Index Development and Standardization to Measure the Research Productivity of Agricultural Scientists

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ABSTRACT

Research Productivity is the work outcome of the scientists in the area of research in a given period of time. Research productivity is the work outcome of agricultural scientists with a minimum of 3 years of experience in research, in form of publications, research projects undertaken, technologies developed, knowledge generated, research guidance offered, awards received, recognition achieved and Intellectual Property Rights (IPR) generated. A number of indices have been used so far to assess research productivity like, h-index, g-index, AR-index RP-index and CP-index, etc. In the present study, an index comprehensively covering all the aspects that contribute to research productivity of agricultural scientists was developed. Initially 9 indicators that are assumed to measure research productivity were identified and given to 30 experts for judgement. Only those indicators with relevancy rating score more than 0.8 were selected for inclusion in the study. They were publication behaviour, research activities undertaken, technologies/ knowledge generated, research guidance and mentoring, awards and recognition, and Intellectual Property Rights (IPR) generation.

Key words: *Research productivity of agricultural scientists; Publication behaviour; Intellectual property rights.*

Agricultural research in India is carried out predominantly by the research scientists working in ICAR and its institutes, SAU's and KVK's and DAATTC's under them for technology generation and technology transfer, as the research done in lab should be taken to field. Hence, the research is mainly dependent on the competency of agricultural scientists and their productivity.

Productivity is nothing but a measure of efficiency of a person completing a task. It is the quintessential indicator of efficiency in any system. According to *Meltzer (1956),* research productivity is a complex phenomenon with a number of inter related components such as creativity, quality, communicability, and it would be a formidable task to combine the various components of scientific productivity into a simple meaningful measure. *Jhansi, RG (1985)* has measured research productivity in terms of number of innovations, quality of innovations, nature of innovations, number

of students guided, type of students guided, quality of dissertation, articles published, the type of journals in which they are published, frequency of publications, whether the scientist is sole author or co-author, number of projects undertaken, single or group project, quality of projects, etc. According to *Creswell (1986),* research productivity can include research publication in professional journals and conference proceedings, writing a book or chapter, gathering and analysing original evidence, working with PG students on dissertations and class projects, obtaining research grants, carrying out editorial duties, obtaining patents and licenses, writing monographs, developing experimental designs, producing works of an artistic or creative nature, engaging in public debates and commentaries. According to *Turnage (1990),* research productivity is the relationship between outputs generated by a system and the inputs provided to create those outputs. According to *Williams (2003),* research

productivity is defined as extent to which research efforts and research products are produced by the researcher. According to *Sudipta Paul (2012)*, research productivity was defined as a composite measure of respondent's research output indicated through seven criteria namely, scientific publication, product developed, research, teaching and extension activities undertaken, awards received, and recognition achieved. *Uritkhinbam, SD (2013)* has measured the scientific productivity in research in terms of projects handled, recommendations in package of practices, awards received in conferences/seminars, varieties developed, field trials conducted and awards received in research.

A number of indices have been used so far to assess research productivity like, h-index (*Hirsch, 2005*), g-index (*Egghe, 2006*), AR-index (*Jin, 2007*), RP-index and CP-index (*Altmann, et al, 2009*) and *Manjunath, and Shashidahra (2011)* etc.

Agricultural research is needed to ensure food safety, improve quality of agricultural products, protect crops and livestock from pests and diseases, determine the best nutrition for people of all ages, sustain soil and other natural resources, ensure profitability for farmers and processors and keep costs down for consumers. Conducting research under the current condition of changing environment and need for sustainability requires more potential and competency among agricultural scientists to cope up with the changing conditions. The knowledge about the status of research productivity among agricultural scientists will help programme planners to gear up their activities in right direction and also administrators, research managers and policy makers to make necessary decisions. It is one among the most important determinants to rank agricultural universities and also determines scientific temperament of an individual scientist. It will help us to bring improvement in working environment and motivate the researchers. Keeping all this in view, present study is undertaken to develop an index to measure the Research Productivity of agricultural scientists.

