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Scientometrics of cereal crops research in India as reflected through Indian Science Abstracts and CAB Abstracts during 1965-2010

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The paper analyses publication output of India on cereal crops as reflected by its coverage in Indian Science Abstracts (ISA) and CAB Abstracts during 1965-2010.The analysis indicates that highest number of papers (43.80%) was published on rice, followed by wheat (24.28%). Agricultural universities and institutions under aegis of Indian Council of Agricultural Research (ICAR) were most productive. Most of the papers were published in Indian journals with low impact factor. The highest number of papers was published in *Indian Journal of Agricultural Sciences*, followed by *Indian Journal of Agronomy*, *Madras Agricultural Journaland Journal of Maharashtra Agricultural University*. Indian Agricultural Research Institute, New Delhi,Tamil Nadu Agricultural University, Coimbatoreand Punjab Agricultural University, Ludhianacontributed about 7% of papers each. The major research was focused on 'genetic and plant breeding' (28.2%) followed by 'agronomic aspects' (27.9%) and pest, diseases and pest control (19.7%). The authorship pattern reveals that co-authored papers accounted for 90% of total output. Citation analysis of the study using Google scholar reveals that 57% of the papers remained uncited and 36.8% papersreceived citations ranging from 1 to 10.Highest number of citations were received by papers published in *Indian Journal of Agronomy*(1446), followed by *Indian Journal of Agricultural Science* (1211), *Euphytica* (1109) and *Theoretical and Applied Genetics* (1000).

Introduction

India is basically an agrarian economy with over two-third of its population living in rural areas which depends on agriculture and related occupations. Agriculture contributes nearly half of the national income and provides employment to about 70 percent of the working population in India. However, now the economy is in a transition phase and is moving towards service economy due to the recent developments in IT and other sectors such as hospitality and tourism. Crop science is the study of scientific approaches used to improve the quality of crops. It is a multidisciplinary research area that deals with plant breeding and genetics, crop physiology, crop production and management and weed science etc.Crop science, especially cereal crops is an important area of scientific research in the field of agriculture sciences in India. After the green revolution in India in the 1960s, growth in production of cereals havebeen particularly significant. Cereals can be classified into three groups: wheat, rice and coarse cereals (maize, sorghum, maize and millets)[1].

Several studies dealing with mapping of research output in different sub-disciplines of agriculture scienceshave been carried out. The present paper is an extension of an earlier study under taken by Tripathi and Garg[11] on Indian crop science research during 2008-2010 based on the papers indexed in three different databases, viz., Scopus, CABAbstracts and Indian Science Abstracts. The present paper uses a time series data for 1965-2010 in gaps of five years each and is the first study on individual crops reported in literature.

Review of literature

Arunachalam and Umarani[2]analyzed 11855 publications of agricultural research output of Indian scientists indexed by CAB Abstracts 1998 and found that majority of papers were published on pests, pathogens and biogenic diseases (1135 papers) and plant production (786 papers). Highest contributions were made by State Agricultural Universities. Indian researchers preferred to publish in journals that originated from UK, USA and India. Majority of papers were published in non-SCI journals. Garget al[3]

analyzed 16891 papers published by Indian agricultural scientists indexed by Science Citation Index Expanded (Web of Science) during 1993-2002 and found that the publication output in the agricultural sciences was declining since 1998. The major research focus was on 'dairy and animal sciences' followed by 'veterinary sciences'. Agricultural universities and institutes under the aegis of Indian council of Agricultural Research produced maximum research output.

Balasubramanian and Ravanan[4] analyzed scientific output in agricultural sciences during last 66 years and found that global agricultural research output showed an upward trend. Regarding country-wise distribution of publications in agricultural research, USA produced the highest number of papers and the most preferred journal was *Agriculture Ecosystems and Environment* publishing 533 papers. NationalScience Foundation of the US made the highest contribution. Garget al[5] analyzed 32574 papers published by USA, UK, China, India and Brazil in the field of 'plant genetics and breeding' research during 2005-2009 and found that USA produced the maximum number of publications followed by China. India produced about 9 per cent of the world publication output. Indian output formed a part of the mainstream science as was seen by the pattern of publication and citation of the research output. Senthilkumaran and Amudhavalli[6]examined literature on spices for the period of 1968 to 2002 with respect to Asia and India using HORT-CD database. The study revealed that India dominates research and development activities on spices in the Asia and Indian Institute of Spices Research, Calicut, is a significant contributor whose scientist tops the list of prolific authors. Seetharam and Rao[7] compared the trends in growth of food science and technology literature produced by CFTRI (Central Food and Technology Research Institute) scientists, Indian food scientists and food scientists of the world during 1950-90. Gargetal[8] analyzed 2899 research papers on 'genetics and heredity' of Indian scientists indexed by Science Citation Index Expanded (Web of Science) during 1991-2008. The analysis indicates a slow growth in the initial stages and the focus of research was on molecular genetics. The authors also found that majority of papers were published in journals that originated from Western countries and in journals having impact factor less than one. Academic institutions had the highest number of papers.

