Indian Contributions to World Soybean Research: Measurement of Research Productivity of Soybean Scientists

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Abstract

The paper studies the measurement of research productivity of Indian scientists contributing to world soybean research for the period 1989-2008 based on the data available in the International Crop CD database. The paper measured the publication share of India in the world publication on soybean, its activity index, growth rate and doubling time, analysed the authorship pattern, various statistical distributions of authorship like mean, variance, binomial distributions, negative binomial distributions, geometric distributions; collaboration coefficient and collaboration index, prolific authors and their dominance factor, applicability of Lotka's law, etc. The paper reveals that India has 2nd rank in research publication with 13.64% share in the world. The activity index of India decreases gradually. The growth rate has also decrease gradually and correspondingly doubling time has increased. The paper reveals high degree of collaboration with 93.10% contributions of joint authorship. The average collaboration coefficient is 0.931 and average collaboration index value is 3.115. Lotka's Law is still found applicable in the study. The paper than calculate dominance factor (DF) of some prolific authors having 25 or more contributions and found most of the authors with low DF value.

Keywords: Research Productivity**,** Indian Contributions, Soybean Research, Activity Index, Statistical Distributions, Collaboration, Dominance Factor.

1. Introduction

India is one among the largest vegetable oil economies in the world. Soybean (Glycine max) is an important vegetable oilseed crop. It is considered to be a cash crop. It is a major source of edible vegetable oils and proteins which contains about 40% protein and 20% oil. It has a wide range of geographical adaptation, unique chemical composition, very high nutritional value, functional health benefits and versatile end uses and has become an important agricultural commodity. Soybean plays a major role in the world food trade. It constitutes about 42% and 56% of area and production respectively of total oilseeds. The current global production of soybean is around 176.64 million MT with USA being the largest producer [1]. India ranks 5th in the area and production of soybean in the world after USA, Brazil, Argentina and China. The contribution of India in world soybean area and production is about 7.8 and 4.2 percent, respectively. In recent years, soybean has assumed important position in the country, as it is one of the most stable kharif crops yielding cost effective production under varied agro – climatic conditions unlike other kharif pulses and oilseeds [2]. Madhya Pradesh state contributes about 67% and 56% in total area and production of soybean and is called as 'Soya state'. Madhya Pradesh, Maharashtra and Rajasthan together contribute about 97% to total area and 96% production of soybean in the country. In 2006-07 India has exported about 0.168 million tonnes soybean oil and 4.396 million tonnes of de-oiled cake (DOC) fetched a foreign earning of about Rs.4316 crores [3].

The soybean seeds, oil and oil cake are economically useful in various ways. Soybean oil is used as cooking medium and for manufacturing several industrial products, such as vanaspati ghee, paints,

linoleum oilcloth, printing inks, soaps, insecticides, disinfectants etc. Soybean seeds are used for preparation of soytofu (Paneer), soya milk, soya sprouts, immature pods, soya nuts, etc. Soybean oil cake is used for preparation of biscuits, protein rich bread and other confectionary, bakery, high protein livestock feed etc. [4].

There are some important bibliometric studies done on Indian contributions to various fields. Rajendran and Parihar (2007)[5] presented a bibliometric study of Laser literature in India for 1995-2005. Ramakrishnan and Ramesh Babu (2007)[6] studied bibliometric analysis of literature on Hepetitis for the period 1984-2003. Sangam and Meera (2008)[7] describes the research collaboration pattern in Indian contributions to Chemical Sciences. Amudhavalli and Florence (2001) [8] presented a profile on Indian productivity in Human Nutrition. Senthilkumaran and Vadivel (2003) [9] presented a bibliometric study on Indian Spices. Amudhavalli and Senthilkumaran (2007) [10] have made cross-national comparison of Spices research amongst the Asian countries over a period 1968-2002. Sooryamorthy (2009) [11] shows that collaboration research in South Africa has been growing steadily and the scientists are highly oriented towards collaborative research. Manuelraj and Amudhavalli (2008) [12] studied the literature on health science and found very high degree of collaboration but correlation amongst the productivity and collaboration is low.