METHODOLOGY

Research Productivity Index :

Stage 1: *Operationalization of Research productivity and selection of indicators & sub-indicators* : Research productivity was operationalized as the work outcome of agricultural scientists with a minimum of 3 years of experience in research, in form of publications, research projects undertaken, technologies developed,

knowledge generated, research guidance offered, awards received, recognition achieved and Intellectual Property Rights (IPR) generated.

The experts were requested to give relevancy rating for the 9 indicators identified, which they find suitable for measuring the research productivity of agricultural scientists of PJTSAU. They were also requested to add other indicators that they find relevant to measure research productivity. The responses were received from 30 experts and 6 indicators with relevancy rating scores more than 0.8 were selected finally.

Stage 2: *Operationalization of the indicators& sub-indicators selected for the study* : The indicators and sub-indicators are operationalized in this stage as given below:

Indicator I: *Publication behaviour* : It was operationalized as the scientific information published by the agricultural scientists in the form of research articles, books, book chapters, technical bulletins, etc., either as first author or co-author, their bibliometric parameters, frequency of publications, publication skills and reading behaviour. It was studied under 5 sub-indicators: Number of publications, Bibliometric parameters, Frequency of publications, Publication skills and Reading behaviour.

Sub-indicators :

1. *Number of publications:* It was operationalized as the number of publications made by the agricultural scientists either as first author or co-author.

2. *Bibliometric parameters*: It was operationalized as the agricultural scientist's publication output in terms of their H-index, RG score, research gate citations, number of reads in research gate and google scholar citations.

3. *Frequency of publications* : It was operationalized as the number of publications made by the agricultural scientists weekly, fortnightly, monthly, quarterly, half yearly, annually, biannually or once in 5 years.

4. *Publication skills* : It was operationalized as the agricultural scientist's ability to publish quality scientific information.

5. *Reading behaviour*: It was operationalized as the reading habit of the agricultural scientists in terms of frequency, extent and purpose.

Indicator II: *Research activities undertaken*: It was operationalized as the extent of research efforts made by the agricultural scientists in terms of different projects executed, paid up trails conducted, scientific fora organized, impact studies carried out and research

fund received, either as P.I. or Co P.I.

Indicator III: Technologies/ knowledge generated: It was operationalized as the number of new products like crop varieties, prototype of tools and techniques, innovative concepts, new apps, etc., or knowledge developed by the agricultural scientists, their attributes and extent of adoption.

Indicator IV: Research guidance and mentoring: It was operationalized as the number of PG or PhD scholars guided as major chairman or member of advisory committee; number of subordinates guided.

Indicator V: Awards and recognition: It was operationalized as the number of awards received by agricultural scientists at different levels like university, state, national and international levels   and the extent to which the agricultural scientists are recognized as a fellow or associate fellow of registered state, national and international science academies and societies, chief editor ofresearch journal, member of editorial board of research journal, for their contribution in research.

Indicator VI: Intellectual Property Rights (IPR) generation: It was operationalized as the number of patents or trademarks that have been applied for or granted to agricultural scientists.

Stage 3: Validity of the Research Productivity Index:

In the present investigation, content validity method was adopted to compute the validity of the Research Productivity Index and it was established by the expert's judgement. Content validity is defined as the extent to which the item measures the underlying indicator selected for index. The items under each indicator were given to the experts to indicate their relevancy rating against 5 point continuum- strongly agree, agree, undecided, disagree and strongly disagree. Only those items with relevancy rating score more than 0.80 were selected for inclusion in the index. All the possible items were identified before administering relevancy test sheets to the experts. No domain was left out to be included in the index.

Stage 4 : *Reliability of the Research Productivity Index*: Internal consistency reliability method was used to test the reliability. The Cronbach Alpha coefficient obtained for the index was found to be 0.888, which indicates good internal consistency of items in the index.