Suryanarayana[9] analysed global research output in tobacco and found that the research output decreased globally after 1987. Tripathiet al[10]analysed 1610 scientific papers produced by 18 animal science research institutes of the Indian Council of Agricultural Research (ICAR) during April 2009—March 2010. Authors found that Indian scientists preferred to publish in Indian journals. The major research focus was on breeding and genetics and Indian Veterinary Research Institute published the highest number of papers.

The present paper is an extension of an earlier study[11] on Indian crop science research during 2008-2010. This paper uses a time series data for 1965-2010 in gaps of five years each and is the first study on individual crops reported in literature.

Objectives of the study

- To examine the output of different crops in Indian Science Abstracts (ISA) and CAB Abstracts databases during 1965-2010in gaps of five years;
- To identify the most prolific institutions in the field of cereal crops;
- To study the communication behavior of Indian agriculture scientists as reflected by the country of publication of papers and their impact factor;
- To identify most prolific authors in the field of crop sciences;
- To identify the sub-disciplines where the crop science output is concentrated; and
- To identify most cited papers in the field of crops sciences.

Methodology

Data for the study was collected from Indian Science Abstracts and CAB Abstracts for the period 1965 to 2010 with five years gaps. Like the previous study[11], the present analysis is also related to six food grain crops (wheat, rice, barley, maize, sorghum, millets). To download the data from the two databases Hindi names/common names/botanical names of crops were used as keywords. The keywords used for downloading records are given below:

1. wheat or *gahu* or *Triticumaestivum*and India, and not buckwheat, and not buck wheat,
2. Barley or *Jau* or *Hordeumvulgare*, and India
3. Maize or *Zea mays* or *makka* or corn, and India, not *Valerinellalocusta*
4. Rice or *chawal* or *dhan* or paddy or *Oryza sativa*, and India, but not rice bean

5. Sorghum or *jowar* or *jwaarie* or *jondhahlaas* or *mutthaari* or *kora* or Sudan grass or millet bloom, and India
6. Millet or *bajra* or *ragi* or Pennisetum, and India, or *Eleusinecoracana*, or *Setariaitalica*; or *Echinochloaesculenta*, or *Panicummiliaceum*

Hard copies of Indian Science Abstracts were used for data collection for the period 1965-1995 and for the remaining years electronic version of the database was used. Downloaded data was entered in MS Excel format for analysis. Data from CAB Abstracts for 1965-1995 was obtained from CD-ROM version and the rest from the online version. The following data elements were downloaded from both databases:

a. Name of the author and his affiliation

b. Title of the paper to identify the subject

c. Name of the journals in which papers were published

d. Year of publication

Subjects of study reported in the publications were identified using different keywords from title of the study. These keywords were chosen from *Crop Science Abstract, Field Crop Science Abstracts, Rice Abstracts, Maize Abstracts, Wheat Barley* and *Triticale Abstract* of CABI. Data were sorted on different variables such as authors and their affiliations, journals used for publishing research results and sub-disciplines of research. Journals indexed by Science Citation Index Expanded (SCIE) were also identified.To arrive at an accurate picture of the output in crop sciences, duplicate records from the downloaded data which dealt with multi-cereal crops were removed.

Results and discussion

Publication output in different cereal crops in ISA and CABI databases

Table 1 gives the output of different cereal crops in the two databases during 1965-2010 in gaps of five years each. Total number of records downloaded from Indian Science Abstracts and from CAB Abstracts were 6202 and 6709 respectively.A total of 2801duplicateand irrelevant records were eliminated from the downloaded records. Thus, 10,100 records wereanalyzed. The data presented in Table 1 indicates that the total output in second block (1990-2010) has increased almost three times to the output in the first block (1965-1985). The pattern of output presented in Figure 1 reveals that papers published on cereal crops are increasingsteadilyexcept for a sharp decline in 1970 and 1990 and a marginal dip in 2010.

Table 2 gives the output in different crops during 1965-2010 in gaps of five years. Data presented in Table 2 indicates that the highest number of papers was published in the rice crop followed by wheat and