Like other disciplines of science and technology, Indian scientists have contributed to world soybean research. Scientists and research scholars, especially those affiliated to some research institutes, usually disseminate the results of their projects in the form of published material, may be journals, conference proceedings, annual reports, bulletins, thesis, etc. So the research publications are major or most significant indicator of productivity. The productivity of any country's research can be measured by using various bibliometric techniques like year-wise growth and distributions, relative growth rate, doubling time, activity index, publication types, authorship patterns, collaboration, statistical distributions etc. The purpose of the present study is to measure the productivity of Indian scientists contributing to world soybean research using various bibliometric techniques. Some important parameters are defined below.

1.1 Activity Index

Activity index highlights the relative research efforts of a country to a given field. The concept was suggested by Frame (1977) to compare any country's performance with the world's performance [13]. The mathematical presentation of activity index (AI) is

$$AI = \frac{\text{(given field's share in the country's publication output)}}{\text{(given field's share in the world's publication output)}} * 100$$

1.2 Collaboration Coefficient

Subrahmanyam (1983) proposed a mathematical formula for calculating collaboration coefficient of authors in a discipline. Collaboration coefficient is the proportion of joint authored publications to total publications [14]. The mathematical presentation of collaboration coefficient (C.C.) is

$$C.C. = \frac{Nm}{Nm + Ns}$$

1.3 Collaboration Index

Collaboration index is the mean number of authors per joint authored publications [15]. The mathematical presentation of collaboration index (C.I.) is

$$C.I. = \frac{\text{No. of Authors of total joint publications}}{\text{Total Joint Publications}}$$

1.4 Lotka's Law

Lotka (1926) presented a law based on his observations. According to this law 'the number of authors making two or more contributions is about $1/n^2$ of those making one contribution. The proportion of all contributors that make a single contribution is about 60%[16].

1.5 Dominance Factor

Dominance factor formula in bibliometrics has been developed by Sudhir Kumar (2008). Dominance Factor (DF) is proportion of number of joint-authored papers of an author as first author (Nmf) to total number of joint-authored papers of the author (Nmt) [17]. Mathematically it is represented as

$$DF = \frac{Nmf}{Nmt}$$

2. Objectives of the Study

The major objectives of the present study, covering the contributions of Indian scientists to world soybean research for the period of 20 years (1989 – 2008) divided into 5 blocks of 4 years each, are:

- to measure the productivity and publication share of Indian scientists in the world with growth rate and doubling time,
- to measure the activity index of India in world soybean research,
- to examine the authorship patterns and the nature of collaborative research,
- to study some statistical distribution patterns,
- to identify the prolific contributors and measuring their productivity (quantity of contributions), and
- to examine the dominance factor of the prolific contributors, etc.

3. Method and Data Sources

The present study has been analysed the contributions made by Indian scientists to the world soybean research. The study covers the contributions made by Indian scientists on world soybean research available in the International Crop CD database. The data for the study has been taken from the Crop CD Database for 20 years during the period 1989 to 2008, divided into five blocks of 4 years each, arranged on the Microsoft Excel Sheet under different fields and analyzed for the study. Statistical analysis has also been carried out.

4 Results

4.1 Publication Share

The publication output on Soybean in the world has been analysed to identify the highly productive countries and provide them ranking according to their publication shares. Table 1 lists the year wise distribution of contributions of top 15 countries and their percentage shares. This table clearly indicates that USA leads all the countries with 7235 (32.41%) contributions. India has 2nd rank with 3045 (13.64%) contributions. China with 2268 (10.16%) contributions, Brazil with 1891 (8.47%) contributions and Japan with 1729 (7.74%) contributions are other leading countries. The table also reveals that India's publication share has decreased continuously from 17.74% in block period 1993-96 to 11.24% in block period 2005-08 comparing to China, Brazil and Japan which shows increase in publication share. India has ranked down from 2nd in block 1989-2004 to 4th in block 2005-2008. Figure 1 presents the distribution of contributions of top five countries.

