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Research productivity of agricultural scientists: Evidences from high performing and low performing institutes

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ABSTRACT

The ever growing concern over enhancing research effectiveness of the public agricultural research system of the country has entailed the crucial need for assessing current status of research productivity. The sample of the study comprised of randomly drawn two hundred agricultural scientists across strata from a high performing and a low performing agricultural institute of India. A research productivity index was developed to measure productivity of respondents under study. The statistical analysis was based upon self-reported data by the scientists under different productivity parameters. The study revealed that there is ample scope of enhancing research productivity among the scientists as the majority (63.5%) of scientists had low to very low level of productivity. In the low performing institute, only 5% of the scientists had higher level of productivity. Even in the high performing institute, only 28% of the scientists had high to very high level of productivity. The findings of the study further indicated the crucial need for revisiting the present system of career advancement for Principal Scientists as the results of a t-test failed to produce a significant value of productivity difference between the Principal Scientists and Senior Scientists. Balanced involvement of the scientists from the low performing institute in research and teaching activities, organization development interventions in regular intervals for ensuring a pro-research and creative organizational environment and allocation of sufficient fund for individual research projects may be suggested among the necessary measures for harnessing optimum research productivity of scientists.

Key words: Agricultural scientists, High performing institute, Low performing institute, Research productivity

The agricultural sector of India has been undergoing burgeoning stresses since the last few decades. In one hand, marginality of agricultural production coupled with the issues like shrinking land-man ratio and sluggish annual growth rate has highly challenged attaining adequacy in food production and on the other hand, the ever growing population pressure along with the pressing issue of global climate change has posed potential threats to food security. The present situation demands greater attention to quality research in agriculture and tangible outputs. There are mainly two major kinds of output of agricultural research-technology/product/process and publications. As far as publication is concerned, it is noteworthy that the highest (26.4%) contribution to the pool of scientific publications in India is made by the scientists of agriculture and allied disciplines (Kumar *et al.* 2009). In technological front, the 'Green Revolution' is exemplary and globally recognized. However, the public agricultural research system is also criticized on several occasions – first, in terms of global impact factor of the journals in which the papers are published, the ICAR articles lag behind (45%) the CSIR articles (Pal *et al.* 2005) and the second, the internal rate of return to research investment in agriculture has shown a declining trend over the years (Chand *et al.* 2012). The agricultural scientists have to solve not only the problems of increasing agricultural production but also issues related to sustainability, equity and environmental protection. The complex nature of agricultural research demands highly motivated scientists in an environment conducive to research. Since agricultural research has become increasingly multi-disciplinary in nature, skills in team playing and communication have become essential in scientific achievement. The lowering of academic and research standard of educational institutions in India in general and the agricultural institutions in particular has been a matter of concern. The present situation demands a highly efficient public agricultural research system to address all the growing concerns over agricultural research and its output. It is well understood that the overall efficiency of the research system largely depends upon productivity of individual scientists. Scientific productivity has been a matter of enquiry since

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the pioneering work of Lotka (1926), although only a few structured efforts have been made so far in India. In this context the present study was undertaken to assess research productivity of scientists engaged in agricultural research and education under the national agricultural research system of India.

MATERIALS AND METHODS

The study utilized an *ex-post facto* research design. The methodology adopted for reaching objective of the study has been described below:

The study was conducted in two differently performing agricultural institutes of India. Purposively, Indian Agricultural Research Institute (IARI), New Delhi was selected among the high performing institutes (HPIs) and Chandra Shekhar Azad University of Agriculture and Technology (CSAUA&T), Kanpur among the low performing institutes (LPIs). The selection was made based upon a preliminary stratification of Indian agricultural universities in three groups, viz. high performing, medium performing and low performing. The mean scores generated on different relevant parameters to rank Indian agricultural universities (Education Times 2009) were utilized for the said stratification. The results of a study (Gupta 2011) to rank Indian agricultural universities on different bibliometric parameters further validated the selection. As far as selection of respondents was concerned it should be mentioned here that the scientists serving a minimum of seven years in the particular institute were only considered in the sampling frame. A multistage disproportionate stratified random sampling technique was applied to select a sample of two hundred agricultural scientists (n=200), hundred each from different cadres of the HPI and LPI.