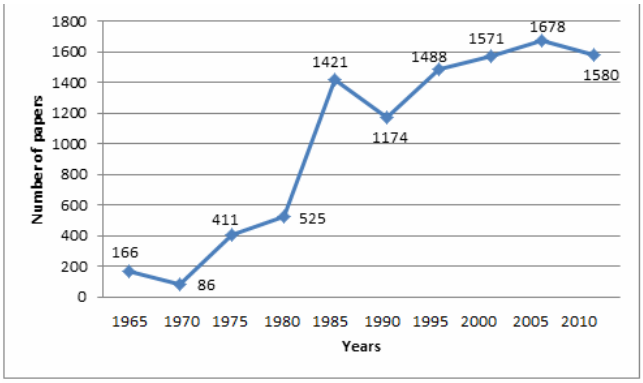

Fig. 1--Growth of publication output

Table 1--Distribution of records from ISA and CAB Abstracts during 1965-2010

Year	No. of ISA records	No. of CAB records	No. of Total records	No. of duplicate records	No. of final records
1965	182	0	182	16	166
1970	98	0	98	12	86
1975	311	113	424	13	411
1980	449	101	550	25	525
1985	836	877	1713	292	1421
1990	498	989	1487	313	1174
1995	995	1066	2061	573	1488
2000	930	1213	2143	572	1571
2005	981	1250	2231	553	1678
2010	922	1100	2022	442	1580
Total	6202	6709	12911	2811	10100
1965-1985	1876	1090	2967	358	2609
1990-2010	4326	5619	9944	2453	7491

Table 2--Distribution of output by cereal crops during 1965-2010 in gaps of five years each

Year	Rice	Wheat	Maize	Barley	Sorghum	Millets	Total output
1965	77	25	22	9	22	11	166
1970	28	32	12	4	8	3	87
1975	184	95	41	19	39	40	418
1980	239	133	56	16	52	47	543
1985	602	353	157	30	178	147	1467
1990	544	295	112	35	148	92	1226
1995	669	354	175	22	177	184	1581
2000	755	434	183	26	141	135	1674
2005	828	463	206	29	153	116	1795
2010	781	389	228	21	128	151	1698
Grand total	4707	2573	1192	211	1046	926	10655**
1965-1985	1130	638	288	78	299	248	2681
1990-2010	3577	1935	904	133	747	678	7974
AI*(1965-1985)	95	99	96	147	114	106	
AI* (1990-2010)	102	101	101	84	95	98	

*Rounded off to the nearest whole number, **Figure differs from actual figure as several papers belonged to multi-crops.

lowest number of papers was published on barley. The output on rice and wheat constituted about 68% of the total output. Remaining 32% papers were distributed among maize (11%), sorghum (10%) and millets (9%) and barley (2%) respectively.Pattern of output during the period 1965-2010 on different crops indicates that the lowest number of papers on each cereal crop was produced in the year 1965 and 1970. In the later period, it increased slowly till 1980 and almost doubled during 1985 and onwards. An analysis of outputwas made to examine as to how the emphasis has changed on different crops during 1965-1990 and 1995-2010 using Activity Index suggested by Schubert and Braun[12] and used by Garget al[13.] The advantage of using activity index over absolute count of publications is that it takes into consideration both the size of the nation/institution as well as the size of the discipline. However, in the present case nation has been replaced with two blocks for which the comparison has been made. Data presented in Table 2 indicates that the activity was higher for coarse cereals in first block as compared to rice and wheat. However, the same has changed in the second block indicating a lower activity for coarse cereals as compared to rice and wheat. One of the possible reasons for this may be the emphasis given in green revolution to increase productivity in rice and wheat as compared to coarse cereals.

Distribution of output by prolific institutions

The distribution of output by performing sectors indicates that State Agriculture Universities (SAUs) and agricultural colleges produced about half (50.74%) of the total papers. The share of institutions under the aegis of Indian Council of Agricultural Research (ICAR) was about one-fourth (25.65%) of the total output. Thus, these two performing sectors published about 76% of the total output in crop science research. Remaining 14% of the output came from other institutions under the aegis of other central/state government agencies as well as private institutions and international institutions.

Table 3 presents data on the distribution of output by prolific institutions. The total output came from 677 institutions located in different parts of India. Of these 25 prolific institutions listed in Table 3 produced nearly two third of the total output and the rest 652 institutes produced the remaining output. Among the prolific institutions, State Agriculture Universities are the major producers. Indian Agriculture Research Institute (IARI), the premier research institute under the aegis of the Indian Council of Agriculture Research produced about 8% of the total output and topped the list. The top four highly productive institutes are Indian Agricultural Research Institute (IARI), New Delhi, followed by Tamil Nadu Agricultural University, Coimbatore, Punjab Agricultural University (Ludhiana) and CCS Haryana Agricultural University (Hisar). The share of these four prolific institutions in the total output is more than one-fifth of the total output.