Table 1: Country wise Distribution of Records in five block periods

S. No	Country	1 1989–1992	2 1993–1996	3 1997–2000	4 2001–2004	5 2005–2008	Total	Cumulative Total	%	Cumulative %	Rank
1	USA	1636 (47.43)	1301 (35.84)	1269 (32.50)	1307 (29.40)	1722 (24.97)	7235	7235	32.41	32.41	I
2	India	417 (12.09)	644 (17.74)	635 (16.26)	574 (12.91)	775 (11.24)	3045	10280	13.64	46.04	II
3	China	204 (5.91)	394 (10.85)	472 (12.09)	380 (8.55)	818 (11.86)	2268	12548	10.16	56.20	III
4	Brazil	33 (0.96)	121 (3.33)	314 (8.04)	573 (12.89)	850 (12.33)	1891	14439	8.47	64.67	IV
5	Japan	242 (7.02)	278 (7.66)	242 (6.20)	383 (8.61)	584 (8.47)	1729	16168	7.74	72.42	V
6	Canada	134 (3.89)	101 (2.78)	112 (2.87)	121 (2.72)	225 (3.26)	693	16861	3.10	75.52	VI
7	Korea Republic	51 (1.48)	62 (1.71)	106 (2.71)	132 (2.97)	203 (2.94)	554	17415	2.48	78.00	VII
8	Argentina	15 (0.43)	29 (0.80)	70 (1.79)	112 (2.52)	162 (2.35)	388	17803	1.74	79.74	VIII
9	Australia	94 (2.73)	59 (1.63)	71 (1.82)	41 (0.92)	54 (0.78)	319	18122	1.43	81.17	IX

10	Egypt	66 (1.91)	77 (2.12)	67 (1.72)	41 (0.92)	57 (0.83)	308	18430	1.38	82.55	X
11	Nigeria	12 (0.35)	17 (0.47)	33 (0.85)	53 (1.19)	136 (1.97)	251	18681	1.12	83.67	XI
12	Taiwan	46 (1.33)	45 (1.24)	28 (0.72)	39 (0.88)	64 (0.93)	222	18903	0.99	84.67	XII
13	Germany	51 (1.48)	40 (1.10)	35 (0.90)	33 (0.74)	60 (0.87)	219	19122	0.98	85.65	XIII
14	France	60 (1.74)	59 (1.63)	27 (0.69)	22 (0.49)	43 (0.62)	211	19333	0.95	86.59	XIV
15	Italy	41 (1.19)	42 (1.16)	29 (0.74)	32 (0.72)	57 (0.83)	201	19534	0.90	87.49	XV
16	Others	347 (10.06)	361 (9.94)	395 (10.12)	603 (13.56)	1086 (15.75)	2792	22326	12.51	100.00	
	Total	3449 (100)	3630 (100)	3905 (100)	4446 (100)	6896 (100)	22326		100		

