

Agriculture Research in India: A Scientometric Mapping of Publications

Anil Sagar, B.S. Kademani and K. Bhanumurthy

Scientific Information Resource Division, Bhabha Atomic Research Centre, Trombay, Mumbai-400 085

E-mail: asagar@barc.gov.in, bsk@barc.gov.in, aditya@barc.gov.in

ABSTRACT

The study analyses the agriculture research publications in India during 1993-2012 based on the Web of Science database. The objective of the study was to perform a scientometric analysis of all agriculture research publications by Indian scientists. The parameters studied include growth of publications and citations, domain-wise distribution of publications and citations, activity index, international collaboration, highly productive institutions, highly preferred journals, and highly cited publications.

Keywords: Agriculture research, scientometrics; publication productivity, quality research, R&D trend, publication efficiency index, specialisation index, agricultural economics & policy, agricultural engineering; agriculture-multidisciplinary, agronomy, dairy & animal sciences

1. INTRODUCTION

The invention of agriculture is one of the great revolution of human history. The availability of nutritional adequacy of food have been driving forces for human evolution and civilisation. People often lived a nomadic life as hunters and gatherers following the migration of animals or moving during seasonal changes in the weather prior to the domestication of plants and animals, some 12,000 years ago. The adoption of agriculture, and the domestication of plants and animals reduced the nomadic lifestyles among groups of people. Communities of humans grew larger. Eventually, as agriculture flourished and produced larger food surpluses, these communities grew into cities, that furthered the pursuit of government, art and technology for which human civilisation is known¹.

Attaining food security had been the major policy issue for the entire nation since independence. Our first Prime Minister, Pandit Jawaharlal Nehru, immediately after independence had accorded the highest importance to agriculture by stating "Everything can wait but not agriculture". Prime Minister Lal Bahadur Shastri had also accorded high importance to agriculturists by equating them with defense personnel, through the slogan as 'Jai Jawan, Jai Kisan'. Recognising the contribution of science for the all round progress of our nation, Prime Minister Atal Bihari Vajpayee further pronounced the slogan as 'Jai Jawan, Jai Kisan and Jai Vigyan'. He also gave a call to double food production in the next one decade. Owing to the vision of all our great

leaders, India could achieve the required success in agriculture. Over six decades since its independence, India has made immense progress towards food security. Indian population has tripled, but food-grain production more than quadrupled: there has thus been substantial increase in available food-grain per capita. India has seen several agricultural revolutions (Green, White, Yellow, Golden, Blue, etc.) resulting major advances in production of milk, oilseeds, fruits, vegetables, fish, and fish products.

The Indian Council of Agricultural Research (ICAR) is an autonomous organisation under the Department of Agricultural Research and Education (DARE), Ministry of Agriculture, Government of India formerly known as Imperial Council of Agricultural Research. It was established on 16 July 1929 as a registered society under the Societies Registration Act, 1860 in pursuance of the report of the Royal Commission on Agriculture. Agriculture research in India was entrusted to the Indian Council of Agricultural Research (ICAR) in 1966. At that time, three national institutes, the IARI, the NDRI and the IVRI and some of them institutes were functionally was brought under ICAR.

The ICAR has played a pioneering role in ushering Green Revolution and subsequent developments in agriculture in India through its research and technology development that has enabled the country to increase the production of food grains by 4 times, horticultural crops by 6 times, fish by 9 times (marine 5 times and inland 17 times), milk 6 times and eggs 27 times since 1950-51, thus making a

visible impact on the national food and nutritional security. It has played a major role in promoting excellence in higher education in agriculture. The ICAR has its headquarters at New Delhi. The Council is the apex body for coordinating, guiding and managing research and education in agriculture including horticulture, fisheries and animal sciences in the entire country. With 99 ICAR institutes and 53 agricultural universities spread across the country is one of the largest national agricultural systems in the world. It is engaged in cutting edge areas of science and technology development and its scientists are internationally acknowledged in their fields².

2. LITERATURE REVIEW

Nasir³, *et al.* have carried out bibliometric analysis of agricultural literature published in Malaysia during 1981-1990. The study highlighted on the key journals that published agricultural literature by Malaysian authors and the publishing practice of corporate bodies.

Arunachalan & Umarani⁴ have studied 11855 Indian agriculture publications during 1998-1999 and the early months of 2000 using CAB database and identified top Indian institutions in different subfields, different journals with their impact factors.

Garg⁵, *et al.* analysed 16891 publications by Indian agricultural scientists during 1993-2002 using Science Citation Index Expanded (Web of Science) and observed that the publication output in the agricultural sciences is on the decline since 1998 onwards.

Bartol⁶ has assessed the characteristics of documents published in national journals and other publications in the countries which participate on the editorial board of the *Journal of Central European Agriculture (JCEA)*. Bibliographic citations from the *CAB Abstracts* database were used. The study found out that Poland is the major contributor of documents, being by far the largest country. Altogether some 378 different agricultural and related life- and environmental science journals have been active in the region during the study period.

Balasubramanian & Ravanani⁷ have studied the global agriculture literature and highlighted the scientific output during 1945-2010 and focused on the growth of literature, highly productive countries and most preferred journals. Gupta⁸ analysed the ranking of India's productive institutions in agricultural sciences, based on the various qualitative indicators during 1999-2008. Borthakur & Singh⁹ attempted to portray the role of Five Year Plans regarding investment, technology transfer and other aspects related to agricultural development in India.

It has observed that although agriculture has been playing the most vital role in Indian economy, during the course of the study and found that not much emphasis has been given to the history of evolution of agricultural research in India.

3. OBJECTIVES

The main objective of the study is to present the growth of agriculture research published during 1993-2012 as per the *Web of Science* database and make the quantitative and qualitative assessment by way of analysing various features of research output such as growth of publications and citations, domain-wise distribution of publications and citations, activity index, domain-wise mean impact factor, international collaboration, highly productive institutions, highly preferred journals and highly cited publications.

4. MATERIALS AND METHODS

Data was collected from Web of Science for the period 1993-2012. It is very difficult to define the scope of agriculture using keywords and combination of keywords which may not always cover the entire gamut of literature on agriculture and there is always every possibility of missing some percentage of literature. Therefore, it was decided to select all the journals on agriculture as per the Journal Citation Reports (JCR-2011) subject categories. A list of 163 journals falling within the scope of agriculture as per JCR subject categories were identified and the articles with at least one Indian author were identified by using country affiliation field. In all, 22615 Indian publications were retrieved during the period (1993-2012) and 98954 citations received to these publications were transferred to spread sheet application and analysed the data as per objectives of the study. The bibliographic fields were analysed by normal count procedure for continents, countries, domains, authorships and journals. Full credit was given to each continent, country regardless of whether it appears first or last in the author byline.

5. RESULTS AND DISCUSSIONS

5.1 Year-wise Distribution of Publications and Citations

A total of 22615 publications were published in agriculture during 1993-2012 and these publications received 98954 citations. Year-wise distribution of publications and citations is given in Table 1 & Fig. 1. The highest number of publications 1917 (8.48 %) were published in 2008. The highest number of citations 8714 (8.81 %) were received in 2007. The highest average citations per publication 8.29 were in 2002. There were 10428 (46.11 %) publications with no citations during the period under study. The highest total impact factor (1865.33) was in 2008. The highest average impact factor per publications (1.29) was in 2006. The highest annual growth rate of publications was observed in two consecutive years 2007 (42.08 %) and 2008 (35.19 %). On considering ten year cumulative growth of publications during 1993-2002 to 2003-2012, a

publication growth rate of 36.52 % was witnessed in the field of agriculture in India.

The citation impact increased to 34.02 % during 1993-1997 to 1998-2012 and the average impact factor (AIF) increased from 8.42 % during 1993-1997 to 1998-2002 to 15.96 % during 2003-2007. On considering the five year cumulative growth of international collaborative publications in different five

year blocks, it is revealed from the data that 58.99 % of growth of international collaborative publications was observed during 1993-1997 to 1998-2002, 38.09 % of publications during 2003-2007.

5.2 Distribution of Publications and Citations in Agriculture Sub-Domains

Based on the classification of subject-categories in Journal Citation Report (JCR) of Thomson

Table 1. Year-wise distribution of publications and citations

| Year | Total no. of publications (%) | Growth rate of publications (%) | Total no. of citations (%) | Average citations per publication | Total impact factor (TIF) | Average impact factor per publication (AIFP) |
|--------------|-------------------------------|---------------------------------|----------------------------|-----------------------------------|---------------------------|--|
| 1993 | 837 (3.7 %) | - | 2710 (2.74 %) | 3.24 | 680 | 0.81 |
| 1994 | 911 (4.03 %) | 8.84 | 3461 (3.5 %) | 3.80 | 770.05 | 0.85 |
| 1995 | 852 (3.77 %) | -6.48 | 3115 (3.15 %) | 3.66 | 693.44 | 0.81 |
| 1996 | 724 (3.2 %) | -15.02 | 4046 (4.09 %) | 5.59 | 627.21 | 0.87 |
| 1997 | 834 (3.69 %) | 15.19 | 3699 (3.74 %) | 4.44 | 598.64 | 0.72 |
| 1998 | 908 (4.02 %) | 8.87 | 4092 (4.14 %) | 4.51 | 786.78 | 0.87 |
| 1999 | 901 (3.98 %) | -0.77 | 4852 (4.9 %) | 5.39 | 706.68 | 0.78 |
| 2000 | 1001 (4.43 %) | 11.10 | 6500 (6.57 %) | 6.49 | 806.60 | 0.81 |
| 2001 | 949 (4.2 %) | -5.19 | 6095 (6.16 %) | 6.42 | 867.34 | 0.91 |
| 2002 | 864 (3.82 %) | -8.96 | 7161 (7.24 %) | 8.29 | 923.08 | 1.07 |
| 2003 | 1077 (4.76 %) | 24.65 | 8062 (7.24 %) | 7.49 | 1007.52 | 0.94 |
| 2004 | 959 (4.24 %) | -10.96 | 6254 (6.32 %) | 6.52 | 911.82 | 0.95 |
| 2005 | 970 (4.29 %) | 1.15 | 6097 (6.16 %) | 6.29 | 908.06 | 0.94 |
| 2006 | 998 (4.41 %) | 2.89 | 7425 (7.5 %) | 7.44 | 1282.96 | 1.29 |
| 2007 | 1418 (6.27 %) | 42.08 | 8714 (8.81 %) | 6.15 | 1598.45 | 1.13 |
| 2008 | 1917 (8.84 %) | 35.19 | 7481 (7.56 %) | 3.90 | 1865.33 | 0.97 |
| 2009 | 1709 (7.56 %) | -10.85 | 4002 (4.04 %) | 2.34 | 1458.00 | 0.85 |
| 2010 | 1778 (7.86 %) | 4.04 | 3338 (3.37 %) | 1.88 | 1688.66 | 0.95 |
| 2011 | 1643 (7.27 %) | -7.59 | 1596 (1.61 %) | 0.97 | 1861.95 | 1.13 |
| 2012 | 1365 (6.04 %) | -16.92 | 254 (0.26 %) | 0.19 | 1735.57 | 1.27 |
| Total | 22615 | - | 98954 | 4.38 | 21778.14 | 0.96 |