We also examined the impact of the research output by these prolific institutions using Citations per

Table 3--Most prolific Institutions*

Sl. no.	Institutes	P	P%	C	C%	RCI	CPP
1	IARI, New Delhi	829	8.2	3312	11.3	1.4	4.0
2	TNAU, Coimbatore	725	7.2	912	3.1	0.4	1.3
3	PAU, Ludhiana	696	6.9	2388	8.2	1.2	3.4
4	CCSHAU, Hisar	557	5.5	1282	4.4	0.8	2.3
5	GBPUA&T, Pantnagar	321	3.2	759	2.6	0.8	2.4
6	CRRI, Cuttack	313	3.1	1057	3.6	1.2	3.4
7	UAS, Bangalore	298	3	583	2.0	0.7	2.0
8	UAS, Dharwad	295	2.9	206	0.7	0.2	0.7
9	ANGRAU, Hyderabad	292	2.9	190	0.7	0.2	0.7
10	MPKV, Rahuri	234	2.3	197	0.7	0.3	0.8
11	BCKVV, Mohanpur	211	2.1	351	1.2	0.6	1.7
12	CSKHPKVV, Palampur	208	2.1	432	1.5	0.7	2.1
13	RAU, Samastipur	190	1.9	267	0.9	0.5	1.4
14	BHU, Varanasi	180	1.8	903	3.1	1.7	5.0
15	IGKVV, Raipur	165	1.6	221	0.8	0.5	1.3
16	OUAT, Bhubaneswar	152	1.5	200	0.7	0.5	1.3
17	Dr. PDKV, Akola	151	1.5	100	0.3	0.2	0.7
18	ICRISAT, Patancheru	145	1.4	1874	6.4	4.5	12.9
19	CSAUAT, Kanpur	136	1.4	296	1.0	0.8	2.2
20	NDUAT, Faizabad	132	1.3	232	0.8	0.6	1.8
21	AAU, Jorhat	122	1.2	277	1.0	0.8	2.3
22	VNMKV, Parbhani	116	1.2	176	0.6	0.5	1.5
23	BAU, Ranchi	107	1.1	146	0.5	0.5	1.4
24	MPKVV, Udaipur	105	1	257	0.9	0.9	2.5
25	JNKVV, Jabalpur	98	1	253	0.9	0.9	2.6
	Total (1-25)	6778	67.1	16871	57.7	0.9	2.5
	Remaining 652 Institutes	3322	32.9	12384	42.3	1.3	3.7
	Total 677Institutes	10100	100	29255	100	1	2.9

*Full names of the institutes given in Appendix

Paper (CPP) and Relative Citation Impact (RCI) and have been described below.

CPP is a relative indicator computed as the average number of citations per paper. It has been widely used in bibliometric studies to normalize a large disparity in volumes of published output among disciplines, countries and institutions for a meaningful comparison of research impact. Here CPP = (Total number of citations for an institution/total number of papers published by India).RCI is a measure of both the influence and visibility of a nation's research in global perspective. RCI is defined as "a country's share of world citations in the subspecialty/country's share of world publications in the subspecialty". RCI = 1 denotes a country's citation rate equal to world citation rate; RCI < 1 indicates a country's citation rate less than world citation rate and also implies that the research efforts are higher than its impact; and RCI > 1 indicates a country's higher citation rate than world's citation rate and also imply high impact research in that country. Here CPP and RCI have been calculated for a meaningful comparison of research output and impact of prolific institutions.

Only five out of top 25 prolific institutes have achieved RCI more than 1. Among these International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), Patancheruhad the highest (4.46) value of RCI followed by Indian Agricultural Research Institute, New Delhi (1.57), Punjab Agricultural University, Ludhiana (1.18), Central Rice Research Institute, Cuttack (1.17) and Banaras Hindu University, Varanasi (1.73).Papers contributed by ICRISAT, Hyderabad also gothighest citation per paper (12.92), followed by BHU, Varanasi (5.02); IARI, New Delhi (4.54) and PAU, Ludhiana (3.43). Average citation per paper was 2.9.Several of the institutes listed in Table 3 had RCI <1 and CPP less than average Indian output. This implies that the

impact of research produced by these institutes is not commensurate with their output.

Communication behavior of Indian crop scientists

This aspect has been examined using two different parameters. These are (i) publishing country of journals where the research results were published and (ii) distribution of output by impact factor of journals.

Distribution of output by publishing country of journals

Paper published by Indian crop science researchers appeared in 738 journals which were published from different parts of the globe. Of these 350 journals were published from India and the remaining 388 were published from 48 different countries from abroad. Table 4 presents the data on the number of papers published by Indian crop scientists in journals published from different countries. About 79% papers appeared in non SCIE indexed journals and the rest 21% in SCIE indexed journals. This indicates that the proportion of papers published by Indian crop scientists appear in journals not indexed by SCIE. Most of these journals originated from India. Further analysis of data indicates that among the journals published from abroad, maximum number of papers was published in journals published from UK, USA, Philippines, The Netherlands and Germany.

Distribution of papers by impact factor

Table 5 shows the distribution of output by impact factor of journals where the research results were published. It indicates that more than three-forth (78.42%) of papers were published in journals having no impact factor. Rest of the papers was published in journals having impact factor equal or more than 1. Only a minuscule proportion of papers were published in journals having impact factor more than 4. Table 6 lists number of papers in journals with impact factor more than four.

