COLLABORATION PATTERN IN RAPESEED &MUSTARD RESEARCH IN THE WORLD: A SCIENTOMENTRIC STUDY

Shilpa Dhoble

Sudhir Kumar

Surendra Kumar

Analyses authorship pattern of 9574 papers published during 14 years (2000-2013) collected from CAB Direct database. The collected was subjected to study: year wise distribution, activity index of India, languages & communication channels. Shows that 99% of articles are published in English of which 95% are published in journals. Reveals that 8839 articles (92.32%) were published in co-authorship, whereas only 735 (7.68%) articles were published by single authors. Degree of collaboration and collaboration indexes are 0.92 and 3.89 respectively. Applies many statistical formulae like mean, variance, binomial distribution, negative binomial distribution, poison distribution on authorship pattern.

Keywords: Collaboration Index; Degree of Collaboration; Rapeseed; Mustard; Brassica; Variance; Binomial; Poisons; Negative Binomial Distributions.

INTRODUCTION

Rapeseed and mustard are very important sources of vegetable oil and proteins all over the world. The botanical name of rapeseed and mustard is Brassica, used as edible oil, food content, and medicine and also in cosmetic products. India has third in production area but lowest in yield [1]. India has second place in area of mustard cultivation among below countries, but last in yield, whereas Germany has less than $1/4^{th}$ area of India. Still the production is three times. This is shown in table 1 that except Canada, the yield in all other countries is double as compared to India in a rather smaller area. They also have produced a big amount of rapeseed & mustard production.

Shilpa Dhoble
School of Studies in Lib.and Inf. Sc.,
Vikram University,
Ujjain (M.P.)
shilpadhoble1@gmail.com

Sudhir Kumar
School of Studies in Lib.and Inf. Sc.,
Vikram University,
Ujjain (M.P.)
sudhirkumarvuujjain@gmail.com

Surendra Kumar
ICAR- Directorate of Soybean,
Khandwa Road,
Indore (M.P.)
skumar9861@gmail.com

Corresponding Author
Shilpa Dhoble

Table 1: Area, Production and Yield of Rapeseed and Mustard of Major Countries

S.No.	Country	Area(lakh ha)		Production(lakh tons)		Yield (kg/ha)	
		2011-12	2012-13	2011-12	2012-13	2011-12	2012-13
1	Germany	13.06	14.66	48.21	57.84	3691	**3947**
2	France	16.07	14.38	54.63	43.7	3399	**3040**
3	UK	7.56	7.15	25.57	21.28	3382	**2976**
4	Poland	7.2	9.21	18.66	26.78	2590	**2908**
5	Ukraine	5.47	9.96	12.04	23.52	2202	**2361**
6	Canada	83.8	80.07	154.1	179.35	1839	**2240**
7	China	73	75	140	144	1918	**1920**
8	USA	7.01	6.85	11.12	8.8	1588	**1285**
9	Australia	23.59	32.72	34.27	41.42	1453	**1266**
10	Russia	9.76	11.2	10.35	13.93	1061	**1244**
11	India	58.9	63.4	66	78.2	1121	**1233**
12	Others	35.6	39.14	70.69	86.51	1986	**2210**

AIM

The paper aims to find out the collaboration pattern among the contributors on mustard research in the world. Collaborative research work is the need of the day and also for future. Many multidisciplinary subjects have emerged in Agriculture, so, collaboration is necessary. Many statistical measures have been used to analyse collaboration pattern