RESULTS AND DISCUSSION

Selection of indicators and sub-indicators for inclusion in the index : The responses were quantified

Table 1. Relevancy rating scores (RRS) of indicators and sub-indicators

Indicator	RRS
Publication behaviour	0.89
Number of publications	0.90
Frequency of publications	0.85
Bibliometric parameters	0.89
Publication skills	0.85
Reading behaviour	0.83
Research activities undertaken	0.90
Teaching activities undertaken	0.57
Extension activities undertaken	0.67
Research and development initiatives launched	0.74
Technologies/knowledge generated	0.93
Awards and Recognition	0.83
Research guidance and mentoring	0.87
Intellectual Property Rights (IPR) generation	0.85

and presented in the Table 1. And it is evident from the Table 1 that the relevancy scores for different indicators and sub-indicators ranged from 0.57 to 0.93. The relevancy rating scores were calculated by dividing the actual score obtained with maximum score obtainable from 30 experts. The indicators with relevancy rating score more than 0.80 were selected for inclusion in the index for measuring the research productivity. Only 6 indicators satisfied this criterion and they were publication behaviour, research activities undertaken, technologies/knowledge generated, research guidance and mentoring, awards and recognition, and Intellectual Property Rights (IPR) generation.

Selection of items : Only those items with relevancy rating score more than 0.80 were selected for inclusion in the index. The relevancy scores were calculated by diving actual score with the maximum score possible. Out of 86 items chosen, 71 items were finally selected for inclusion in the index. The responses for items of the index were quantified and given in the Table 2.

Research productivity index: Research productivity index of agricultural scientists of PJTSAU was calculated by using the selected indicators for inclusion in the index. The different indicators selected for inclusion in the index had different number of items under them. Hence, the scores of all 6 indicators were normalized using the formula given below:

$$U_{ij} = \frac{Y_{ij} - Min_{yj}}{Max_{ij} - Min_{yj}}$$

Where,

U_{ij} = Unit score of the ith respondents on j[th] component

Y_{ij} = Value of ith respondent on the jth component

Max_{yj} = Maximum score on the jth component

Min_{yj} = Minimum score on the jth component

Table 2. Relevancy rating score (RRS) of items under each indicator

Items	RRS
Publication behaviour	
Research articles	0.96
Books/Monographs	0.92
Book chapters	0.9
Book edited	0.95
Technical bulletins	0.9
Success stories	0.72
Short communication	0.78
Papers presented in scientific fora	0.89
Newspaper articles	0.76
Review articles	0.87
Abstracts	0.86
Popular articles	0.75
Discussion papers	0.79
Abstracts presented in scientific fora	0.9
Policy briefs	0.85
Bibliometric parameters	
H-index	0.93
RG score	0.87
Research gate citations	0.85
Number of reads in Research gate	0.92
Google scholar citations	0.9
Patented citations	0.67
Frequency of publications-Weekly/ fortnightly/ monthly/ yearly/ biannually/ once in 5 years	0.91
Publication skills	
Identification of peer reviewed scientific journals and their database	0.85
Identification of structure of a research article	0.84
Usage of sophisticated scientific techniques to organize information	0.83
Ability to analyse main ideas of a research article	0.83
Ability to interpret data, graphics of a research paper	0.82
Summarization of scientific information	0.8
Ability to critically discuss and write the research article	0.81
Ability to draw conclusions after reviewing literature	0.87
Ability to cite references according to the rules of scientific writing	0.89
Ability to elaborate keywords of a research topic	0.86
Reading behaviour	
Reading habit- regular/occasional/never	0.8
Extent of reading- completely/partially/focused	0.87
Purpose of reading- to gain knowledge/to practically apply the knowledge/hobby	0.86
Research activities undertaken	
PJTSAU network projects	0.9
On-going state level research projects	0.75
On-going national level research projects	0.77
On-going international level research projects	0.73
Externally funded & Industry sponsored projects	0.9
Research & development initiatives	0.65
Rese. fund received-ICAR/Uni./external sources	0.85
Revolving fund generated	0.69
Research consultancy offered	0.7
Impact studies carried out	0.87
Scientific fora organized	0.89
Paid up trials conducted	0.83
ICAR projects	0.96
RKVY projects	0.9
AICRP projects	0.93
Technologies/Knowledge generated	
HYV/Hybrids	0.9
Varieties registered with PPVFR	0.89
Mobile apps/expert systems/extension models	0.88
New machinery/farm tools/prototypes	0.87
Novel germplasms registered with NBPGR	0.89
Awareness knowledge	0.85
How to knowledge	0.84
Principles knowledge	0.83
Technologies developed	0.82
Extension models	0.75
Agriculturally important insect resources	0.79
Research guidance and mentoring	
Number of PG scholars guided as major chairman	0.85
No. of PG scholars guided as member of advisory committee	0.8
No. of PhD scholars guided as major chairman	0.82
No. of PhD scholars guided as member of advisory committee	0.82
No. of fellowships awarded by National institutions like DBT/DST/BOYSCAST/CSIR/ICAR/MHRD/ INSA/UGC/ICSSR to the students guided	0.87
No.of subordinates guided	0.89
Awards and recognition	
No. of international awards received from FAO/UN/ CGIAR and registered international scientific bodies	0.8
No. of national awards received from ICAR/DBT/ DST/ and Mahindra Samriddhi Agri-India and agri-business and national scientific bodies	0.81
No. of awards received from state govt./uni.reputed registered societies & agro industries	0.81
No.of young scientist awards/medals received from national professional scientific societies & universities	0.83
Fellow of registered international, national and state science academies & societies (NAAS/NAS/TAS/ CHAI/ISGPB/ISSS/IIAR/ISA/ISAE)	0.83
Associate fellow of registered international, national and state science academies & societies (NAAS/ NAS/TAS/CHAI/ISGPB/ISSS/IIAR/ISA/ISAE)	0.8
Life member of registered international & national professional scientific societies	0.87
Annual member of registered international & national professional scientific societies	0.82
Secretary of registered international & national professional scientific societies	0.86
Chief editor of research journals	0.85
Editor of research journals	0.83
Member of editorial board of research journals	0.83
Referee for research articles and books	0.83
Reviewer of NAAS rated journals	0.82
National professor	0.7
Member of policy making bodies/task force/ QRT/RAC/BOM	0.8
IPR (Intellectual property rights) generation	
No.of patents applied for	0.83
No. of patents granted	0.85
No. of trademarks applied for	0.8
No.of trademarks granted	0.81

The score of each component ranged from 0 to 1 i.e. when Y_{ij} is minimum the score is 0 and when Y_{ij} is maximum the score is 1.

$$RPI = \frac{RP_1 + RP_2 + RP_3 + RP_4 + RP_5 + RP_6}{6}$$

Where,

RPI= Research Productivity Index

RP_1 = Normalized indicator value of publication behaviour

RP_2 = Normalized indicator value of research projects undertaken

RP_3 = Normalized indicator value of technologies/knowledge generated

RP_4 = Normalized indicator value of research guidance and mentoring

RP_5= Normalized indicator value of awards and recognition

RP_6 = Normalized indicator value of Intellectual Property Rights generated

The obtained index value ranged from 0 to 1. Based on the values obtained, the agricultural scientists were categorized into 5 classes- very low, low, medium, high and very high based on the range obtained. The highest score among the respondents was 0.88 while lowest score was 0.11 (Table 3).

CONCLUSION

In the recent times, agriculture has contributed significantly to our nation's growth. Despite of that, contemporary challenges like increasing demand,

Table 3. Categorization of Research Productivity index values

Category	Class interval
Very low	0.11-0.26
Low	0.27-0.42
Medium	0.43-0.58
High	0.59-0.74
Very high	0.75-0.90

climate change and environmental pollution demands more efficient research in agriculture. Sophisticated research depends upon the competency of the personnel working in the research field, which necessitates its computation and further improvement. The index developed in this study can be used to measure research productivity of agricultural scientists. Research productivity is one among the important indicators that reflects the ability of universities and colleges to conduct research efficiently. The index developed can be used by administrators, policy makers to assess the current potential of scientists and to devise strategies for further improvement.

CONFLICTS OF INTEREST

The authors have no conflicts of interest.

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