Most common journals used by Indian scientists

Data was analyzed to identify the most common journals used by Indian scientists for publishing their research results. It indicates that of the 20 most common journals (Table 7) where Indian scientists published their research results originated from India except two journals. These two journals are *Crop Research* (UK)and*International Rice Research Newsletter* (Philippines).These two journals published 248 papers each. The remaining journals published from India published about 38% of the total papers.

Subject distribution of research output

Using several key words related to crop science research, we identified six disciplines in which the research output was published. The distribution of

Table 5--Distribution of papers by impact factor of

Range of IF	No of papers	Percent
Zero	7920	78.42
≤1	1346	13.33
>1≤2	411	4.07
>2≤3	301	2.98
>3≤4	90	0.89
> 4	32	0.32
Total	10100	100.00

Table 4--Distribution of research output by publishing country of journals

Publishing country of journals	No. of papers in non-SCI journals	No. of papers in SCI journals	No. of papers	%
India	6674	1305	7979	79.0
UK	374	153	527	5.22
USA	179	278	457	4.52
Philippines	306	2	308	3.05
Netherlands	14	227	241	2.39
Germany	50	82	132	1.31
Canada	71	2	73	0.72
Japan	36	17	53	0.52
Hungary	16	28	44	0.44
Italy	22	12	34	0.34
South Korea	4	21	25	0.25
Total	7746	2127	9873	97.75
Other 38 countries	157	70	227	2.25
Grant Total	7903	2197	10100	100

Table 6--Journals having impact factor> 4

Sl. no	Journal title	Publishing country	IF	Papers
1	*Molecular Biology and Evolution*	UK	10.353	1
2	*Current Biology*	USA	9.494	1
3	*New Phytologist*	UK	6.736	5
4	*Plant Physiology*	USA	6.555	7
5	*Environment International*	UK	6.248	1
6	*Plant Molecular Biology Reporter*	Netherlands	5.319	1
7	*Environmental Science& Technology*	USA	5.257	2
8	*Journal of Experimental Botany*	UK	5.242	3
9	*Journal of Applied Ecology*	UK	4.74	1
10	*Water Research*	UK	4.655	1
11	*Biochemistry Journal*	UK	4.654	1
12	*Critical Reviews in Plant Science*	USA	4.356	1
13	*Molecular Plant Microbe Interactions*	USA	4.307	1
14	*Bio Energy Research*	USA	4.25	1
15	*Plant and Cell Physiology*	Japan	4.134	3
16	*Plant Cell and Environment*	UK	4.134	1
17	*Heredity*	UK	4.11	1
	23 journals having IF < 4			90
	52 journals having IF < 3			301
	69 journals having IF < 2			411
	82 journals, IF <1, but not zero			1346
	495 journals having IF=0			7920
	Total: 738 Journals			10100

*Impact factor based on Journal Citation Report 2013

Table 7--Most common Indian journals used by Indian scientists*

Sl. no	Name of Journal	Papers	IF	Percent
1	*Indian Journal of Agricultural Science*	435	0.18	4.3
2	*Indian Journal of Agronomy*	432	NA	4.3
3	*Madras Agricultural Journal*	368	NA	3.6
4	*Journal of Maharashtra Agricultural University*	313	NA	3.1
5	*Oryza*	265	NA	2.6
6	*Environmental Ecology*	249	NA	2.5
7	*Journal of Indian Society of soil science*	230	NA	2.3
8	*Indian Journal of Genetics & Plant Breeding*	200	0.20	2.0
9	*Indian Journal of Weed Science*	161	NA	1.6
10	*Annals of Agricultural Research*	160	NA	1.6
11	*Indian Phytopathology*	148	NA	1.5
12	*Mysore Journal of Agricultural Science*	143	NA	1.4
13	*Current Science*	141	0.91	1.4
14	*Agricultural Science Digest*	132	NA	1.3
15	*Indian Journal of Plant Physiology*	112	NA	1.1
16	*Indian Farming*	111	NA	1.1
17	*Karnataka Journal of agricultural Sciences*	109	NA	1.1
18	*Pesticides*	99	NA	1.0

*Lists journals publishing 1% or more of the papers

output in these disciplines is shown in Table 8. It indicates that highest number of papers was published in the discipline of genetics and plant breeding (29.84%) followed by agronomic aspects (21.73%), physiological and biochemical aspects (17.11%). These three sub-disciplines together constitute about70% of the total output. Rest 30%was scattered in the remaining three sub-disciplines. The number of papers in plant genetics and breeding are more, because, the agricultural scientists are working in the field on rice and wheat crops to increase their yield. Figure 2 indicates that the output has significantly increased in all subfields in second block (1990-2010) as compared to the first block (1965- 1985).