LITERATURE REVIEW

The research conducted by Vijay [2] on food Science and Technology studies collaborative research and authorship trends in India. The degree of collaboration was found to be 0.91. This research reported an increasing trend towards collaborative research. Senthilkumaran and Amudhavalli [3] have analyzed spices literature in India. Many bibliometric patterns have been studied in this paper like collaboration pattern, publication wise studies, activity index, etc. Kumar and Kumar [4] have studied research publication patterns of oilseeds scientists. Collaboration patterns like degree of collaboration, collaboration index and dominance factor were identified in 3330 contributions from many oilseeds research institutes of India. Kumar [5] has examined the applicability of Lotka's Law to research productivity of Council of Scientific and Industrial Research (CSIR), India based on two databases SCI-CD-ROM and Web of Science. Mamdapur and others [6] have studied the analysis of articles in 'Baltica Astronomy' published during 2000–2008. The paper analyses the distribution of contributions and authorship pattern of contributions. The paper reveals that multi-authored contributions dominate researches in the field. Single authored contributions account only for 23.91% papers. Degree of collaboration ranges between 0.67 and 0.89. Khatun and Ahmed [7] have used quantitative analysis to identify the literature growth, authorship pattern, collaboration and journal distribution on diarrhoeal disease research. Jain and Kumar [8] have analyzed Indian contributions to world Soybean (Soyabean) research by measuring research productivity of soybean (Soyabean) scientists. Study on Solar cell research in Indian publications has been done by Dutt and Nikam [9] for the period 1991-2010. Calculates co-authorship index, international collaborative index, domestic and international collaboration of Indian scientists. Kumar and Kumar [10] have analysed productivity of Directorate of Rapeseed and Mustard Research and also study collaboration among the scientists. Poorni and others [11] have studied Medline database on Indian conservative dentists and endodontists.

METHODOLOGY

Many electronic databases are available pertaining to the agriculture and oilseeds. Data on mustard research publications from India and whole of the world is collected from CAB Direct, available at Directorate of Soybean Research, Indore. At the time of conducting research, the available data was collected for 14 years (2000-2013). Following statistical formulae have been used in this paper.

Degree of Collaborations (Collaboration Coefficient)

Formula by Subrahmanyam [12]. It is the ratio of multiple authored papers in all the papers. Higher is the value, higher is collaboration. The values does not exceed 1.00.

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

Where, Ns = Single Authored Publications
Nm = Multiple Authored Publications
C.C. = Degree of Collaboration

Collaboration Index

Formula by Lawani [13]. It is based on publication of joint authorship only. Single authored papers are excluded. Higher is the value, high is collaboration.

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

Statistical Formulae

It is for all the papers number of authors. It includes single authored papers also. Since the value is affected by single authored papers, the results may be misleading though figures are more representative

$$\text{i) Mean} = \frac{\sum f_i X}{N} = \frac{f_1X_1 + f_2X_2 + \ldots\ldots + f_nX_n}{N}$$

Where, X_i = Value of i^{th} item X

N = Total Number of items

$$\text{ii) Variance} = \frac{\sum (X_i - \text{Mean})^2}{N}$$

iii) Binomial distributions = **Mean –1**

iv) Negative binomial distribution

$$(k) = \frac{1.\ (\text{Mean} - 1)2}{\text{Variance} - (\text{Mean} - 1)}$$

v) Geometric Distribution (p) = Mean^{-1}

vi) Poisson Distribution (λ) = Mean x (1 – e$^{-\text{Mean}}$)

Where, e^n= Exponent of n

HYPOTHESIS

Degree of collaboration among authors in rapeseed and mustard research is very high globally. Presumed mathematically as:

H_0: D.C. ≥ 0.90

H_1: D.C. < 0.90

DATA ANALYSIS

This part of the study analyses research output in rapeseed and mustard in the world. Total 76 countries have contributed in the database.

Geographical Distribution

Contributions of top five countries on the subject have been presented in table 1. India leads the world. India contributed highest number of 3588 (37.48%) articles, followed by USA with 1098 (11.47%), UK with 1004 (10.49%), Netherlands with 599 (6.26%) and Germany with 460 (4.80%). Remaining 71 countries contributed only 2825 (29.51%) research publications in the database.