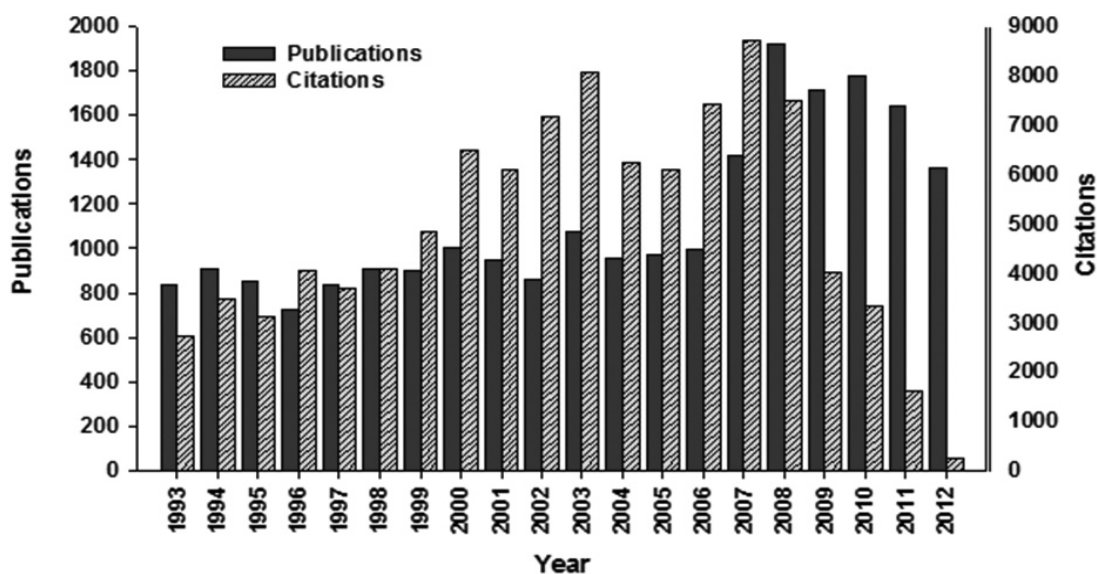


Figure 1. Year-wise distribution of publications and citations in agriculture research in India.

Reuters, the publication output data of agriculture research was classified into 5 domains during 1993-2012. Dairy & animal sciences accounts for the largest share 8713 (38.53 %) of publications in the total Indian output in Agriculture which received 13682 (13.83 %) citations followed by agriculture-multidisciplinary with 6168 (27.27 %) publications and 15912 (16.08 %) citations, agronomy with 5430 (24.01 %) publications and 38130 (38.53 %) citations, agricultural engineering with 2254 (9.97 %) publications and 30925 (31.25 %) citations and agricultural economics & Policy with 50 (0.22 %) publications, and 305 (0.31 %) citations (Table 2).

The highest growth rate of publications was observed during 2008-2012 in various domains: Agricultural Economics & Policy (160 %), Agricultural Engineering (99.66 %), Agronomy (98.23 %), Agriculture-

Multidisciplinary (48.02 %), and Dairy & Animal Sciences (22.15 %).

The research activity increased during 1993-2002 to 2003-2012 in various domains: Agricultural Engineering (71.20 %), Agricultural Economics & Policy (61.11 %), Agronomy (53.16%), Agriculture-Multidisciplinary (30.36 %), and Dairy & Animal Sciences (15.17 %).

5.3 Share of International Collaborative Publications in Agriculture Sub-domains

In all, there were 1744 international collaborative publications in Indian agriculture research during 1993-2012. The highest international collaborative publications were in Agronomy (1061) followed by Agriculture-Multidisciplinary (261) and Agricultural Engineering (257). Table 3 provides sub-domain share of international collaborative publications in various agriculture sub-domains.

Table 2. Domain-wise distribution of publications and citations in agriculture research (1993-2012)

| Domains | Total no. of publications (%) | Total no. of citations (%) | Average citations per publication (ACP) |
|---------------------------------|-------------------------------|----------------------------|---|
| Dairy & Animal Sciences | 8713 (38.53 %) | 13682 (13.83 %) | 1.57 |
| Agriculture-Multidisciplinary | 6168 (27.27 %) | 15912 (16.08 %) | 2.58 |
| Agronomy | 5430 (24.01 %) | 38130 (38.53 %) | 7.02 |
| Agricultural Engineering | 2254 (9.97 %) | 30925 (31.25 %) | 13.72 |
| Agricultural Economics & Policy | 50 (0.22 %) | 305 (0.31 %) | 6.10 |
| Total | 22615 | 98954 | 4.38 |

Table 3. Share of international collaboration in agriculture sub-domains

| Year | Agricultural economics & policy | Agricultural engineering | Agriculture multidisciplinary | Agronomy | Dairy & animal sciences |
|------|---------------------------------|--------------------------|-------------------------------|----------------|-------------------------|
| 1993 | 3 (162.11 %) | 35 (41.96 %) | 295 (129.23 %) | 151 (75.14 %) | 353 (109.47 %) |
| 1994 | 1 (49.65 %) | 52 (57.27 %) | 311 (125.17 %) | 151 (69.03 %) | 396 (112.83 %) |
| 1995 | 1 (53.09 %) | 51 (60.06 %) | 261 (112.32 %) | 166 (81.15 %) | 373 (113.63 %) |
| 1996 | 0 (0.00 %) | 39 (54.05 %) | 233 (118.00 %) | 136 (78.23 %) | 316 (113.29 %) |
| 1997 | 1 (54.23 %) | 31 (37.29 %) | 225 (98.92 %) | 151 (75.41 %) | 426 (132.58 %) |
| 1998 | 1 (49.81 %) | 43 (47.51 %) | 246 (99.33 %) | 178 (81.65 %) | 440 (125.78 %) |
| 1999 | 0 (0.00 %) | 50 (55.68 %) | 283 (115.16 %) | 174 (80.43 %) | 394 (113.50 %) |
| 2000 | 3 (135.55 %) | 53 (53.12 %) | 284 (104.02 %) | 208 (86.54 %) | 453 (117.46 %) |
| 2001 | 3 (142.98 %) | 67 (70.84 %) | 268 (103.54 %) | 194 (85.14 %) | 417 (114.05 %) |
| 2002 | 1 (52.35 %) | 83 (96.38 %) | 126 (53.47 %) | 223 (107.49 %) | 431 (129.48 %) |
| 2003 | 0 (0.00 %) | 85 (79.19 %) | 255 (86.81 %) | 246 (95.13 %) | 491 (118.33 %) |
| 2004 | 4 (188.65 %) | 83 (86.84 %) | 230 (87.93 %) | 224 (97.28 %) | 418 (113.13 %) |
| 2005 | 1 (46.63 %) | 72 (74.47 %) | 269 (101.68 %) | 230 (98.75 %) | 398 (106.50 %) |
| 2006 | 1 (45.32 %) | 148 (148.79 %) | 276 (101.4 %) | 231 (96.40 %) | 342 (88.95 %) |
| 2007 | 4 (127.59 %) | 196 (138.68 %) | 436 (112.74 %) | 309 (90.76 %) | 473 (86.58 %) |
| 2008 | 7 (165.16 %) | 274 (143.41 %) | 554 (105.96 %) | 532 (115.58 %) | 550 (74.47 %) |
| 2009 | 5 (132.33 %) | 191 (112.13 %) | 447 (95.9 %) | 479 (116.73 %) | 587 (89.15 %) |
| 2010 | 1 (25.44 %) | 216 (121.89 %) | 502 (103.52 %) | 505 (118.29 %) | 554 (80.87 %) |
| 2011 | 5 (137.64 %) | 259 (158.16 %) | 415 (92.61 %) | 470 (119.14 %) | 494 (78.04 %) |
| 2012 | 8 (265.08 %) | 226 (166.12 %) | 252 (67.69 %) | 472 (144.01 %) | 407 (77.39 %) |

5.4 Activity Index in Agriculture Sub-domains

The activity index (AI) characterises the relative research efforts of a country in a given subject. On analysing the growth and decline in publication productivity using normalised activity index¹⁰⁻¹³, it was observed that the highest activity index in various Agriculture sub-domains were: Agricultural Economics & Policy (139.8 %) during 2008-12, Agricultural engineering (139.07 %) during 2008-12, Agriculture-multidisciplinary (116.84 %) during 1993-97, Agronomy (121.7 %) during 2008-12, and Dairy & animal sciences (119.87 %) during 1998-02 (Fig. 2 and Table 4).