Authorship pattern

During the period 1965-2010, the total contributions were made by 28,086authors. Table 9 presents data about the authorship pattern in crop sciences. It indicates that about one-third of the papers were two authored and more than half of the papers were published as multi-authored (3 and 4 authors) and mega-authored (> 4 authors) papers. The share of papers written by single authors was lowest.This is because the discipline of crop science is multidisciplinary which involves several researchers from different disciplines.We examined how the pattern of co-authorship has changed during the second block (1990-2010) as compared to the first block (1965-1985) using Co-authorship Index (CAI) suggested by Garg and Padhi[14]. It has been obtained by calculating proportional output of single, two, multi and mega-authored papers for two different blocks. Value of CAI = 100 implies co-authorship effort for a particular type of authorship corresponds to the Indian average, CAI > 100 reflects higher than average co-authorship effort, and CAI < 100 lower than average co-authorship effort in that block for a given type of authorship pattern. Based on the values provide in Table 9, it is observed that the values of CAI has increased significantly for multi and mega authored papers in second block as compared to the first block and the CAI has decreased for single and two authored papers has decreased in second block as

Table 8--Distribution of output according to sub-disciplines of crop science research

	Agronomic aspects	Genetics and plant breeding	Harvest, storage & agricultureengineering	Pest, disease & pest control	Physiological& biochemical aspect	Soil, climate & Environmental aspects	Total
1965	38	41	3	45	17	22	166
1970	22	43	2	9	2	8	86
1975	84	97	15	101	38	76	411
1980	140	114	9	126	49	87	525
1985	287	351	50	381	133	219	1421
1990	335	324	30	229	70	186	1174
1995	437	460	25	266	98	202	1488
2000	517	396	34	274	94	256	1571
2005	547	531	22	298	49	231	1678
2010	417	486	55	260	81	281	1580
Total	2824	2843	245	1989	631	1568	10100
Percent	27.96	28.15	2.43	19.69	6.25	15.52	100.00

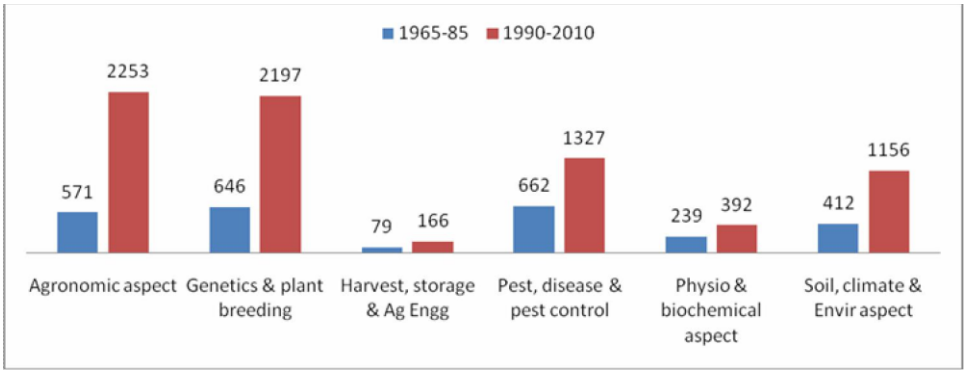

Fig. 2--Growth of output in two blocks

Table 9--Authorship pattern

Block year	Single authored papers (CAI)	Two-authored papers (CAI)	Multi-authored papers (CAI)	Mega authored papers (CAI)	Total
1965-85	390(136.8)	1205 (123.6)	937 (81.2)	76 (34.6)	2608
1990-10	703 (85.8)	2534 (90.5)	3489 (105.2)	766 (121.4)	7492
	1093	3739	4426	842	10100

Table 10--Highly productive authors (considering first author only)and their citations

Sl. no.	Authors	Affiliation	No. of papers	Citations	CPP
1	Walia U S	PAU, Ludhiana	18	71	3.9
2	Mote UN	MPKV, Rahuri	16	18	1.1
3	Chauhan, JS	CRRI, Cuttuck	12	27	2.3
4	Das N R	BCKV, Mohanpur	12	2	0.2
5	Rai K N	ICRISAT,Patancheru	12	107	8.9
6	Ghosh A	CRRI, Cuttack	11	11	1.0
7	Satyanarayana E	ANGRAU, Hyderabad	11	15	1.4
8	Sharma S N	IARI, New Delhi	11	88	8.0
9	Singh A R	MAU, Parbhani	11	24	2.2
10	Jadhav A S	MPKV, Rahuri	10	12	1.2
11	Matiwade P S	UAS, Dharwad	10	00	0.0
12	PANWAR R S	CCSHAU, Hisar	10	17	1.7
13	Sharma H C	ICRISAT, Patancheru	10	135	13.5
14	Singh G	NDUAT, Faizabad	10	42	4.2

compared to the first block. This implies that the share of multi and mega authored papers has increased in second block as compared to the first block.