Table 2: Country-Wise Distribution of Publications on Rapeseed and Mustard Research in the World

Year	India	USA	UK	Netherlands	Germany	Others	Total	%
2000	233	56	44	14	24	133	504	5.26%
2001	220	59	30	26	27	165	527	5.50%
2002	297	71	47	40	22	196	673	7.03%
2003	296	62	55	28	37	150	628	6.56%
2004	265	72	47	41	27	200	652	6.81%
2005	314	74	60	51	27	186	712	7.44%
2006	249	77	77	43	23	201	670	7.00%
2007	258	70	76	67	34	210	715	7.47%
2008	259	99	70	51	29	181	689	7.20%
2009	241	63	71	65	34	196	670	7.00%
2010	229	68	85	34	42	233	691	7.22%
2011	223	123	95	44	40	250	775	8.09%
2012	263	115	122	47	49	286	882	9.21%
2013	241	89	125	48	45	238	786	8.21%
Total	**3588**	**1098**	**1004**	**599**	**460**	**2825**	**9574**	**100.00%**
%	**37.48%**	**11.47%**	**10.49%**	**6.26%**	**4.80%**	**29.51%**	**100.00%**	

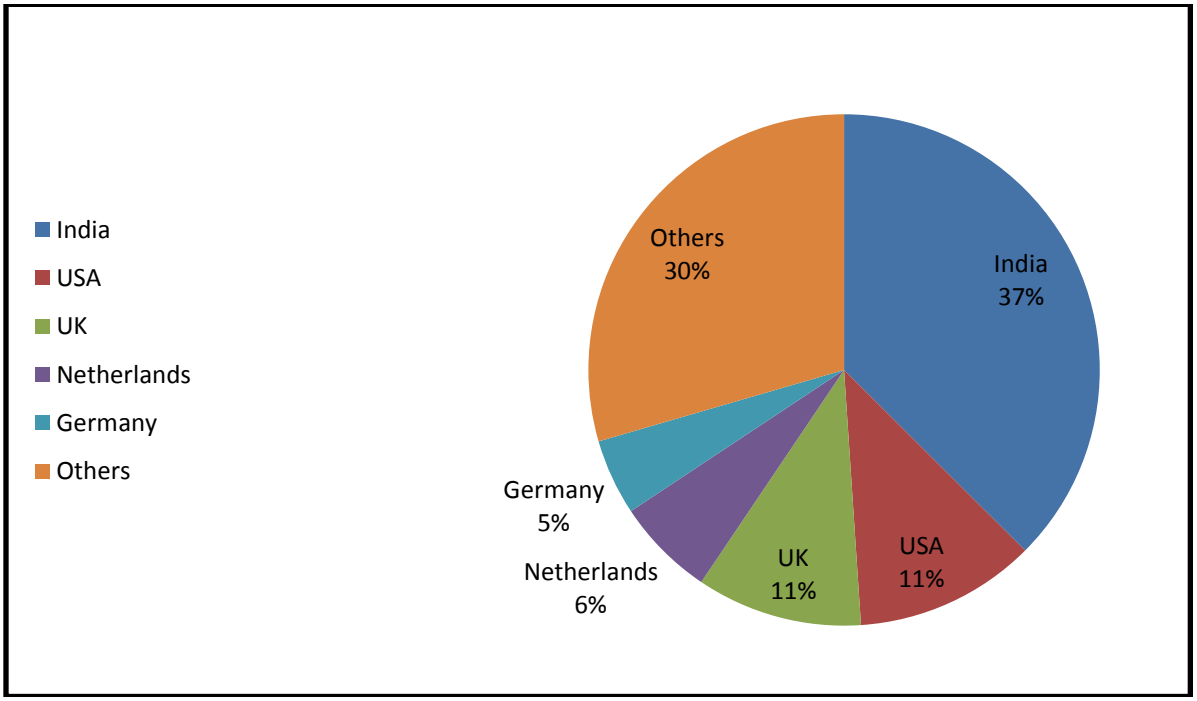

Fig1: Country-Wise Distributions of Publications in Rapeseed and Mustard Research in the World

Communication Channels

Table 3 shows distribution of articles on mustard research in different types of publications. Highest 9115 (95.21%) articles have been published in journals, followed by 286 (2.99%) in conferences, 107(1.12%) in books or book chapters. Other medium of publications have been used only by 66 (0.69%) articles.

