while the multiplier between Zone 2 and Zone 3 is 11.86. The average multiplier value across the zones is found to be 8.43. This variation in multiplier values indicates a partial conformity to Bradford's Law, suggesting that while the distribution does not strictly follow the theoretical ratio, the overall scattering pattern of journals aligns reasonably well with the law.

Therefore, 1: n: n^2

=13:13*8.43: 13*$(8.43)^2$

= 13: 109.59: 923.8437

=1046.4337

$$\text{Percentage error} = \frac{\text{Value of 1: n: } n^2 \text{ - Total no. of journals}}{\text{Total no. of journals}} \text{ X100}$$

Therefore,

Percentage error = [(1046.4337-849)/849] *100

= 1046.4337-849=197.4337

= 197.4337/849= 0.232548

= 0.232548*100

Percentage error = 23.25%

The results indicate a relatively high percentage of error in fitting the observed data to Bradford's theoretical model. Although the calculated Bradford multipliers show some degree of similarity, they do not closely correspond to the expected constant multiplier value (k = 8.43). This variation suggests inconsistency in the geometric progression across zones. Therefore, it can be concluded that the distribution of 'Plant Breeding' literature in the present study does not strictly conform to the three-zone model of Bradford's Law of Scattering.

4.5 Graphical Formulation

According to Sudhier (2010), "the graphical formulation serves as an experimental verification of the verbal formulation, demonstrating a regular pattern in the distribution of scientific publications." The graphical approach, further developed by Brookes (1969), attempts to validate the verbal formulation of Bradford's Law of Scattering through visual representation.

When Bradford's Law holds true, the graphical distribution typically exhibits three distinct characteristics: (i) an initial sharp rise representing the core or highly productive journals; (ii) a substantial linear segment indicating a systematic relationship between the variables; and (iii) a gradual 'droop' or decline at the tail end, reflecting the scattering of articles across less productive journals and possible incompleteness of the bibliography.

In the present study, the graphical formulation has been employed as a visual tool to examine and support the verbal formulation of Bradford's Law of Scattering.

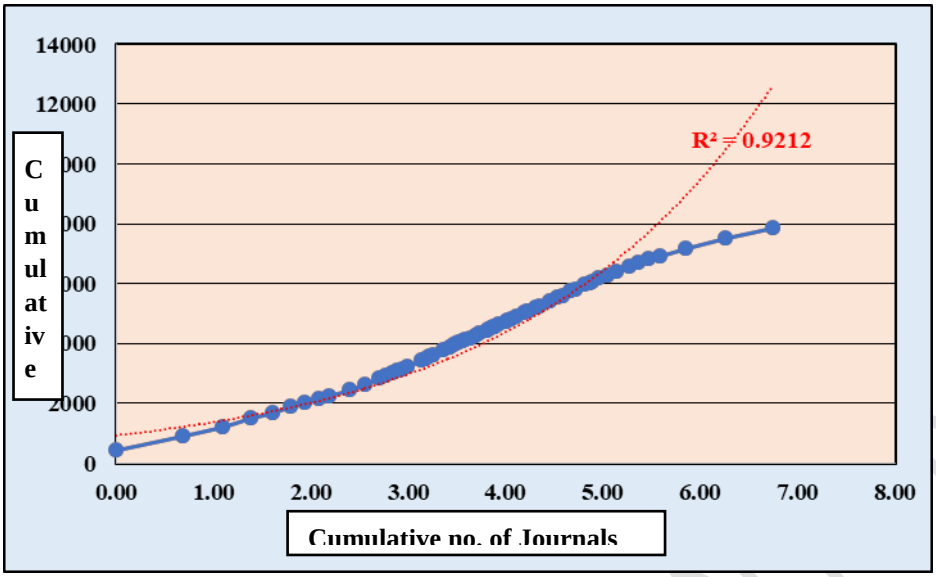

Figure 3: Bradford's Bibliograph for Journals Distribution

The graph in the Fig 3 shows the logarithmic plot of cumulative publications on the horizontal (X- axis) against the cumulative number of journals on the vertical (Y- axis). In this study, plotting the journals against their productivity results in a 'Bradford curve' that features a characteristic 'Groos droop'.

5. Conclusion

The application of Bradford's Law of Scattering to plant breeding research in India indicates a distinct trend in the spreading of scientific research methods. The majority of significant research output is published in a comparatively small core group of journals, with the left over articles dispersed across a variety of less specific journals. The presence of key publications that serve as primary avenues of communication for plant breeding scientists is reflected in this emphasis. Significant agricultural and plant science publications that regularly provide excellent research on crop enrichment, genetics, and breeding methods are usually found in the core zone in India.

For researchers, librarians, and policymakers, identifying these main journals is extremely useful since it facilitates effective literature retrieval, journal subscription decisions, and research planning. Furthermore, the tendency toward scattering indicates that plant breeding is an interrelated discipline that draws on research findings from publications in agronomy, biotechnology, genetics, and environmental sciences. This picture shows how plant breeding is increasingly useful for addressing issues such as sustainable agriculture, climate change, and food security. However, Bradford's Law is a valuable tool for mapping the intellectual landscape of plant breeding research in India. In furtherance of support our understanding of information dissemination patterns, it also helps us make better decisions

regarding academic publishing, research planning, and library administration. Advancing plant breeding initiatives, which are crucial to ensuring food security, agricultural sustainability, and economic development in India, is ultimately conserved by insights from these types of studies.

REFERENCES

Allard, R. W. (1999). *Principles of plant breeding*. John Wiley & Sons.

Bradford S C. (1934). Sources of information on specific subjects. Reprinted in (1985). *Journal of Information Science, 10*(4), 173-180.

Bradford, S. C. (1950). Documentation, Public Affairs Press, Washington. DC.

Briggs, F. N., & Knowles, P. F. (1967). Introduction to plant breeding.

Brookes, B. C. (1969). Bradford's law and Bibliography of Science. *Nature, 224*(5223), 953-

Hosamani, S. C., Krishnamurthy, C., & Patil, R. R. (2025) Research Article Application of Bradford's Law of Scattering to the Light Pollution Literature in India. *International Journal of Advanced Research (IJAR), 13*(10), 132-140.

https://www.webofknowledge.com (2026).

Savanur, K. P. (2019). Application of Bradford's Law of Scattering to the Economics Literature of India and China: A Comparative Study. *Asian Journal of Information Science and Technology*, *9*(1), 1-7.

Stoskopf, N. C., Tomes, D. T., Christie, B. R., & Christie, B. R. (2019). *Plant breeding: theory and practice*. CRC Press.

Sudhier, K. G. (2010). Application of Bradford's law of scattering to the physics literature: a study of doctoral theses citations at the Indian institute of science. *DESIDOC Journal Technology, 30*(02), 03-14.

Vickery, B.C. (1948). Bradford law of scattering, *Journal of Documentation, 4*(3), 198-203.