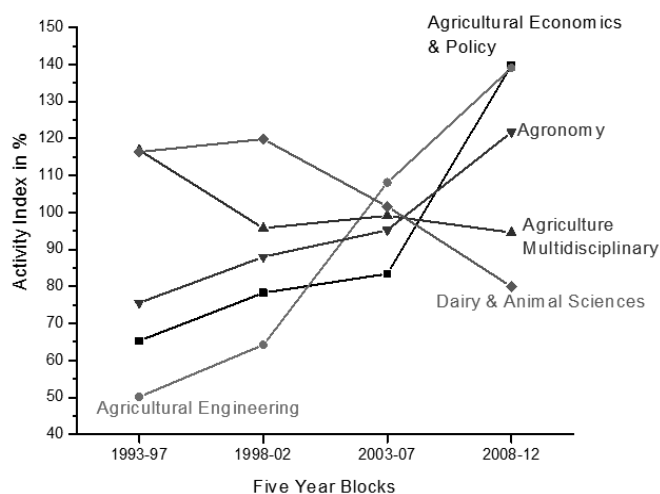


Figure 2. Activity index (AI) in agriculture sub-domains during 1993-2012.

5.5 Variation of Mean Impact Factor in Agriculture Sub-domains

Figure 3 gives the distribution of various agriculture domains according to mean impact factor during the period under study. It is revealed from this analysis that there is a significant variation in mean impact factor in various agriculture science domains. The highest mean impact factor (3.59) is for agriculture engineering followed by Agronomy (1.37) and Agricultural Economics & Policy (1.35).

5.6 International Collaboration

In recent years, every country has realised the importance of collaborative research to tackle many scientific problems resulting in many international collaborations¹⁴. Table 5 and Fig. 4 provide international collaboration pattern with Indian institutions in agriculture research. Indian Institutions had the highest number of collaborative publications with countries like the USA, Australia, Germany, England, Philippines, Canada, Mexico, Japan, China, Netherlands, France, and South Korea.

5.7 International Collaborative Publications in Agriculture Sub-domains

The International collaboration trend in various sub-domains is given in Table 6. Out of 22615 publications, there were 1744 (7.71 %) publications were international collaborative publications with 104 countries. Indian scientists had highest (480) international collaborative publications scientists with USA followed by Australia with 158 publications,

Table 4. Activity index (AI) in agriculture sub-domains during 1993-2012

| Five year blocks | Five year blocks-wise number of publications and activity index (AI) | | | | | Total |
|------------------|--|--------------------------|-------------------------------|-----------------|-------------------------|--------------|
| | Agricultural economics & policy | Agricultural engineering | Agriculture multidisciplinary | Agronomy | Dairy & animal sciences | |
| 1993-1997 | 6 (65.27 %) | 208 (50.19 %) | 1325 (116.84 %) | 755 (75.62 %) | 1864 (116.36 %) | 4158 |
| 1998-2002 | 8 (78.27 %) | 296 (64.24 %) | 1207 (95.73 %) | 977 (88.02 %) | 2135 (119.87 %) | 4623 |
| 2003-2007 | 10 (83.42 %) | 584 (108.07 %) | 1466 (99.13 %) | 1240 (95.25 %) | 2122 (101.58 %) | 5422 |
| 2008-2012 | 26 (139.8 %) | 1166 (139.07 %) | 2170 (94.58 %) | 2458 (121.70 %) | 2592 (79.98 %) | 8412 |
| Total | 50 | 2254 | 6168 | 5430 | 8713 | 22615 |

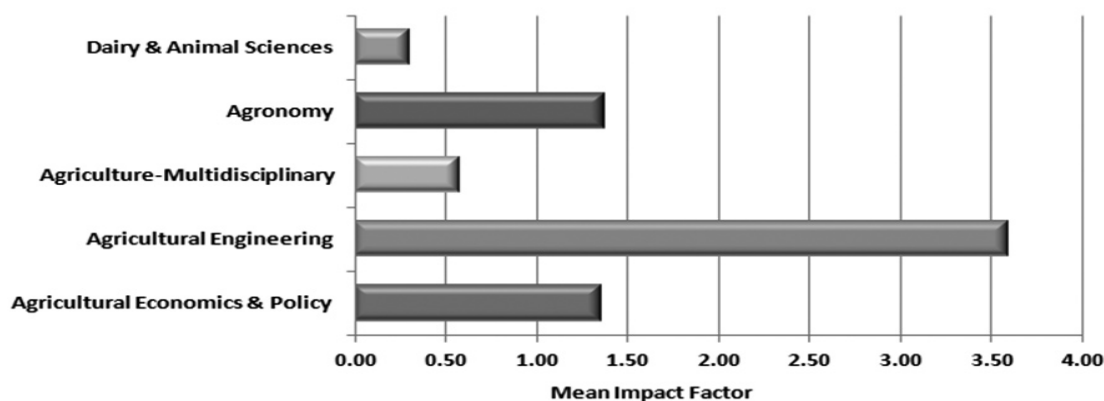


Figure 3. Variation of mean impact factor in agriculture domains.

Table 5. India's international collaborative publications in Agriculture research

| Rank | Country | Total citations per publication (%) | Total citations (%) | Average citations per publication | Total impact factor (TIF) | Average impact factor (AIF) |
|-------|--------------------|-------------------------------------|---------------------|-----------------------------------|---------------------------|-----------------------------|
| 1 | USA | 480 (2.12 %) | 6772 (6.84 %) | 14.11 | 1067.44 | 2.22 |
| 2 | Australia | 158 (0.7 %) | 1947 (1.97 %) | 12.32 | 337.92 | 2.14 |
| 3 | Germany | 150 (0.66 %) | 2371 (2.40 %) | 15.81 | 324.18 | 2.16 |
| 4 | England | 137 (0.61 %) | 3436 (3.47 %) | 25.08 | 321.21 | 2.34 |
| 4 | Philippines | 137 (0.61 %) | 2836 (2.87 %) | 20.70 | 317.14 | 2.31 |
| 5 | Canada | 97 (0.43 %) | 1058 (1.07 %) | 10.91 | 198.52 | 2.05 |
| 6 | Mexico | 89 (0.39 %) | 1176 (1.19 %) | 13.21 | 187.41 | 2.11 |
| 7 | Japan | 83 (0.37 %) | 1116 (1.13 %) | 13.45 | 168.92 | 2.04 |
| 8 | China | 80 (0.35 %) | 1293 (1.13 %) | 16.16 | 175.45 | 2.19 |
| 9 | Netherlands | 74 (0.33 %) | 998 (1.01 %) | 13.49 | 146.80 | 1.98 |
| 10 | France | 61 (0.27 %) | 1126 (1.14 %) | 18.46 | 162.29 | 2.66 |
| 10 | South Korea | 61 (0.27 %) | 797 (0.81 %) | 13.07 | 180.54 | 2.96 |
| 11 | Scotland | 47 (0.21 %) | 661 (0.67 %) | 14.06 | 102.67 | 2.18 |
| 12 | Wales | 44 (0.19 %) | 909 (0.92 %) | 20.66 | 84.58 | 1.92 |
| 13 | Kenya | 41 (0.18 %) | 624 (0.63 %) | 15.22 | 93.83 | 2.29 |
| 14 | Nepal | 38 (0.17 %) | 530 (0.54 %) | 13.95 | 63.02 | 1.66 |
| 15 | Italy | 35 (0.15 %) | 388 (0.39 %) | 11.09 | 72.34 | 2.07 |
| 16 | Iran | 34 (0.15 %) | 327 (0.33 %) | 9.62 | 46.92 | 1.38 |
| 17 | Thailand | 33 (0.15 %) | 773 (0.78 %) | 23.42 | 69.25 | 2.10 |
| 18 | Bangladesh | 32 (0.14 %) | 582 (0.59 %) | 18.19 | 60.68 | 1.90 |
| 19 | Brazil | 31 (0.14 %) | 698 (0.71 %) | 22.52 | 93.80 | 3.03 |
| 20 | Syria | 30 (0.13 %) | 490 (0.50 %) | 16.33 | 57.32 | 1.91 |
| 21 | Nigeria | 28 (0.12 %) | 311 (0.31 %) | 11.11 | 58.54 | 2.09 |
| 22 | Taiwan | 25 (0.11 %) | 140 (0.14 %) | 5.60 | 71.10 | 2.84 |
| 23 | Belgium | 24 (0.11 %) | 459 (0.46 %) | 19.13 | 57.91 | 2.41 |
| 24 | Pakistan | 23 (0.10 %) | 406 (0.41 %) | 17.65 | 35.84 | 1.56 |
| 25 | Ethiopia | 21 (0.09 %) | 153 (0.15 %) | 7.29 | 37.00 | 1.76 |
| 25 | Indonesia | 21 (0.09 %) | 505 (0.51 %) | 24.05 | 39.24 | 1.87 |
| 25 | Spain | 21 (0.09 %) | 367 (0.37 %) | 17.48 | 44.52 | 2.12 |
| 25 | Sri Lanka | 21 (0.09 %) | 157 (0.16 %) | 7.48 | 37.98 | 1.81 |
| 26 | Sweden | 20 (0.09 %) | 373 (0.38 %) | 18.65 | 49.87 | 2.49 |
| 27 | Israel | 19 (0.08 %) | 172 (0.17 %) | 9.05 | 43.19 | 2.27 |
| 27 | Malaysia | 19 (0.08 %) | 415 (0.42 %) | 21.84 | 61.48 | 3.24 |
| 28 | Mali | 18 (0.08 %) | 167 (0.17 %) | 9.28 | 37.90 | 2.11 |
| 29 | New Zealand | 18 (0.08 %) | 276 (0.28 %) | 15.33 | 39.84 | 2.21 |
| 30 | Denmark | 17 (0.08 %) | 160 (0.16 %) | 9.41 | 37.42 | 2.20 |
| 30 | Switzerland | 17 (0.08 %) | 388 (0.39 %) | 22.82 | 45.93 | 2.70 |
| 31 | Zimbabwe | 15 (0.07 %) | 161 (0.16 %) | 10.73 | 33.52 | 2.23 |
| 32-44 | Other 66 countries | 296 (1.31 %) | 4329 (4.37 %) | 14.63 | 621.07 | 2.10 |

Germany with 150 publications, England with 137 publications and Philippines with 137 publications. The agronomy domain witnessed the highest number (1061) of international collaborative followed by agriculture-multidisciplinary with 261 publications and agricultural engineering with 257 publications.