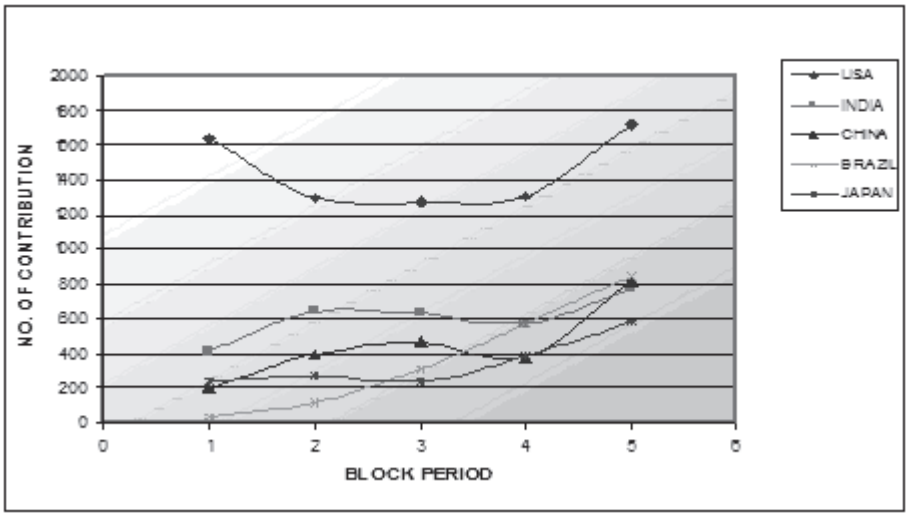

Figure 1: Distribution of Records of top five countries in five block periods

4.2 Activity Index

Table 2 shows the activity index of Indian scientists contributing to world soybean research. The activity index is 73.01 in block period 1989-92, which increased to 102.89 during block period 1993-96. It is then started to decrease during other block periods and finally reduced to as low as 70.83 during block period 2005-08. This decline in activity index from 102.89 to 70.83 reveals that the Indian scientists are becoming less active and their productivity has decreased as compared to world activity. The value of activity index more than 100 shows that the country is more active than over all world while the value of activity index less than 100 shows the country less active.

Table 2: Activity Index of India

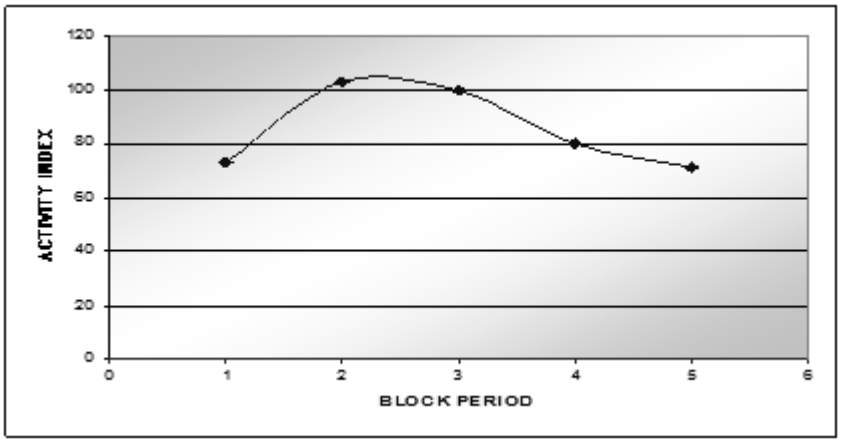

Figure 2: Activity Index of India

4.3 Growth Rate and Doubling Time

Table 3 shows the relative growth rate (GR) and doubling time (DT) of Indian contributions. There is gradual decrease in the relative growth rate of Indian contributions from 0.233 during block period 1989-92 to 0.073 during block period 2005-08. Correspondingly the table shows increase in doubling time from 2.97 during block period 1989-92 to 9.44 during block period 2005-08.

Table 3: Growth Rate and Doubling Time of Indian Contributions

S. No	Block period	No. of Records	Cumulative records	Ln	Growth Rate	Doubling Time
1	1989 – 1992	417	417	6.033		
2	1993 – 1996	644	1061	6.967	0.233	2.97
3	1997 – 2000	635	1696	7.436	0.117	5.91
4	2001 – 2004	574	2270	7.728	0.073	9.51
5	2005 – 2008	775	3045	8.021	0.073	9.44