A number of techniques have been devised so far to measure research productivity, such as h-index (Hirsch 2005), g-index (Egghe 2006), AR-index (Jin 2007), RP-index and CP index (Altmann *et al.* 2009). These indices considered only bibliometric indicators- publication and citation as a measure of research productivity. However, Jauch and Glueck (1975) in their study argued that a single criterion based measurement of research productivity had not reflected research performance precisely and was not acceptable to the evaluators and researchers as an effective measure.

In the present study, research productivity was operationalized as a composite measure of respondents' research output over seven years period of time indicated through research activities undertaken, products developed, scientific publications contributed, teaching activities involved with, extension activities undertaken, awards received and recognitions earned. Specific sub indicators under each of the mentioned productivity indicators were finalized after thorough literature review, job analysis of agricultural scientists and holding discussion with eminent scientists. A panel was formulated with twenty five experts to find out the cumulative and mean relative weightage of each of the selected productivity indicators and sub-indicators. The scoring technique of the sub indicators mainly comprised of the number of accomplishments upon a sub indicator and its relative mean weightage. However, a different scoring technique was adapted for two sub indicators- research publication (for which the NAAS rating of the particular journal was taken into consideration) and externally funded research projects (for which the amount of fund associated with the project was taken into account).The following Research Productivity Index (RPI) developed, helped in obtaining the composite productivity values of the respondents under study.

$$\text{RPI}= \sum_{i=1}^{7} I_i$$

$$\text{and } I_i = \sum_{j=n}^{x=100} (P_j w_x) W_x$$

where, I_i , Score obtained upon the particular research productivity broad indicator, i = 1,2,……7; P_j, score obtained upon the constituent sub-indicators, j = 1,2,……..n; w_x, weightage assigned to the sub-indicator, x = 1,2,…....100; W_x, weightage assigned to broad indicator, x = 1,2,……,100

Content validity of the measuring instrument was established through a panel of twenty five experts. The method of test retest was employed taking 30 non sample respondents and the coefficient of reliability obtained was 0.85.

Data were collected through personal interview method using a structured interview schedule. The collected data were analyzed using relevant statistical tools and techniques namely, cumulative cube root frequency, arithmetic mean, percentage and frequency distribution, standard deviation and independent sample t-test.

RESULTS AND DISCUSSION

At the outset, it should be mentioned here that the research, teaching, and extension activities undertaken by the scientists were based on team work, e.g. research projects and development of a product included principal investigators and their associates. Similarly, training activities took into consideration contribution of both the course director and course coordinators. Likewise, designing a course curricula involved more than one scientist and scientific publications comprised first and co-authors' contributions. Thus, there were possibilities of reporting of a single scientific contribution by several scientists who were part of the team. Therefore, it will be misleading to multiply the average number of contributions with the total number of respondents under a particular cadre or institute to find out the total number of output of the cadre or the institute.

Research project and its physical output: products and publications

Research being highly a matter of team work, the scientists of the LPI and HPI were involved in more than one research project at a time either as the research team leader or associate. The main funding sources of the research projects were either an external agency or the institute itself. As compared to only 1.68 research projects accomplished

Table 1 Mean number of research projects undertaken, products developed and scientific publications made per scientist during the seven years (August 2003 to July 2010)

Scientific activity	LPI (n_1=100)	HPI (n_2=100)	Pooled sample (n=200)
Research projects	1.68	6.01	3.85
Products	0.46	1.64	1.05
Scientific publications	27.09	41.37	34.08

by each scientist of the LPI, on an average 6.01 research projects were completed by each scientist of the HPI during the period under report (Table 1). Thus, the average number of research projects accomplished per scientist from the pooled sample of respondents was 3.85.