5.8 Highly Productive Indian Institutions in Agriculture Research

The impact of the research output has been examined using the citations these institutions received. Out of thirty nine institutions listed in Table 7 only 18 institutions account for 53.44 %

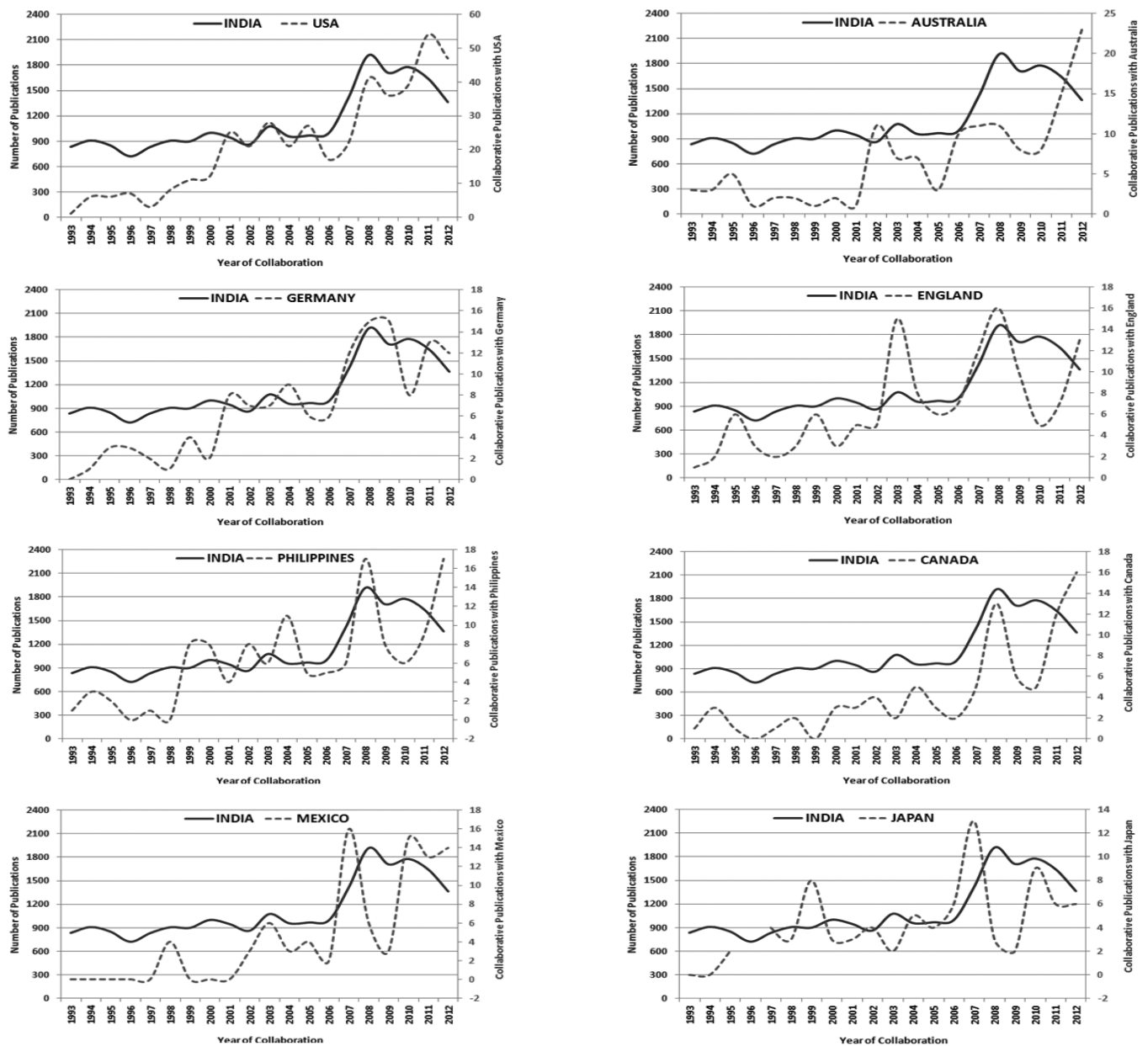


Figure 4. Top collaborative countries with India in agriculture research (1993-2012).

Table 6. International collaboration in agriculture sub-domains by the Indian scientists

| Sub-domains | International collaborative publications (%) | Total citations (%) | Average citations per publication (ACP) | Total impact factor (TIF) | Average impact factor (AIF) |
|---------------------------------|--|------------------------|---|---------------------------|-----------------------------|
| Agronomy | 1061 (4.69 %) | 14586 (14.74 %) | 13.75 | 2141.39 | 2.02 |
| Agriculture-Multidisciplinary | 261 (1.15 %) | 2651 (2.68 %) | 10.16 | 507.30 | 1.94 |
| Agricultural Engineering | 257 (1.14 %) | 4900 (4.95 %) | 19.07 | 861.93 | 3.35 |
| Dairy & Animal Sciences | 131 (0.58 %) | 692 (0.70 %) | 5.28 | 173.15 | 1.32 |
| Agricultural Economics & Policy | 34 (0.15 %) | 243 (0.25 %) | 7.15 | 42.20 | 1.24 |
| Total | 1744 (7.71 %) | 23072 (23.32 %) | 55.41 | 3725.97 | 2.14 |

of the total citations, of which only 12 institutions, namely, IIT D-Delhi, CFTRI-Mysore, BARC-Mumbai, DU-New Delhi, IIT K-Kharagpur, BHU-Varanasi, AMU-Aligarh, ICRISAT-Patancheru, NBRI-Lucknow, IARI-New Delhi, TNAU-Coimbatore, UAS-Bangalore

had average citations per publication higher than the national average (4.38). For the rest 6 institutions, the citation/paper was less. This again indicates that the Indian research output in the field of agriculture is of local relevance and is thus not connected with the

Table 7. Highly productive institutions in agriculture research during 1993-2012

| Rank | Institutes | TP (%) | TC (%) | ACP | AIF | Trend | |
|------|---------------------|---------------|---------------|-------|------|--------------|-----------|
| | | | | | | Publications | Citations |
| 1 | IVRI, Izatnagar | 1566 (6.92 %) | 2593 (2.62 %) | 1.66 | 0.36 | | |
| 2 | PAU, Ludhiana | 1349 (5.97 %) | 4782 (4.83 %) | 3.54 | 0.73 | | |
| 3 | IARI, New Delhi | 1149 (5.08 %) | 7499 (7.58 %) | 6.53 | 1.29 | | |
| 4 | CCSHAU, Hisar | 1075 (4.75 %) | 4332 (4.38 %) | 4.03 | 0.64 | | |
| 5 | ICRISAT, Patancheru | 735 (3.25 %) | 6825 (6.90 %) | 9.29 | 1.84 | | |
| 6 | NDRI, Karnal | 729 (3.22 %) | 1628 (1.65 %) | 2.23 | 0.53 | | |
| 7 | GBPUAT, Pantnagar | 672 (2.97 %) | 1814 (1.83 %) | 2.70 | 0.56 | | |
| 8 | CSKHPKV, Palampur | 472 (2.09 %) | 645 (0.65 %) | 1.37 | 0.36 | | |
| 9 | AAU, Gauhati | 384 (1.70 %) | 304 (0.31 %) | 0.79 | 0.27 | | |
| 10 | TNAU, Coimbatore | 373 (1.65 %) | 2215 (2.24 %) | 5.94 | 1.07 | | |
| 11 | CSWRI, Avikanagar | 324 (1.43 %) | 1191 (1.20 %) | 3.68 | 0.54 | | |
| 11 | TNVSU, Chennai | 324 (1.43 %) | 189 (0.19 %) | 0.58 | 0.18 | | |
| 12 | GADVASU, Ludhiana | 308 (1.36 %) | 135 (0.14 %) | 0.44 | 0.23 | | |
| 13 | IIT K, Kharagpur | 293 (1.30 %) | 3307 (3.34 %) | 11.29 | 2.21 | | |
| 14 | UAS, Bangalore | 286 (1.26 %) | 1510 (1.53 %) | 5.28 | 0.78 | | |
| 15 | BHU, Varanasi | 266 (1.18 %) | 2620 (2.65 %) | 9.85 | 2.10 | | |
| 16 | BCAU, Kalyani | 264 (1.17 %) | 786 (0.79 %) | 2.98 | 0.75 | | |
| 17 | SEKUAT, Jammu | 247 (1.09 %) | 151 (0.15 %) | 0.61 | 0.30 | | |
| 18 | CIRG, Makhdoom | 232 (1.03 %) | 655 (0.66 %) | 2.82 | 0.38 | | |
| 19 | JNKVV, Jabalpur | 222 (0.98 %) | 231 (0.23 %) | 1.04 | 0.24 | | |
| 20 | CFTRI, Mysore | 205 (0.91 %) | 3411 (3.45 %) | 16.64 | 2.67 | | |
| 21 | ANGRAU, Hyderabad | 204 (0.90 %) | 440 (0.44 %) | 2.16 | 0.42 | | |
| 22 | IGFRI, Jhansi | 194 (0.86 %) | 281 (0.28 %) | 1.45 | 0.44 | | |
| 22 | OUAT, Bhanjanagar | 194 (0.86 %) | 144 (0.15 %) | 0.74 | 0.26 | | |
| 23 | CARI, Izatnagar | 191 (0.84 %) | 506 (0.51 %) | 2.65 | 0.64 | | |
| 24 | NBAGR, Karnal | 184 (0.81 %) | 577 (0.58 %) | 3.14 | 0.56 | | |
| 25 | DU, New Delhi | 178 (0.79 %) | 2024 (2.05 %) | 11.37 | 2.73 | | |
| 26 | BAU, Ranchi | 173 (0.76 %) | 306 (0.31 %) | 1.77 | 0.22 | | |
| 27 | GAU, Anand | 169 (0.75 %) | 385 (0.39 %) | 2.28 | 0.36 | | |
| 28 | KAU, Thrissur | 166 (0.73 %) | 580 (0.59 %) | 3.49 | 0.65 | | |
| 29 | NBRI, Lucknow | 159 (0.70 %) | 1104 (1.12 %) | 6.94 | 2.24 | | |
| 30 | AMU, Aligarh | 156 (0.69 %) | 1530 (1.55 %) | 9.81 | 2.53 | | |
| 31 | AAU, Anand | 155 (0.69 %) | 150 (0.15 %) | 0.97 | 0.32 | | |
| 32 | IIT D, Delhi | 154 (0.68 %) | 2660 (2.69 %) | 17.27 | 3.41 | | |
| 33 | IIHR, Bangalore | 152 (0.67 %) | 384 (0.39 %) | 2.53 | 0.53 | | |
| 34 | NBPGR, New Delhi | 151 (0.67 %) | 535 (0.54 %) | 3.54 | 1.14 | | |
| 35 | CAZRI, Jodhpur | 146 (0.65 %) | 726 (0.73 %) | 4.97 | 0.95 | | |
| 36 | BARC, Mumbai | 143 (0.63 %) | 1837 (1.86 %) | 12.85 | 2.38 | | |
| 37 | YSPUHF, Solan | 134 (0.59 %) | 145 (0.15 %) | 1.08 | 0.29 | | |