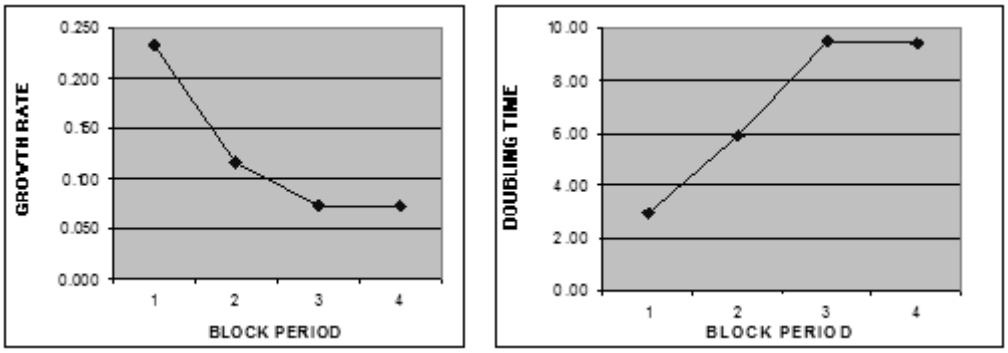

Figure 3: Growth Rate and Doubling Time of Indian contributions

4.4 Authorship Patterns

Table 4 shows various facets of authorship patterns of Indian contributions. Out of the 3045 Indian contributions only 210 contributions (6.9%) are found with single authorship. The remaining 2835 contributions (93.1%) are of joint-authorship. This reveals higher collaboration among Indian scientists contributing to soybean research. The number of authors in collaborated papers ranges between two to ten. Highest 952 contributions (31.3%) have collaboration of two authors, followed by 887 contributions (29.1%) having three authors, 555 contributions (18.2%) having four authors and 282 contributions (9.26%) having five authors.

The collaboration coefficient (CC) and the collaboration index (CI) calculated for the block period 1989-92 to block period 2005-08 is also given in table 4. The collaboration coefficient has increased from 0.899 during block period 1989-92 to 0.955 during block period 2005-08 with an average 0.931. It reveals that the team research is predominant. The collaboration index also increased continuously from 2.590 during block period 1989-92 to 3.372 during block period 2005-08 with an average 3.115.

Table 4: Distribution of Authorship Patterns

No. of Authors	1 1989 – 1992	2 1993 – 1996	3 1997 – 2000	4 2001 – 2004	5 2005 – 2008	Total Records	%	Total Authors	%
1	42	55	40	38	35	210	6.9	210	2.21
2	185	222	197	141	207	952	31.3	1904	20.1
3	116	192	192	163	224	887	29.1	2661	28.1
4	57	125	109	106	158	555	18.2	2220	23.4
5	12	36	56	78	100	282	9.26	1410	14.9
6	3	13	29	23	31	99	3.25	594	6.26
7	2	0	9	13	10	34	1.12	238	2.51
8	0	1	3	4	1	9	0.3	72	0.76
9	0	0	0	4	5	9	0.3	81	0.85
10	0	0	0	1	1	2	0.07	20	0.21
More than 10	0	0	0	3*	3**	6	0.2	74	0.78
Total Records	417	644	635	574	775	3045	100	9484	100
Total Authors	1080	1841	1987	1963	2613	9484			
Collaboration Coefficient	0.899	0.915	0.937	0.934	0.955	0.931			
Collaboration Index	2.590	2.859	3.129	3.420	3.372	3.115			

* 33 authors, ** 41 authors,

Table 5 presents cumulative distribution of authorship patterns for the block period 1989-92 to block period 2005-08.

Table 5: Cumulative Distribution of Authorship Patterns

Sr. No.	Block Period	No. of Authors											Total
		One	Two	Three	Four	Five	Six	Seven	Eight	Nine	Ten	Ten+	
1	1989-1992	42	185	116	57	12	3	2	0	0	0	0	417
2	1989-1996	97	407	308	182	48	16	2	1	0	0	0	1061
3	1989-2000	137	604	500	291	104	45	11	4	0	0	0	1696
4	1989-2004	175	745	663	397	182	68	24	8	4	1	3	2270
5	1989-2008	210	952	887	555	282	99	34	9	9	2	6	3045

Table 6 presents the basic statistical distributions and parameter values obtained from the application of selected probability distributions on authorship distribution pattern viz. Mean, Variance, Binomial distributions, Negative Binomial distributions, Geometric distributions, etc.