Most prolific authors

Based on first author count, Table 10 lists prolific authors who have published 10 or more paper during 1965-2010 in journals.Of these, first two authors belonged to Punjab Agricultural University, Ludhiana (18 papers) followed by Mahatma PhuleKrishiVidyapeeth, Rahuri (16 papers). Next two authors belonged to Central Rice Research Institute, Cuttack (Orissa), Bidhan Chandra KrishiVidyapeeth, Kalyani (WB). Among the prolific authors, Sharma H of ICRISAT had the highest value for CPP followed by Sharma S of IARI.

Distribution of citations

Table 11 presents data on the distribution pattern of citations of papers. The citation data was examined using Google scholar. Itindicates that more than two-third papers (69.84%) were indexed by Google Scholar and the rest 30.2% papers were not indexed by Google scholar. The analysis indicates thatmore than half (57.16%) the papers were not cited and the rest were cited one or more times. Of these about 30% were cited between one to five times. Only a small fraction of papers were cited more than 10 times. Table 12 presents data on the highly cited authors. Out of 25 highly cited papers, six papers were

Table 11--Distribution of citations

Ranging of citation	No. of papers	%	Total citations
Zero	5773	57.16	0
1	1119	11.08	1119
2	815	8.07	1630
3	493	4.88	1479
4	375	3.71	1400
5	262	2.59	1310
6-10	652	6.46	5060
11 to 20	334	3.31	4732
21 to 30	124	1.23	2997
31 to 40	60	0.59	2101
41 to 50	27	0.27	1223
51 to 60	18	0.18	974
61 to 70	12	0.12	786
71 to 80	11	0.11	805
81 to 90	7	0.07	594
91 to 100	3	0.03	290
more than 100	15	0.15	2755
Total	10100	100	29255

Table 12--Highly cited papers

Sl. no.	Authors	Affiliation	Journal & its bibliographic details	Citations
1	Gupta P K and Varshney R K	CCSU, Meerut	*Euphytica*, 113 (2000) 165-185	613
2	Joshi S P, Gupta V S, Aggarwal RK, Ranjekar PK and Brar D S	NCL, Pune	*Theoretical and Applied Genetics*, 100 (2000) 1311-20	392
3	Prasad M, Varshney RK, Roy J K, Balyan H S and Gupta P K	CCSU, Meerut	*Theoretical and Applied Genetics*, 100(2000) 584-92	270
4	Sairam R K, Srivastava G C and Saxena D C	IARI, New Delhi	*BiologiaPlantarum*, 43(2) (2000) 245-251	144
5	Reddy B V S, Ramesh S, Reddy P S, Ramaiah B, Salimath PM and KachapurRajashekar	ICRISAT, Patancheru	*Journal of Semi-Arid Tropical Agricultural Research*, 46 (2005) 79-86	142
6	Yadav R L, Dwivedi B S and Pandey P S	PD-CSR, Modipuram, Meerut	*Field Crops Research*, 65(1)(2000) 15-30	140
7	Barman S C, Sahu R K, Bhargava S K and Chaterjee C	ITRC, Lucknow	*Bulletin Environmental Contamination and Toxicology*, 64 (2000) 489-496	139
8	Sairam,R K and Saxena D C,	IARI, New Delhi	*Journal of Agronomy and Crop Science*, 184 (2000) 55-61	138
9	Hemamalini G S, Shashidhar H E and HittalmaniShailaja	UAS,Bangalore	*Euphytica*, 112 (2000) 69-78	126
10	Yadav R L, Dwivedi B S, Kamta Prasad, Tomar O K, Shurpali N J and Pandey P	PD-CSR, Modipuram,	*Field Crops Research*, 68(3) (2000) 219-246	121
11	Krishna K R, Shetty KG, Dart P J and Andrews D J,	ICRISAT, Patancheru	*Plant and Soil*, 86 (1985) 113-125	118
12	Tyagi A K and Mohanty Amitabh,	University of Delhi	*Plant Science*, 158 (1-2) (2000) 1-18	111
13	Singh B R and Singh D P,	CCSHAU, Hisar	*Field Crops Research*, 42(2-3) (1995) 57-67	104
14	Pathak H, Li C and Wassmann R,	IARI, New Delhi	*Bio-geoScience*, 2 (2005) 113-123	103
15	Tyagi N K, Sharma D K and Luthra S K,	CSSRI, Karnal	*Agricultural Water Management*, 45(1) (2000) 43-64	103
16	Balasubramanian V, Morales, A C, Cruz ,R T, Thiyagarajan TM, Nagarajan R, Babu M, Abdulrachman S and Hai L H,	IARI, New Delhi	*International Rice Research Notes*, 25(1) (2000) 4-8	98
17	Ray S K, Rajeshwari R and Sonti R V	CCMB, Hyderabad	*Molecular Plant Microbe Interactions*, 13(4) (2000) 394-401	98
18	Pareek A, Singla S L and Grover A	University of Delhi	*Plant Molecular Biology*, 29 (1995) 293-301	97
19	Mishra N P, Tasneem-Fatma and Singhal G S	JNU, New Delhi	*PhysiologiaPlantarum*, 95 (1995) 77-82	90
20	Garg R N, Pathak H, Das D K and Tomar R K,	IARI, New Delhi	*Environmental Monitoring and Assessment*, 107 (2005) 1-9	87
21	Rao B L and Husain A	CIMAP, Lucknow	*Mycopathologia*, 89 (1985) 177-80	86
22	Sharma D C, Chatterjee C and Sharma C P	LucknowUniversity, Lucknow	*Plant Science*, 111(1-2) (1995) 145-151	86
23	Saseendran S A, Singh K K, Rathore L S, Singh S V and Sinha S K,	NC-MRWF, New Delhi	*Climatic Change*, 44 (2000) 495-514	85
24	Aggarwal G C, Sidhu A S, Sekhon N K, Sandhu K S and Sur H S,	PAU, Ludhiana	*Soil & Tillage Research*, 36(3-4) (1995) 129-139	83
25	MajumdarDeepanjan, Sushil Kumar, Pathak H, Jain M C and Upendra Kumar	IARI, New Delhi	*Agriculture Ecosystems & Environment*, 81(3) (2000) 163-169	82