Table 3: Communication Channels of Publications in Rapeseed and Mustard Research in the World

S. No.	Publication Type	Journal Articles	Conference Papers	Books, &Book Chapters	Bulletins	Miscellaneous	Total	Percentage
1	**2000**	475	18	4	1	6	504	5.26%
2	**2001**	495	16	8	5	3	527	5.50%
3	**2002**	632	23	10	3	5	673	7.03%
4	**2003**	587	26	10	2	3	628	6.56%
5	**2004**	616	12	13	5	6	652	6.81%
6	**2005**	667	31	12	1	1	712	7.44%
7	**2006**	645	17	3	3	2	670	7.00%
8	**2007**	683	14	14	3	1	715	7.47%
9	**2008**	655	21	8	3	2	689	7.20%
10	**2009**	649	19	0	0	2	670	7.00%
11	**2010**	650	34	6	0	1	691	7.22%
12	**2011**	745	15	11	0	4	775	8.09%
13	**2012**	853	22	4	2	1	882	9.21%
14	**2013**	763	18	4	1	0	786	8.21%
	Total	**9115**	**286**	**107**	**29**	**37**	**9574**	**100.00%**
	Percentage	**95.21%**	**2.99%**	**1.12%**	**0.30%**	**0.39%**	**100.00%**	

Medium of Communication

Table 4 reveals English is the popular language of research publications in the research. It is used by 8517 (88.96%) papers and ranks first, followed by Chinese with 321 (3.35%), Polish with 266(2.78%), Russian with 75 (0.78%), and German with 74 (0.77%). Other 22 languages have only 321(3.35%) papers.

Table 4: Language-Wise Distribution of Publications

S. No.	Year	English	Chinese	Polish	Russian	German	Others	Total	%
1	**2000**	447	21	9	6	5	16	504	5.26%
2	**2001**	457	9	11	10	12	28	527	5.50%
3	**2002**	600	9	24	10	4	26	673	7.03%
4	**2003**	557	17	13	7	10	24	628	6.56%
5	**2004**	567	23	26	9	8	19	652	6.81%
6	**2005**	644	23	21	4	4	16	712	7.44%
7	**2006**	587	21	28	6	5	23	670	7.00%
8	**2007**	624	20	29	5	4	33	715	7.47%
9	**2008**	618	33	14	3	0	21	689	7.20%
10	**2009**	600	13	24	1	5	27	670	7.00%
11	**2010**	595	35	22	2	8	29	691	7.22%
12	**2011**	694	31	14	8	6	22	775	8.09%
13	**2012**	800	41	11	4	3	23	882	9.21%
14	**2013**	727	25	20	0	0	14	786	8.21%
	Total	**8517**	**321**	**266**	**75**	**74**	**321**	**9574**	**100.00%**
	%	**88.96%**	**3.35%**	**2.78%**	**0.78%**	**0.77%**	**3.35%**	**100.00%**	

Authorship Patterns

This is the main part of the study. Table 5 presents authorship pattern in mustard research in the world. As many as, 8839 (92.32%) articles have been published in joint-authorship whereas only 735 (7.68%) articles were contributed by single authors. Highest 2468 (25.78%) have been published by three authors, followed by 2152 (22.48%) articles by two authors, 1853(19.35%) by four authors, 1047(10.97%) by five authors and 1319(13.78%) articles by more than five authors. It means the number of authors in collaborated papers have increased considerably.

The table has calculated percentages of authorship for each year considering total of year as 100%. The table reveals that on an average there are only 7.68% single authored papers. The percentage of single authorship papers has fluctuated and slowly decreased in the research. Also two and three authored papers have decreased marginally. On the other hand, the number of 4 & 5 authored papers has increased. Thus, we can infer that there is an increasing trend in the number of authors in writing research papers. On other hand, the trend of VI + authors is continuously and vigorously increasing from approximately 7% to 21%. It is nearly three times from the year of 2000.