Table 6: Statistical Distributions of Authorship Patterns

Sr. No.	Block Period	Mean (μ)	Variance (σ)	Binomial (w)	Negative Binomial (k)	Geometric (p)
1	1989-1992	2.590	0.034	1.590	-1.625	0.386
2	1989-1996	2.753	0.035	1.753	-1.789	0.363
3	1989-2000	2.894	0.005	1.894	-1.899	0.346
4	1989-2004	3.027	0.027	2.027	-2.054	0.330
5	1989-2008	3.112	0.010	2.112	-2.122	0.321

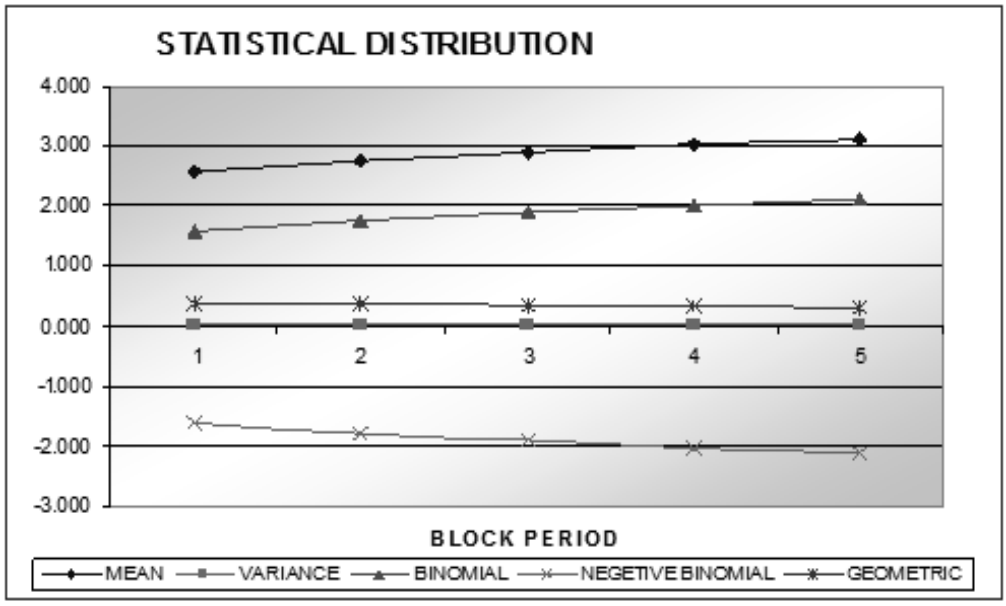

Figure 4: Statistical Distribution of Authorship Patterns

4.5 Prolific Authors and their Dominance Factor

Table 7 reveals the number of contributions made by individual authors. There are total 4244 authors, out of which 2542 authors made only one contribution each while 772 authors made two contributions, 387 authors made three contributions and 178 authors made four contributions each respectively.

On the other hand highest 55 contributions were made by one author, followed by another author made 53 contributions. There are 10 authors made 30-50 contributions each, while 17 authors made 20-29 contributions each. These authors are said to be highly productive.

Table 7: Distribution of Records of Authors

S. No.	No. of Authors	No. of Contributions by each author	Total Authorship
1	1	55	55
2	1	53	53
3	1	47	47
4	1	42	42
5	1	38	38
6	2	37	74
7	1	36	36
8	1	35	35
9	1	34	34
10	1	32	32
11	1	30	30
12	3	29	87
13	1	28	28
14	1	26	26
15	1	25	25
16	3	22	66
17	3	21	63
18	5	20	100
19	1	19	19
20	3	**18**	54
21	4	17	68
22	10	16	160
23	5	15	75
24	8	14	112
25	10	**13**	130
26	10	12	120
27	16	11	176

28	16	10	160
29	15	9	135
30	39	8	312
31	43	7	301
32	52	6	312
33	104	5	520
34	178	4	712
35	387	3	1161
36	772	2	1544
37	2542	1	2542
Total	4244		9484

Lotka's law has been used to measure the productivity of authors. Table 8 presents observed and expected number of authors with ten or less contributions. Table reveals that there is partial similarity between observed number and expected number of authors. The values for four or more authors found equivalent. So the Lotka's Law is almost applicable in present study.