mainstream of Agriculture. This also indicates the well known fact that citations/paper is very skewed.

In term of citations IARI-New Delhi topped the list with 7499 (7.58 %) citations; followed by ICRISAT-Patancheru 6825 (6.9 %); PAU-Ludhiana 4782 (4.83 %); CCSHAU-Hisar 4332 (4.38 %); CFTRI-Mysore 3411 (3.45 %); IIT K-Kharagpur 3307 (3.34 %); IIT D-Delhi 2660 (2.69 %); BHU-Varanasi 2620 (2.65 %) citations; IVRI-Izatnagar 2593 (2.62 %); TNAU-Coimbatore 2215 (2.24 %); DU-New Delhi 2024 (2.05 %); BARC-Mumbai 1837 (1.86 %).

In term of publications IVRI-Izatnagar topped the list with 1566 (6.92 %) publications; followed by PAU-Ludhiana 1349 (5.97 %); IARI-New Delhi 1149 (5.08 %); CCSHAU-Hisar 1075 (4.75 %); ICRISAT-Patancheru 735 (3.25 %); NDRI-Karnal 729 (3.22 %); GBPUAT-Pantnagar 672 (2.97 %); and CSKHPKV-Palampur with 472 (2.09 %) publications.

5.9 Specialisation Index

Specialisation index (SI) is the relationship between a country's share of global publications for a field of research and its world share of publications in all disciplines. If they are higher than 1 that indicates subjects in which research is especially active, and thus supported as priorities by the research policy decision-makers. Conversely, an index of less than 1 indicates the non priority area¹⁵. The institutes having ≥ 40 publications considered for this analysis.

5.9.1 Specialisation Index in Agricultural Economics & Policy

There were 6 institutes with specialisation index ≥ 1.21 (Table 8). IGKV-Raipur obtained highest

Table 8. Institutes-wise specialisation index in agricultural economics & policy sub-domain

| Institutes/ universities | Specialisation index (SI) | Agricultural economics & policy | | | |
|-----------------------------|---------------------------------|-----------------------------------|--------------------------------|--------------------------------------|---|
| | | Total no. of publications (TP) | Total no. of citations (TC) | Average citations per publication | International collaborative publications |
| IGKV, Raipur | 5.32 | 1 | 5 | 5 | 1 |
| DU, New Delhi | 5.08 | 2 | 12 | 6 | 0 |
| OUAT, Bhanjanagar | 4.66 | 2 | 5 | 2.5 | 2 |
| IARI, New Delhi | 1.57 | 4 | 19 | 4.75 | 3 |
| ICRISAT, Patancheru | 1.23 | 2 | 20 | 10 | 1 |
| TNAU, Coimbatore | 1.21 | 1 | 0 | 0 | 1 |

Table 9. Institutes-wise specialisation index of agricultural engineering sub-domain

| Institutes/ universities | Specialisation index (SI) | Agriculture Engineering | | | |
|-----------------------------|---------------------------------|-----------------------------------|--------------------------------|--------------------------------------|---|
| | | Total no. of publications (TP) | Total no. of citations (TC) | Average citations per publication | International collaborat- ive publications |
| YSPUHF, Solan | 3.17 | 116 | 82 | 0.71 | 0 |
| CFTRI, Mysore | 2.84 | 159 | 2614 | 16.44 | 7 |
| IIHR, Bangalore | 2.70 | 112 | 155 | 1.38 | 1 |
| CRRRI, Cuttack | 2.40 | 87 | 345 | 3.97 | 4 |
| NDUAT, Faizabad | 2.40 | 81 | 85 | 1.05 | 0 |
| BCAU, Kalyani | 1.93 | 139 | 161 | 1.16 | 5 |
| CSAUAT, Kanpur | 1.92 | 33 | 20 | 0.61 | 0 |
| IIPR, Kanpur | 1.91 | 49 | 49 | 1.00 | 4 |
| IARI, New Delhi | 1.82 | 569 | 2035 | 3.58 | 21 |
| DWR, Karnal | 1.76 | 34 | 46 | 1.35 | 0 |
| MPUAT, Udaipur | 1.73 | 48 | 47 | 0.98 | 1 |
| CRIDA, Hyderabad | 1.71 | 42 | 83 | 1.98 | 2 |
| CAZRI, Jodhpur | 1.61 | 64 | 87 | 1.36 | 0 |
| AMU, Aligarh | 1.53 | 65 | 92 | 1.42 | 3 |
| CSKHPKV, Palampur | 1.51 | 195 | 175 | 0.90 | 0 |
| MPKV, Rahuri | 1.47 | 24 | 8 | 0.33 | 0 |
| CARI, Andamans | 1.46 | 27 | 34 | 1.26 | 1 |
| OUAT, Bhanjanagar | 1.46 | 77 | 52 | 0.68 | 1 |
| SEKUAT, Jammu | 1.40 | 94 | 45 | 0.48 | 1 |
| CSSRI, Karnal | 1.39 | 46 | 92 | 2.00 | 1 |

specialisation index of 5.32 in the area of agricultural economics & policy sub-domain followed by DU-New Delhi 5.08; OUAT-Bhanjanagar 4.66; IARI-New Delhi 1.57; ICRISAT-Patancheru 1.23; and TNAU-Coimbatore 1.21.

5.9.2 Specialisation Index in Agricultural Engineering

There were 62 institutes involved in research in agricultural engineering sub-domain. IIT G-Gauhati obtained highest specialisation index of 8.17 in the area of agricultural engineering followed by IIT D-Delhi 7.95; IICT-Hyderabad 7.2; IIT M-Chennai 7.2; IIT B-Mumbai 6.76; BU-Coimbatore 6.4; IIT K-Kharagpur 6.34; IIT R-Roorkee 5.97; CIAE-Bhopal 5.89; NCL-Pune 4.43; and NBRI-Lucknow 3.16. Table 9 provides top 20 institutes as per specialisation index.

5.9.3 Specialisation Index in Agriculture-Multidisciplinary

There were 69 institutes involved in research in agricultural-multidisciplinary sub-domain. YSPUHF-Solan obtained highest specialisation index of 3.17 in the area of agriculture-multidisciplinary followed by CFTRI-Mysore 2.84; IIHR-Bangalore 2.7; CRRI-Cuttack 2.4; NDUAT-Faizabad 2.4; BCAU-Kalyani 1.93; CSAUAT-Kanpur 1.92; IIPR-Kanpur 1.91; IARI-New Delhi 1.82; DWR-Karnal 1.76; MPUAT-Udaipur 1.73; CRIDA-Hyderabad 1.71; and CAZRI-Jodhpur 1.61. Table 10 provides top 20 institutes as per specialisation index.

5.9.4 Specialisation Index in Agronomy

There were 64 institutes involved in research in agronomy sub-domain. ICRISAT-Patancheru obtained highest specialisation index of 3.53 in the area of agronomy followed by JAU-Junagadh 3.23; UM-Mysore 2.94; TNAU-Coimbatore 2.41; NBPGR-New Delhi 2.37; CSSRI-Karnal 2.31 IISS-Bhopal 2.22; DU-New Delhi 2.22; DWR-Karnal 2.17; NCL-Pune 2.13; AU-Annamalai Nagar 2.05; and PDAU-Akola 2.02. Table 11 provides top 20 institutes as per specialisation index.