Collaboration Coefficient and Collaboration Index

Table 6 calculates values of degree of collaboration and collaboration index. Degree of collaboration values varies from 0.91 to 0.93 with an average 0.92. Collaboration index values have increased from 3.32 to 4.33 with an average of 3.89.

Table 5: Author-Wise Distribution of Publications on Rapeseed and Mustard Research in the World (in Percentages)

S.No.	Year	Single Author	Two Authors	Three Authors	Four Authors	Five Authors	VI and more Authors	Total
1	2000	**47**	**151**	**144**	**92**	**34**	**36**	**504**
		9.33%	29.96%	28.57%	18.25%	6.75%	7.14%	100.00%
2	2001	**54**	**153**	**142**	**93**	**48**	**37**	**527**
		10.25%	29.03%	26.94%	17.65%	9.11%	7.02%	100.00%
3	2002	**65**	**186**	**192**	**127**	**50**	**53**	**673**
		9.66%	27.64%	28.53%	18.87%	7.43%	7.88%	100.00%
4	2003	**66**	**162**	**158**	**119**	**53**	**70**	**628**
		10.51%	25.80%	25.16%	18.95%	8.44%	11.15%	100.00%
5	2004	**67**	**166**	**178**	**124**	**51**	**66**	**652**
		10.28%	25.46%	27.30%	19.02%	7.82%	10.12%	100.00%
6	2005	**63**	**159**	**203**	**128**	**72**	**87**	**712**
		8.85%	22.33%	28.51%	17.98%	10.11%	12.22%	100.00%
7	2006	**42**	**162**	**183**	**116**	**71**	**96**	**670**
		6.27%	24.18%	27.31%	17.31%	10.60%	14.33%	100.00%
8	2007	**45**	**160**	**188**	**137**	**97**	**88**	**715**
		6.29%	22.38%	26.29%	19.16%	13.57%	12.31%	100.00%
9	2008	**43**	**125**	**182**	**151**	**88**	**100**	**689**
		6.24%	18.14%	26.42%	21.92%	12.77%	14.51%	100.00%
10	2009	**35**	**127**	**173**	**135**	**90**	**110**	**670**
		5.22%	18.96%	25.82%	20.15%	13.43%	16.42%	100.00%
11	2010	**50**	**126**	**169**	**141**	**94**	**111**	**691**
		7.24%	18.23%	24.46%	20.41%	13.60%	16.06%	100.00%
12	2011	**55**	**150**	**170**	**161**	**106**	**133**	**775**
		7.10%	19.35%	21.94%	20.77%	13.68%	17.16%	100.00%
13	2012	**48**	**178**	**219**	**165**	**112**	**160**	**882**
		5.44%	20.18%	24.83%	18.71%	12.70%	18.14%	100.00%
14	2013	**55**	**147**	**167**	**164**	**81**	**172**	**786**
		7.00%	18.70%	21.25%	20.87%	10.31%	21.88%	100.00%
	Total	**735**	**2152**	**2468**	**1853**	**1047**	**1319**	**9574**
	%	7.68%	22.48%	25.78%	19.35%	10.94%	13.78%	100.00%

Table 6: Degree of Collaboration & Collaboration Index of Publications on Rapeseed and Mustard Research in the World

S.No.	Year	Single Authored Papers	Total Single Authors	Multiple Authored Papers	Total Multiple Authors	Total Papers	Total Authors	Coll. Coefficient	Coll. Index
1	2000	47	47	457	1517	504	1564	0.91	3.32
2	2001	54	54	473	1626	527	1680	0.90	3.44
3	2002	65	65	608	2112	673	2177	0.90	3.47
4	2003	66	66	562	2054	628	2120	0.89	3.65
5	2004	67	67	585	2089	652	2156	0.90	3.57
6	2005	63	63	649	2535	712	2598	0.91	3.91
7	2006	42	42	628	2355	670	2397	0.94	3.75
8	2007	45	45	670	2596	715	2641	0.94	3.87
9	2008	43	43	646	2616	689	2659	0.94	4.05
10	2009	35	35	635	2624	670	2659	0.95	4.13
11	2010	50	50	641	2634	691	2684	0.93	4.11
12	2011	55	55	720	3019	775	3074	0.93	4.19
13	2012	48	48	834	3397	882	3445	0.95	4.07
14	2013	55	55	731	3166	786	3221	0.93	4.33
	Total	**735**	**735**	**8839**	**34340**	**9574**	**35075**	**0.92**	**3.89**