The major physical output of the research projects included different kinds of products like crop varieties, prototypes of tools and techniques, new concepts, extension methodologies etc. On an average, 1.05 products were generated by each scientist during the seven years period. In this regard, the average contribution of HPI scientists (1.64) was found to be more than three times higher than the LPI scientists (0.46). The other important output of research was scientific publications which included research papers, authored and edited books, book chapters, popular articles, short communications and conference proceedings. During the period, the average number of publications per scientist from the pooled sample was 34.08. As compared to 41.37 publications contributed by each scientist of the HPI, scientists from the LPI on an average produced 27.09 publications during the period under study.The publication productivity of an organization is positively influenced by the history and culture of the organization (Jha *et al.* 2004).The wide variation in research project accomplishment and the resultant product-publication attainment among the scientists of the two differently performing agricultural institutes signified a crucial need for the LPI to revisit into its research administration and research policies. Research output largely depends upon active personal involvement of the scientists in research projects. It was found that as compared to only 13% scientists from the HPI, as high as 45.3% scientists from the LPI were not attached to any externally funded research projects.The extent of adequacy and efficiency in utilization of available resources like research infrastructure and modern equipments is directly related to quality of research and its output. At the same time, adequate fund for research is an inevitable requirement. Institutes having higher amount of budgetary provision per scientist have been found to be much more productive than the poorly funded institutes (Pal *et al.* 2005).

Teaching and extension activities

Along with research, different kinds of teaching and extension activities undertaken by the respondents over the past seven years under study were also taken into consideration for assessing scientific productivity. Among the teaching activities undertaken, the most important ones have been reported. It is noteworthy that the average number of courses designed by each scientist of the LPI (2.03) during the study period was higher than the HPI scientists (1.89) had designed. Similarly, the average number of teaching manuals produced by each scientist of the LPI (1.35) was also higher than the HPI scientists (1.20) had produced. Lower involvement of scientists of the LPI in research projects, coupled with these evidences clearly indicate that the LPI being basically a State Agricultural University expected from its scientists to put primary thrust upon teaching. Accordingly, the scientists of the LPI paid larger attention to teaching than research. Although moderate level of teaching increases research performance (Mitchell and Rebne 1995), teaching load may also act as a hindering factor to research productivity (Maske *et al.* 2003). The average number of courses designed and teaching manuals produced per scientist from the pooled sample was respectively 1.96 and 1.28 during the seven years period. As far as supervising M Sc and Ph D students was concerned, it could be noticed that each scientist from the pooled sample on an average supervised 4.75 M Sc and Ph D students during the seven years (Table 2). Supervision to students' research projects was provided either as major advisor and co-advisor or as a member of the advisory committee. On an average, one out of ten (9.48 percent) students supervised by the scientists of the LPI and about one fourth (24.99 percent) of the students supervised by the scientists of the HPI were able to receive awards at institute, national, international level or from a recognized professional society.

The extension activities conducted by the scientists of the two institutes included different kinds of training and other extension activities like consultancy services, farmer-scientist interface meets, organization of *krishi melas* etc. The data in Table 2 showed that on an average per scientist from the pooled sample conducted 6.97 training programmes and 17.47 other extension activities during the seven years period under report. The extension activities performed by the scientists mainly aimed at awareness generation, education and skill development of scientists and other

Table 2 Mean number of teaching activities involved with and extension activities undertaken per scientist during the seven years (August 2003 to July 2010)

Teaching and extension activity	LPI (n_1=100)	HPI (n_2=100)	Pooled sample (n=200)
Courses designed	2.03	1.89	1.96
Teaching manual produced	1.35	1.20	1.28
M Sc and Ph D students supervised	4.81	4.68	4.75
% students guided receiving awards	9.48	24.99	17.24
Training programmes conducted	5.95	7.98	6.97
Other extension activities conducted	15.33	19.60	17.47

technicians, agri-preneurs and other stakeholders on technological and methodological advancements in different areas of agriculture.