5.9.5 Specialisation Index in Dairy & Animal Sciences

There were 60 institutes involved in research in dairy & animal sciences sub-domain. NRCC-Bikaner obtained highest specialisation index of 2.60 in the area of dairy & animal sciences followed by NRCC-Bikaner 2.6; GADVASU-Ludhiana 2.59; CIRG-Makhdoom 2.58; TNVASU-Chennai 2.58; IVRI-Izatnagar 2.57; NBAGR-Karnal 2.55, NDRI-Karnal 2.55; PDP-Hyderabad 2.54; and CSWRI-Avikanagar 2.51. Table 12 provides top 20 institutes as per specialisation index.

5.10 Preferred Journals by Scientists

The distribution of agricultural publications were spread over 163 journals across the world. More than 60 % of the publications are published in only 8 key-journals. Table 13 gives the leading journals

Table 10. Institutes-wise specialisation index of agriculture-multidisciplinary sub-domain

| Institutes/ Universities | Specialisation index (SI) | Agricultural Engineering | | | |
|-----------------------------|---------------------------------|-----------------------------------|--------------------------------|--------------------------------------|---|
| | | Total no. of publications (TP) | Total no. of citations (TC) | Average citations per publication | International collaborat- ive publications |
| IIT G, Gauhati | 8.17 | 44 | 258 | 5.86 | 1 |
| IIT D, Delhi | 7.95 | 122 | 2402 | 19.69 | 15 |
| IICT, Hyderabad | 7.20 | 66 | 743 | 11.26 | 1 |
| IIT M, Chennai | 7.20 | 33 | 592 | 17.94 | 7 |
| IIT B, Mumbai | 6.76 | 33 | 599 | 18.15 | 2 |
| BU, Coimbatore | 6.40 | 37 | 1857 | 50.19 | 9 |
| IIT K, Kharagpur | 6.34 | 35 | 324 | 9.26 | 24 |
| IIT R, Roorkee | 5.97 | 185 | 2405 | 13.00 | 7 |
| CIAE, Bhopal | 5.89 | 37 | 173 | 4.68 | 4 |
| NCL, Pune | 4.43 | 38 | 551 | 14.50 | 1 |
| NBRI, Lucknow | 3.16 | 50 | 492 | 9.84 | 3 |
| AMU, Aligarh | 2.57 | 40 | 1054 | 26.35 | 3 |
| TNAU, Coimbatore | 2.56 | 95 | 406 | 4.27 | 10 |
| BHU, Varanasi | 2.34 | 62 | 822 | 13.26 | 5 |
| DU, New Delhi | 2.31 | 41 | 658 | 16.05 | 4 |
| OU, Hyderabad | 2.12 | 15 | 297 | 19.80 | 2 |
| BARC, Mumbai | 2.10 | 30 | 419 | 13.97 | 4 |
| PU, Chandigarh | 1.92 | 14 | 231 | 16.50 | 0 |
| CFTRI, Mysore | 1.76 | 36 | 740 | 20.56 | 0 |
| AU, Annamalai Nagar | 1.65 | 12 | 132 | 11.00 | 4 |

Table 11. Institutes-wise specialisation index of agronomy sub-domain

| Institutes/ universities | Specialisation index (SI) | Agronomy | | | |
|-----------------------------|---------------------------------|------------------------------|---------------------------|--|---|
| | | Total no. of publications | Total no. of citations | Average citations per publication (ACP) | International collaborat- ive publications (ICP) |
| ICRISAT, Patancheru | 3.53 | 623 | 6073 | 9.75 | 282 |
| JAU, Junagadh | 3.23 | 66 | 29 | 0.44 | 0 |
| UM, Mysore | 2.94 | 43 | 357 | 8.30 | 11 |
| TNAU, Coimbatore | 2.41 | 216 | 1669 | 7.73 | 36 |
| NBPGR, New Delhi | 2.37 | 86 | 437 | 5.08 | 9 |
| CSSRI, Karnal | 2.31 | 67 | 651 | 9.72 | 12 |
| IISS, Bhopal | 2.22 | 64 | 354 | 5.53 | 1 |
| DU, New Delhi | 2.22 | 95 | 1062 | 11.18 | 18 |
| DWR, Karnal | 2.17 | 37 | 337 | 9.11 | 15 |
| NCL, Pune | 2.13 | 44 | 1133 | 25.75 | 18 |
| AU, Annamalai Nagar | 2.05 | 36 | 87 | 2.42 | 2 |
| PDAU, Akola | 2.02 | 30 | 129 | 4.30 | 0 |
| CSAUAT, Kanpur | 1.92 | 29 | 36 | 1.24 | 1 |
| IIPR, Kanpur | 1.91 | 43 | 180 | 4.19 | 6 |
| PU, Chandigarh | 1.83 | 32 | 450 | 14.06 | 1 |
| CRIDA, Hyderabad | 1.80 | 39 | 120 | 3.08 | 1 |
| OU, Hyderabad | 1.76 | 30 | 252 | 8.40 | 10 |
| IARI, New Delhi | 1.74 | 481 | 4837 | 10.06 | 80 |
| BHU, Varanasi | 1.72 | 110 | 1455 | 13.23 | 44 |
| NBRI, Lucknow | 1.70 | 65 | 445 | 6.85 | 1 |
| BARC, Mumbai | 1.69 | 58 | 462 | 7.97 | 1 |

Table 12. Institutes-wise specialisation index of dairy & animal sciences sub-domain

| Institutes/ universities | Specialisation index (SI) | Dairy & Animal Sciences | | | |
|-----------------------------|---------------------------------|-----------------------------------|--------------------------------|--|---|
| | | Total no. of publications (TP) | Total no. of citations (TC) | Average citations per publication (ACP) | International collaborat- ive publications (ICP) |
| NRCC, Bikaner | 2.60 | 71 | 129 | 1.82 | 0 |
| GADVASU, Ludhiana | 2.59 | 307 | 135 | 0.44 | 2 |
| CIRG, Makhdoom | 2.58 | 231 | 606 | 2.62 | 6 |
| TNVASU, Chennai | 2.58 | 322 | 175 | 0.54 | 3 |
| IVRI, Izatnagar | 2.57 | 1548 | 2550 | 1.65 | 9 |
| NBAGR, Karnal | 2.55 | 181 | 571 | 3.15 | 2 |
| NDRI, Karnal | 2.55 | 717 | 1586 | 2.21 | 15 |
| PDP, Hyderabad | 2.54 | 89 | 262 | 2.94 | 1 |
| CSWRI, Avikanagar | 2.51 | 313 | 1138 | 3.64 | 1 |
| NIANP, Bengaluru | 2.43 | 105 | 366 | 3.49 | 4 |
| CARI, Izatnagar | 2.41 | 177 | 461 | 2.60 | 2 |
| WBUAFS, Kolkata | 2.31 | 114 | 140 | 1.23 | 6 |
| JNKVV, Jabalpur | 2.05 | 175 | 133 | 0.76 | 0 |
| RAU, Bikaner | 2.02 | 91 | 80 | 0.88 | 1 |
| AAU, Gauhati | 1.92 | 284 | 153 | 0.54 | 0 |
| BAU, Ranchi | 1.73 | 115 | 102 | 0.89 | 0 |
| MAU, Parbhani | 1.70 | 44 | 36 | 0.82 | 0 |
| GBPUAT, Pantnagar | 1.46 | 378 | 347 | 0.92 | 2 |
| ANGRAU, Hyderabad | 1.41 | 111 | 154 | 1.39 | 2 |
| GAU, Anand | 1.38 | 90 | 139 | 1.54 | 0 |