Table 8: Distribution of Authors by Lotka's Law

No. of Contributions	Observed No. of Authors	Observed % of Authors	Expected No. of Authors	Expected % of Authors	Difference
1	2542	100.00	2542	100.00	–
2	772	30.37	636	25.00	– 136
3	387	15.22	282	11.11	– 105
4	178	7.00	159	6.25	– 19
5	104	4.09	102	4.00	– 2
6	52	2.05	71	2.78	+ 19
7	43	1.69	52	2.04	+ 9
8	39	1.53	40	1.56	+ 1
9	15	0.59	31	1.23	+ 16
10	16	0.63	25	1.00	+ 9
More than 10	96				

Table 9 presents the ranking list of top 18 prolific authors (rank 1 to 15) with Dominance Factor (DF) who made 25 or more contributions each. S. D. Billore tops the list with 55 contributions having DF 0.455. Followed by O. P. Joshi with 53 contributions (DF 0.154) and O. P. Singh with 47 contributions (DF 0.426). V. M. Raut with 42 contributions (DF 0.286) and P. S. Bhatnagar with 38 contributions (DF 0.389) are also the followers.

S. S. Mehetre with 26 contributions has highest DF 0.840 followed by S. K. Dubey with 29 contributions and DF 0.833 shows the higher dominance over their co-authors. On the other hand G. S. Chauhan with 36 contributions and M. Singh with 32 contributions have very low DF 0.028 and 0.031 respectively.

Table 9: Ranking List of Prolific Authors with Dominance Factor

S. No.	Name	Single Authored	Multiple Authored	First Authored	Total	Dominance Factor	Rank
1	Billore-SD	0	55	25	55	0.455	I
2	Joshi-OP	1	52	8	53	0.154	II
3	Singh-OP	0	47	20	47	0.426	III
4	Raut-VM	0	42	12	42	0.286	IV
5	Bhatnagar-PS	1	36	14	38	0.389	V
6	Halvankar-GB	0	37	15	37	0.405	VI
7	Singh-KJ	0	37	12	37	0.324	VI
8	Chauhan-GS	0	36	1	36	0.028	VII
9	Taware-SP	0	35	11	35	0.314	VIII
10	Tiwari-SP	1	33	10	34	0.303	IX
11	Singh-M	0	32	1	32	0.031	X
12	Chandel-AS	0	30	6	30	0.200	XI
13	Bhatia-VS	1	28	10	29	0.357	XII
14	Deotale-RD	0	29	4	29	0.138	XII
15	Dubey-SK	17	12	10	29	0.833	XII
16	Kundu-S	0	28	9	28	0.321	XIII
17	Mehetre-SS	1	25	21	26	0.840	XIV
18	Sharma-AN	9	16	9	25	0.563	XV

5. Discussion and Conclusion

Considering the above facts it is concluded that Indian scientists, contributing to world soybean research, have higher publication share. India obtains 2nd rank in world publication on soybean research after USA. The activity index of India is decreasing which shows declining in the research work by Indian scientists on soybean research. It also shows India less active than all over the world. Growth rate is decreasing gradually and doubling time is increasing. This declining also supports the above fact. So it is recommended to encourage the scientists to do more and more

research and publish the results in the form of articles. The authorship pattern shows majority of joint authorship contributions with 93% and high collaboration coefficient (0.931) which reveals that team research is predominant. Two, three and four author collaboration is common trend among Indian scientists. There are 4244 authors contributing out of which 2542 authors have single contribution. Also very few authors have 25 or more contributions. This is a poor sign in measuring productivity of any country. Lotka' Law is found almost applicable in the present study. The value of dominance factor of most of the prolific authors is found low (less than 0.500) which should be a good sign for collaboration.

This type of investigation may be useful for understanding the importance of research and development activities, measuring the productivity of countries, performance of scientists. It helps in making research and development policies for improving the productivity of scientists in various fields.

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