Awards and recognitions

Scientists with outstanding accomplishment in research, teaching and extension activities, had been conferred with different kinds of awards by different organizations including state government organizations, Indian Council of Agricultural Research, State Agricultural Universities, international organizations, professional societies etc. There was a notable difference in the number of awards received by the two differently performing institutes under study. During the seven years period of time, each scientist of the LPI on an average had received 0.6 award, whereas each scientist of the HPI on an average had received 1.94 awards (Table 3). A notable difference could also be observed between the scientists of the two institutes in terms of their peer recognition. Peer recognition in the present study referred to achieving prestigious posts like chief editor and member of the editorial board of a peer reviewed journal, fellow, president or secretary of a recognized professional society, national professor, national fellow, fellow of National Academy of Agricultural Sciences etc. On an average, each scientist of the HPI had received 0.92 mean peer recognitions as against 0.24 mean peer recognitions received by the LPI scientists during the reporting period. Herzberg (1968) in his two-factor theory of motivation mentioned about 'hygiene' factors (like salary) which are prerequisite for sustaining motivation and certain 'motivators' (like recognition) which actually result in higher performance. Awards and recognition received by individual scientists of an organization enhance prestige of the organization which in turn promotes higher productivity.

Composite productivity: the variation, its significance and distribution pattern

The mean composite productivity value as calculated for the pooled sample of the two differently performing institutes confirmed that the HPI scientists ($\bar{x}$=3.15, s=1.64) were much more (53.64%) productive than the LPI scientists ($\bar{x}$=1.46, s=1.64) and the productivity difference was statistically significant [t (198) =9.37, P<0.01] (Table 4). The significant difference in research productivity between the scientists of the two institutes although should be attributed to the differences in organizational research environment, recruitment procedure, promotional policy and other organizational factors, influence of certain personal factors like creativity, research aptitude and achievement motivation in this particular regard should not be overlooked. A cadre wise comparison depicted that the Professors ($\bar{x}$=1.89, s=1.41) of the LPI were 45.88% more productive than the Associate Professors ($\bar{x}$=1.02, s=0.86) of the same institute and the measured difference in productivity was statistically significant [t (98) =3.77, P<0.01]. As compared to Associate Professors, the Professors of the LPI had higher professional experiences and most of them were in the research management positions of the institute. By virtue of these supervisory positions, the Professors of the LPI had greater access and control over man power and financial resources which resulted in their higher level of productivity when compared to the Associate Professors.

As observed by Knorr and Mittermeir (1980), an upward move in the formal or informal position hierarchy in the research laboratory results in a shift of research role from goal execution to goal-setting and thereby acts as the major explanatory variable accounting for productivity differences. The argument could also be made in case of the HPI. Unlike the LPI where only a little proportion of Professors did not hold a research management position, a larger proportion of Principal Scientists of the HPI were not in any such position. The mean age of Principal Scientists of the HPI was found to be 50.36 years and they on an average were left with a minimum of 12 years of scientific service without any further promotional opportunities. Hence, it may be quite difficult for the Principal Scientists of the HPI to sustain their achievement motivation which may also result in stagnation of their research productivity level. Such a prediction was found to be appropriate in course of the present study, the findings of which revealed that although the Principal Scientists ($\bar{x}$=3.18, s=1.41) of the HPI were 6.61% more productive than the Senior Scientists ($\bar{x}$=3.11, s=1.85) of the same institute, the productivity difference was statistically 'insignificant' [t (98) =0.20, P>0.5] (Table 5).

Following cumulative cube root frequency method and based upon the composite productivity values,the respondents were categorized into five different productivity groups – very low (0-1.19), low (1.19-2.44), average (2.44-3.88), high (3.88-5.87) and very high (5.87-9.68). The percentage distribution along the five point productivity continuum showed a skewed pattern of distribution for the pooled sample of respondents (Fig 1). It is noteworthy that as much as 63.5% of the pooled sample of scientists had low

Table 3 Mean number of awards received and recognition earned per respondent during the seven years (August 2003 to July 2010)

Awards and recognition	LPI (n_1=100)	HPI (n_2=100)	Pooled sample (n=200)
Awards	0.60	1.94	1.27
Peer recognition	0.24	0.92	0.58