Table 13. Preference of journals for publication in agriculture

| Rank | Journal name | IF 2011 | Total no. of publications (TP) (%) | Cumul. % of TP | Total no. of citations (TC) (%) | Average citations per publication (ACP) |
|------|--|---------|------------------------------------|----------------|---------------------------------|---|
| 1 | <i>Indian Journal of Animal Sciences</i> | 0.12 | 6297 (27.84 %) | 27.84 | 5403 (5.46 %) | 0.86 |
| 2 | <i>Indian Journal of Agricultural Sciences</i> | 0.17 | 3980 (17.6 %) | 45.44 | 3517 (3.55 %) | 0.88 |
| 3 | <i>Bioresource Technology</i> | 4.98 | 1290 (5.7 %) | 51.15 | 23838 (24.09 %) | 18.48 |
| 4 | <i>Research on Crops</i> | 0.05 | 507 (2.24 %) | 53.39 | 36 (0.04 %) | 0.07 |
| 5 | <i>Asian-Australasian Journal of Animal Sciences</i> | 0.58 | 457 (2.02 %) | 55.41 | 155 4 (1.57 %) | 3.40 |
| 6 | <i>Euphytica</i> | 1.55 | 442 (1.95 %) | 57.36 | 4096 (4.14 %) | 9.27 |
| 7 | <i>International Journal of Agricultural and Statistical Sciences</i> | 0.01 | 404 (1.79 %) | 59.15 | 48 (0.05 %) | 0.12 |
| 8 | <i>Journal of Agricultural and Food Chemistry</i> | 2.82 | 403 (1.78 %) | 60.93 | 5648 (5.71 %) | 14.01 |
| 9 | <i>Journal of Agrometeorology</i> | 0.00 | 364 (1.61 %) | 62.54 | 91 (0.09 %) | 0.25 |
| 10 | <i>Legume Research</i> | 0.09 | 308 (1.36 %) | 63.90 | 39 (0.04 %) | 0.13 |
| 11 | <i>Communications In Soil Science and Plant Analysis</i> | 0.51 | 299 (1.32 %) | 65.23 | 787 (0.80 %) | 2.63 |
| 12 | <i>Journal of the Science of Food and Agriculture</i> | 1.44 | 291 (1.29 %) | 66.51 | 2159 (2.18 %) | 7.42 |
| 13 | <i>Indian Journal of Animal Research</i> | 0.02 | 288 (1.27 %) | 67.79 | 19 (0.02 %) | 0.07 |
| 14 | <i>Small Ruminant Research</i> | 1.30 | 285 (1.26 %) | 69.05 | 1708 (1.73 %) | 5.99 |
| 15 | <i>Agricultural Water Management</i> | 2.00 | 256 (1.13 %) | 70.18 | 2508 (2.53 %) | 9.80 |
| 16 | <i>Theoretical and Applied Genetics</i> | 3.30 | 253 (1.12 %) | 71.30 | 6318 (6.38 %) | 24.97 |
| 17 | <i>Journal of Irrigation and Drainage Engineering-Asce</i> | 0.94 | 242 (1.07 %) | 72.37 | 1577 (1.59 %) | 6.52 |
| 18 | <i>Biomass & Bioenergy</i> | 3.65 | 233 (1.03 %) | 73.40 | 3422 (3.46 %) | 14.69 |
| 18 | <i>Journal of Agronomy and Crop Science</i> | 2.43 | 233 (1.03 %) | 74.43 | 1658 (1.68 %) | 7.12 |
| 19 | <i>Journal of Applied Animal Research</i> | 0.40 | 231 (1.02 %) | 75.45 | 284 (0.29 %) | 1.23 |
| 20 | <i>Field Crops Research</i> | 2.47 | 225 (0.99 %) | 76.44 | 3124 (3.16 %) | 13.88 |
| 21 | <i>Plant Breeding</i> | 1.60 | 216 (0.96 %) | 77.40 | 1559 (1.58 %) | 7.22 |
| 22 | <i>Seed Science and Technology</i> | 0.62 | 215 (0.95 %) | 78.35 | 756 (0.76 %) | 3.52 |
| 23 | <i>Crop Protection</i> | 1.40 | 212 (0.94 %) | 79.29 | 1873 (1.89 %) | 8.83 |
| 23 | <i>Genetic Resources and Crop Evolution</i> | 1.55 | 212 (0.94 %) | 80.23 | 1365 (1.38 %) | 6.44 |
| 24 | <i>Crop Science</i> | 1.64 | 189 (0.84 %) | 81.06 | 2186 (2.21 %) | 11.57 |
| 25 | <i>Annals of Applied Biology</i> | 2.18 | 176 (0.78 %) | 81.84 | 936 (0.95 %) | 5.32 |
| 26 | <i>AMA-Agricultural Mechanization In Asia Africa and Latin America</i> | 0.05 | 173 (0.76 %) | 82.60 | 24 (0.02 %) | 0.14 |
| 27 | <i>Animal Nutrition and Feed Technology</i> | 0.32 | 165 (0.73 %) | 83.33 | 118 (0.12 %) | 0.72 |
| 28 | <i>Buffalo Bulletin</i> | 0.10 | 163 (0.72 %) | 84.05 | 33 (0.03 %) | 0.20 |
| 29 | <i>Industrial Crops and Products</i> | 2.47 | 160 (0.71 %) | 84.76 | 1046 (1.06 %) | 6.54 |
| 30 | <i>Allelopathy Journal</i> | 0.85 | 156 (0.69 %) | 85.45 | 374 (0.38 %) | 2.40 |
| 31 | <i>Plant and Soil</i> | 2.73 | 138 (0.61 %) | 86.06 | 1935 (1.96 %) | 14.02 |
| 32 | <i>Range Management and Agroforestry</i> | 0.19 | 137 (0.61 %) | 86.67 | 43 (0.04 %) | 0.31 |
| 33 | <i>Animal Reproduction Science</i> | 1.75 | 133 (0.59 %) | 87.26 | 929 (0.94 %) | 6.98 |
| 34 | <i>Cereal Research Communications</i> | 0.39 | 120 (0.53 %) | 87.79 | 209 (0.21 %) | 1.74 |
| 35 | <i>Animal Feed Science and Technology</i> | 1.69 | 119 (0.53 %) | 88.31 | 1031 (1.04 %) | 8.66 |
| 36 | <i>Agroforestry Systems</i> | 1.38 | 111 (0.49 %) | 88.80 | 806 (0.81 %) | 7.26 |

Table 14. Distribution of publications and citations as per impact factor range

| Impact factor (JCR 2011) | No. of journals | Total no. of publications (TP) (%) | Total no. of citations (TC) (%) | Average citations per publication (ACP) |
|-----------------------------|-----------------|---------------------------------------|------------------------------------|--|
| 0.01 to \leq 1.00 | 80 | 14980 (66.24 %) | 16858 (17.04 %) | 1.13 |
| 1.01 to \leq 2.00 | 54 | 3470 (15.34 %) | 26401 (26.68 %) | 7.61 |
| 2.01 to \leq 3.00 | 20 | 1925 (8.51 %) | 20632 (20.85 %) | 10.72 |
| 3.01 to \leq 4.00 | 6 | 549 (2.43 %) | 10480 (10.59 %) | 19.09 |
| 4.01 to \leq 5.20 | 2 | 1327 (5.87 %) | 24492 (24.75 %) | 18.46 |
| Without IF | 1 | 364 (1.61 %) | 91 (0.09 %) | 0.25 |
| Total | 163 | 22615 (100 %) | 98954 (100 %) | 4.38 |

Table 15. Highly cited publications in agriculture (≥ 600 citations)

| Rank | Bibliographic details | Times cited | Country collaboration | Author(s) in byline | Document type | Subject |
|------|--|----------------|------------------------------------|------------------------|------------------|-------------------------------|
| 1 | Microbial decolorisation of textile... (1996), by Banat, <i>et al.</i> , <i>Bioresource Technol.</i> , 58(3), 217-27 | 668 | England, India | 4 | Article | Agricultural Engineering |
| 2 | The development and use of... (2000), by Gupta, <i>et al.</i> , <i>Euphytica</i> , 113(3), 163-85 | 282 | India | 2 | Review | Agronomy |
| 3 | Physical removal of textile dyes from... (2000), by Nigam, <i>et al.</i> , <i>Bioresource Technol.</i> , 72(3), 219-26 | 282 | England, India | 5 | Article | Agricultural Engineering |
| 4 | Studies on the antioxidant activity of... (2002), by Singh, <i>et al.</i> , <i>J. Agr. Food Chem.</i> , 50(1), 81-86 | 277 | India | 3 | Article | Agriculture-Multidisciplinary |
| 5 | Removal of dyes from... (1996), by Namasivayam, <i>et al.</i> , <i>Bioresource Technol.</i> , 7(1), 37-43 | 249 | India | 5 | Article | Agricultural Engineering |
| 6 | Polyhydroxyalkanoates... (2003), by Reddy, <i>et al.</i> , <i>Bioresource Technol.</i> , 87(2), 137-46 | 237 | India | 4 | Review | Agricultural Engineering |
| 7 | Microbial and plant derived... (2007), by Ahluwalia, <i>et al.</i> , <i>Bioresource Technol.</i> , 98(12), 2243-57 | 234 | India | 2 | Review | Agricultural Engineering |
| 8 | Dye removal from aqueous solution... (2003), by Garg, <i>et al.</i> , <i>Bioresource Technol.</i> , 89(2), 121-124 | 224 | India | 4 | Article | Agricultural Engineering |
| 9 | Jatropha bio-diesel production... (2008), by Achten <i>et al.</i> , <i>Biomass Bioenerg.</i> , 32(12), 1063-84 | 216 | Belgium, Kenya, Netherlands, India | 7 | Review | Agricultural Engineering |
| 10 | Applications of pectinases in the... (2001), by Kashyap, <i>et al.</i> , <i>Bioresource Technol.</i> , 7(3), 215-27 | 214 | India | 4 | Review | Agricultural Engineering |
| 11 | Genome mapping, molecular markers... (1997), by Mohan, <i>et al.</i> , <i>Mol. Breeding.</i> , 3(2), 87-103 | 213 | India, Japan | 7 | Review | Agronomy |
| 12 | Agricultural waste material... (2008), by Sud, <i>et al.</i> , <i>Bioresource Technol.</i> , 99(14), 6017-27 | 200 | India | 3 | Review | Agricultural Engineering |
| 13 | Emerging geminivirus problems... (2003), by Varma, <i>et al.</i> , <i>Ann. Appl. Biol.</i> , 142(2), 145-64 | 193 | India | 2 | Review | Agriculture-Multidisciplinary |

| Rank | Bibliographic details | Times cited | Country collaboration | Author(s) in byline | Document type | Subject |
|------|--|-------------|---|---------------------|---------------|--------------------------|
| 14 | Molecular markers and their... (1999), by Gupta, <i>et al.</i> , <i>Plant Breeding.</i> , 118 (5), 369-90 | 188 | India | 4 | Review | Agronomy |
| 15 | Experimental and kinetic studies... (2007), by Kavitha, <i>et al.</i> , <i>Bioresource Technol.</i> , 98(1), 14-21 | 185 | South Korea, India | 2 | Article | Agricultural Engineering |
| 16 | Prospects and potential of fatty... (2005), by Azam, <i>et al.</i> , <i>Biomass Bioenerg.</i> , 29(4), 293-302 | 183 | India | 3 | Article | Agricultural Engineering |
| 17 | Understanding and improving salt... (2005), by Chinnusamy, <i>et al.</i> , <i>Crop Sci.</i> , 45(2), 437-48 | 183 | USA, India | 3 | Review | Agronomy |
| 18 | Analysis of genetic diversity... (2003), by Mohammadi, <i>et al.</i> , <i>Crop Sci.</i> , 43(4), 1235-48 | 181 | India, Iran | 2 | Review | Agronomy |
| 19 | Genetic mapping of 66 new... (2002), by Gupta, <i>et al.</i> , <i>Theor. Appl. Genet.</i> , 105(2-3), 413-22 | 177 | India, England, France, Germany, Argentina, USA, Mexico, Australia, Switzerland | 20 | Article | Agronomy |
| 20 | Biodiesel production from jatropha... (2007), by Tiwari, <i>et al.</i> , <i>Biomass Bioenerg.</i> 31(8), 569-75 | 175 | India | 3 | Article | Agricultural Engineering |
| 21 | Biodiesel production from mahua... (2005), by Ghadge, <i>et al.</i> , <i>Biomass Bioenerg.</i> , 28(6), 601-05 | 171 | India | 2 | Article | Agricultural Engineering |
| 22 | Genetic Diversity in European... (1995), by Link, <i>et al.</i> , <i>Theor. Appl. Genet.</i> , 90(1), 27-32 | 160 | India, Germany | 5 | Article | Agronomy |

each with impact factor, publications, citations, and average citations per publication.