produced by IARI scientists, followed by two papers each from ICRISAT, CCS University Meerut, PD-CSR,Modipuram,Univerisity of Delhi,Delhi. Rest were produced by scientists from different state agricultural universities/ICAR institutes. All the highly cited papers were published in journals published from abroad.

Conclusion

Agricultural progress holds the key to India's economic development as it is the major source of livelihood of about two-third of the Indian population. The present scientometric analysis of the crop science research performed in India 1965-2010 with a gap of five years is the first study where data by crops has

been analyzed. The study has identified most active institutions engaged in agricultural research, areas of research in crop science, journals used for communication and the impact of the crop science research output. Like other studies referred under review of literature it also indicates that State Agriculture Universities (SAUs) and Indian Agriculture Research Institute are the major producers of output and the research findings are mainly published in journals originated from India with low impact.The findingsof the present study will be beneficial for the scholars and scientists who are engaged in research of various disciplines of crop science as well as policy makers in the field of agricultural sciences.

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Appendix

Full Name	Abbreviations
Indian Agricultural Research Institute, New Delhi	IARI
Tamil Nadu Agricultural University, Coimbatore	TNAU
Punjab Agricultural University, Ludhiana	PAU
CCS Haryana Agricultural University, Hisar	CCSHAU
G.B. Pant University of Agriculture and Technology, Pantnagar	GBPUA&T
Central Rice Research institute, Cuttack	CRRI
University of Agricultural Sciences, Dharwad/Banglore	UAS
AcharyaN.G.Ranga Agricultural University, Hyderabad	ANGRAU
Mahatma PhuleKrishiVidyapeeth, Rahuri	MPKV
Bidhan Chandra KrishiViswavidyalaya, Mohanpur	BCKV
CSK Himachal Pradesh KrishiVishvavidyalaya, Palampur	CSKHPKV
Rajendra Agricultural University, Samastipur	RAU
Banaras Hindu University, Varanasi	BHU
Indira Gandhi KrishiVishwavidyalaya, Raipur	IGKVV
Orissa University of Agriculture Technology, Bhuvaneshwar	OUAT
Dr. PanjabraoDeshmukhKrishiVidyapeeth, Akola	PDKV
International Crops Research Institute for the Semi-Arid Tropics, Patancheru	ICRISAT
Chandra.Shekar Azad University of Agriculture and Technology, Kanpur	CSAUAT
Narendra.Dev University of Agriculture and Technology, Faizabad	NDUAT
Assam Agricultural University, Jorhut	AAU
VasantraoNaikMarathwadaKrishiVidyapeeth, Parabhani	VNMKV
Birsa Agricultural University, Ranchi	BAU
MaharanaPratap University of Agriculture &Technology, Udaipur	MPUAT
Jawaharlal.NehruKrishiVishwaVidyalaya, Jabalpur	JNKVV
National Chemical Laboratory, Pune	NCL
ChaudharyCharan Singh University, Meerut	CCSU
Project Directorate for Cropping Systems Research, Modipuram	PD-CSR
Industrial Toxicology Research Centre, Lucknow	ITRC
Central Soil Salinity Research Institute, Karnal	CSSRI
Centre for Cellular and Molecular Biology, Hyderabad	CCMB
Jawaharlal Nehru University, New Delhi	JNU
Central Institute for Medicinal& Aromatic Plants, Lucknow	CIMAP
National Centre for Medium Range Weather forecasting, New Delhi	NC-MRWF
Indian Council of Agricultural Research, New Delhi	ICAR
Marathwada Agricultural University, Parbhani,	MAU