Statistical Analyses

Table 7 displays statistical values of probability distributions applied on authorship patterns in the study. Mean values for each year range from 3.10 to 4.10 with an average 3.66. Variance ranges from 2.07 to 3.98. Other statistical distributions and parameter values of binomial distribution, negative binomial distribution, geometric distribution, Poisson distribution, etc are shown in the table. Trends of these distributions also support the higher collaboration pattern. Binomial distribution ranges between 2.10 to 3.10 and negative binomial distribution between -145.05 to 180.44. Geometric distribution ranges between 0.25 to 0.32.Poisson distribution ranges in between 69.10 to 246.77.

Table 7: Statistical Distribution of Authorship Patterns on Publications of Rapeseed and Mustard Research in the World

S.No.	Year	Total Papers	Total Authors	Mean	Variance	(w)	(w)	(p)	(λ)
1	2000	504	1564	3.10	2.07	2.10	-145.05	0.32	69.10
2	2001	527	1680	3.19	2.21	2.19	180.44	0.31	77.26
3	2002	673	2177	3.23	2.29	2.23	85.33	0.31	82.16
4	2003	628	2120	3.38	2.85	2.38	11.84	0.30	98.73
5	2004	652	2156	3.31	2.67	2.31	14.77	0.30	90.26
6	2005	712	2598	3.65	2.95	2.65	23.29	0.27	140.23
7	2006	670	2397	3.58	3.00	2.58	15.85	0.28	128.04
8	2007	715	2641	3.69	3.16	2.69	15.46	0.27	148.46
9	2008	689	2659	3.86	3.74	2.86	9.33	0.26	183.04
10	2009	670	2659	3.97	3.09	2.97	70.89	0.25	210.00
11	2010	691	2684	3.88	4.38	2.88	5.55	0.26	188.89
12	2011	775	3074	3.97	3.68	2.97	12.27	0.25	209.42
13	2012	882	3445	3.91	3.96	2.91	8.03	0.26	194.10
14	2013	786	3221	4.10	3.98	3.10	10.83	0.24	246.77
	Total	**9574**	**35075**	**3.66**		**2.66**	**-2.66**	**0.27**	**142.88**

Note: *w= Binomial distribution, k= Negative binomial distribution, p= Geometric distribution andλ = Poisson distribution*

TEST OF HYPOTHESES

The hypothesis has been tested as follows:

Degree of Collaboration is Very High among Authors in the Research

Mathematically: H_0: **D.C.** $\geq$ **0.90**
H_1: **D.C.** $<$ **0.90**

Table 6 provides year wise degree of collaboration. It ranges between 0.89 to 0.95 with 0.92 as an average degree of collaboration.

Now for application of t test,

Calculated mean = 0.92
Hypothetic mean = 0.90
S.D. = 0.02
N = 14

Tabulated t value on 0.05 significance level for degree of freedom (13) = 1.77 (as per standard table)
Calculated t-test value:

$$t = \frac{0.92 - 0.90}{0.02\sqrt{14}} = 0.27$$

Here 0.27< 1.77

Which means calculated value of t is less than tabulated t value.

So, the null hypothesis is accepted.

It may, therefore, be concluded that high degree of collaboration is found in between authors in rapeseed and mustard research in the world.

CONCLUSION

The paper studied collaboration attitude of scientists in rapeseed and mustard research. High collaborative trend has been found in research publications in the world with an average collaboration coefficient 0.92 and collaboration index 3.89 authors per paper. Most of the authors published their articles in collaboration with three authors or more. Single authorship trend has been on the decline during the period under purview. Journals are found to be most preferred means of communication by the scientists, while English language was found to be most popular language of communication of research in the field.

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