5.11 Impact Factor-wise Distribution of Publications and Citations

Around 98.39 % (22251) of the total publications were published in the journals with impact factors (IF) ranging from 0.001 to 5.2 and received 99.91 % (98863) citations, and around 0.91 % (91) publications published in journals having 0 impact factor. A significantly large number of publications 66.24 % (16858) appeared in journals having impact factors 0.01 to ≤ 1.00 . Table 14 gives distribution of publications and citations according to impact factor range of journal publications.

5.12 Highly Cited Publications

The most highly cited 60 Agriculture publications (which have got at least 100 citations) during the period under study are listed in Table 15. The number of citations does not necessary indicate the quality of paper, but it is a measure of its impact and or visibility in this field. Out of 60 highly cited publications 43 are journal articles and 17 are review articles.

6. CONCLUSIONS

The present work studied the growth of Agriculture output, its distribution in different domains, communication pattern of Indian Agriculture scientists, citation pattern of the research output, highly productive institutions, activity profile and the impact of their research output as seen through citations as per web of science during 1993-2012. A total of 22615 publications were published in Agriculture during 1993-2012 and these publications received 98954 citations. The highest number of publications 1917 (8.48 %) were published in 2008. The highest number of citations 8714 (8.81 %) were received in 2007. The highest average citations per publication 8.29 were in 2002. There were 10428 (46.11 %) publications with no citations during the period under study. The highest total impact factor (1865.33) was in 2008. The highest average impact factor per publications (1.29) was in 2006.

India had 1744 (7.71 %) international collaborative publications with 104 countries in Agriculture. Indian Institutions had the highest number of collaborative publications with countries like the USA, Australia, Germany, England, Philippines, Canada, Mexico, Japan, China, Netherlands, France, and South Korea.

Dairy & Animal Sciences accounts for the largest share 8713 (38.53 %) of publications in the total Indian publications output in Agriculture. followed by Agriculture-Multidisciplinary with 6168 (27.27 %) publications, Agronomy with 5430 (24.01 %) publications, Agricultural Engineering with 2254 (9.97 %) publications and Agricultural Economics & Policy with 50 (0.22 %) publications.

Indian Veterinary Research Institute, Izatnagar had the highest number (1566) of publications followed by Punjab Agriculture University, Ludhiana with 1349 publications, Indian Agricultural Research Institute, New Delhi with 1149 publications, CCS Haryana Agriculture University, Hisar with 1075 publications, ICRISAT-Patancheru with 735 publications, NDRI-Karnal with 729 publications, GBPUAT-Pantnagar with 672 publications, CSK Himachal Pradesh Krishi Vishwavidyalaya-Palampur with 472 publications, Assam Agricultural University, Gauhati with 384 publications and Tamil Nadu Agr. Univ-Coimbatore with 373 publications.

Indian Agriculture publications were spread over 163 journals across the world. More than 60% of the publications were published in only 8 key-journals. Most of the publications in Agriculture are published in Indian and low impact factor journals. Around 98.39 percent of the total publications were published in the journals with impact factors (IF) ranging from 0.001 to 5.20 and received 99.91 percent citations. A significantly large number of publications 66.24 % appeared in journals having impact factor 0.01 to <1.00.

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About the Authors

Mr Anil Sagar is working as Technical Officer 'C' at the Scientific Information Resource Division, Bhabha Atomic Research Centre (BARC), Mumbai, since 1996. He has published more than 50 publications in national and international journals. His areas of interest include: Scientometrics and knowledge management.

Dr B.S. Kademani is working as Scientific Officer 'G' at the Scientific Information Resource Division, BARC, Mumbai, since 1988. He has published more than 115 papers in national and international journals. His areas of interest include: Scientometrics, library management, and knowledge management.

Dr K. Bhanumurthy is Head, Scientific Information Resource Division, BARC, Mumbai. He has more than 130 research publications to his credit. His areas of interest include: Materials joining, nuclear materials, materials characterisation, reactor design and analysis, metallic fuels, scientometrics, digital resources, and knowledge management.

Highly productive institutions

| Abbreviation | University/institute name |
|--------------|--|
| AAU | Assam Agricultural University, Gauhati |
| AAU | Anand Agricultural University, Anand |
| AMU | Aligarh Muslim University, Aligarh |
| ANGRAU | Acharya N G Ranga Agricultural University, Hyderabad |
| AU | Annamalai University, Annamalainagar |
| BARC | Bhabha Atomic Research Centre, Mumbai |
| BAU | Birsa Agricultural University, Ranchi |
| BCAU | Bidhan Chandra Agricultural University, Kalyani |
| BHU | Banaras Hindu University, Varanasi |
| CARI | Central Avian Research Institute, Izatnagar |
| CARI | Central Agricultural Research Institute, Andamans |
| CAZRI | Central Arid Zone Research Institute, Jodhpur |
| CCSHAU | Chaudhary Charan Singh Haryana Agricultural University, Hisar |
| CFTRI | Central Food Technological Research Institute, Mysore |
| CIAE | Central Institute of Agricultural Engineering, Bhopal |
| CIRG | Central Institute for Research on Goats, Makhdoom |
| CRIDA | Central Research Institute for Dryland Agriculture, Hyderabad |
| CRRRI | Central Rice Research Institute, Cuttack |
| CSAUAT | Chandra Shekhar Azad University of Agriculture & Technology, Kanpur |
| CSKHPKV | Chaudhary Sarwan Kumar Himachal Pradesh Krishi Vishwa Vidyalay, Palampur |
| CSSRI | Central Soil Salinity Research Institute, Karnal |
| CSWRI | Central Sheep and Wool Research Institute, Avikanagar |
| DU | Delhi University, New Delhi |
| DWR | Directorate Wheat Research, Karnal |
| GADVASU | Guru Angad Dev Veterinary and Animal Sciences University, Ludhiana |
| GAU | Gujarat Agricultural University, Anand |
| GBPUAT | Govind Ballabh Pant University of Agriculture and Technology, Pantnagar |
| IARI | Indian Agricultural Research Institute, New Delhi |
| ICRISAT | International Crops Research Institute for the Semi, Arid, Tropics, Patancheru |
| IGFRI | Indian Grassland and Fodder Research Institute, Jhansi |
| IGKV | Indira Gandhi Krishi Vishwavidyalaya, Raipur |
| IICT | Indian Institute of Chemical Technology, Hyderabad |
| IIHR | Indian Institute of Horticultural Research, Bangalore |
| IIPR | Indian Institute of Pulses Research, Kanpur |
| IISS | Indian Institute of Soil Science, Bhopal |
| IIT D | Indian Institute of Technology, Delhi |
| IIT K | Indian Institute of Technology, Kharagpur |
| IIT R | Indian Institute of Technology, Roorkee |
| IVRI | Indian Veterinary Research Institute, Izatnagar |
| JAU | Junagadh Agricultural University, Junagadh |
| JNKVV | Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur |
| KAU | Kerala Agricultural University, Thrissur |
| MAU | Marathwada Agriculture University, Parbhani |
| MPKV | Mahatma Phule Krishi Vidyapeeth, Rahuri |

Cont...

| Abbreviation | University/institute name |
|---------------------|--|
| MPUAT | Maharana Pratap University of Agriculture and Technology, Udaipur |
| NBAGR | National Bureau of Animal Genetic Resources, Karnal |
| NBPGR | National Bureau of Plant Genetic Resources, New Delhi |
| NBRI | National Botanical Research Institute, Lucknow |
| NCL | National Chemical Laboratory, Pune |
| NDRI | National Dairy Research Institute, Karnal |
| NDUAT | Narendra Dev University of Agriculture and Technology, Faizabad |
| NIANP | National Institute of Animal Nutrition and Physiology, Bengaluru |
| NRCC | National Research Centre on Camel, Bikaner |
| OU | Osmania University, Hyderabad |
| OUAT | Orissa University of Agriculture and Technology, Bhanjanagar |
| PAU | Punjab Agricultural University, Ludhiana |
| PDAU | Dr. Panjabrao Deshmukh Agricultural University, Akola |
| PDP | Project Directorate on Poultry, Hyderabad |
| PU | Punjab University, Chandigarh |
| RAU | Rajasthan Agriculture University, Bikaner |
| RAU | Rajendra Agricultural University, Samastipur |
| SEKUAT | Sher, e, Kashmir University of Agricultural Sciences and Technology, Jammu |
| TNAU | Tamil Nadu Agricultural University, Coimbatore |
| TNVASU | Tamil Nadu Veterinary and Animal Sciences University, Chennai |
| UAS | University of Agricultural Sciences, Bangalore |
| UM | University of Mysore, Mysore |
| WBUAFS | West Bengal University of Animal and Fishery Sciences, Kolkata |
| YSPUHF | Dr. Yashwant Singh Parmar University of Horticulture and Forestry, Solan |