Table 4 Composite productivity of different groups of respondents (n=200)

Respondent category		Mean ($\bar{x}$)	Standard deviation(s)
Associate Professor	[n_{AP}=70]	1.02	0.86
Professor	[n_P=30]	1.89	1.41
Pooled sample of LPI	[n_1=100]	1.46	1.12
Senior Scientists	[n_{SS}=50]	3.11	1.85
Principal Scientists	[n_{PS}=50]	3.18	1.41
Pooled sample of HPI	[n_2=100]	3.15	1.64

Table 5 Calculated t values depicting significance of productivity difference among the cadres of agricultural scientists (n=200)

Test Group	t value
Associate Professor (LPI) and Professor (LPI)	3.77** with 98 df
Senior Scientists (HPI) and Principal Scientists (HPI)	0.20 with 98 df
Associate Professors (LPI) and Senior Scientists (HPI)	-8.27** with 118 df
Professors (LPI) and Principal Scientists (HPI)	-3.95** with 78 df
Pooled sample (HPI and LPI)	-9.37** with 198 df

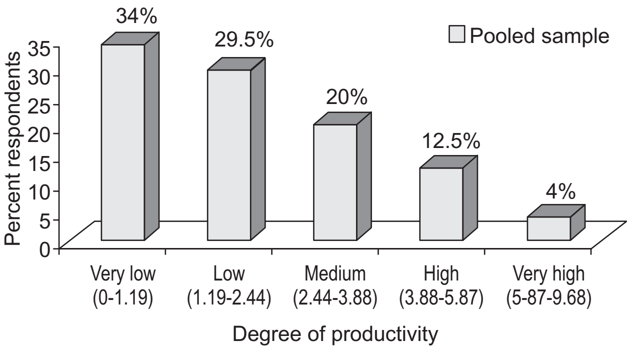

Fig 1 Distribution of pooled sample of respondents according to their level of productivity

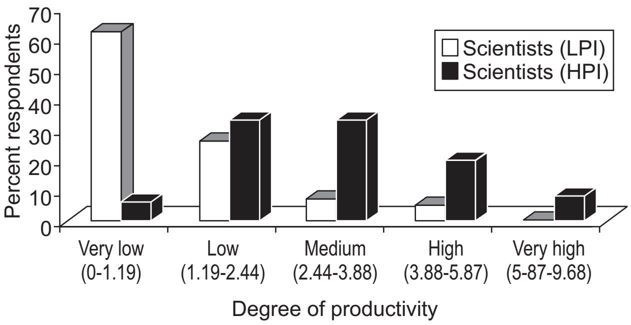

Fig 2 Distribution of respondents from the LPI and HPI according to their level of productivity

to very low level of productivity, 20% of them had medium level of productivity and remaining only 16.5% had high to very high level of productivity.

In case of the LPI also, distribution of composite productivity values of the scientists followed a skewed pattern (Fig 2). Only 5% of scientists from the LPI had higher level of productivity. The investigation also pointed out that even in the HPI only 28% of the scientists had high to very high level of productivity. As much as 39% of them had low to very low level of productivity and 33% of them had medium level of productivity. The findings of the study was similar to that of Mehta (2005) who observed that more than 90% publication productivity was restricted only to 8-10% of the scientists. Thus the present study strongly approved the hypothesis of Narin and Breitzman (1995) that technological creativity and productivity is very highly concentrated only in a smaller proportion of highly talented individuals.

IMPLICATIONS FOR AGRICULTURAL RESEARCH POLICY

As indicated by findings of the study, the research productivity scenario prevailing among the agricultural scientists did not produce a very rosy picture. The situation calls for an immediate attention for enhancing research productivity of the scientists of National Agricultural Research System of the country. The research institutes in general and the low performing institutes in particular should take up in regular intervals certain organization development interventions to ensure prevalence of a pro-research and creative organizational climate and sustainability of achievement motivation among the scientists. A system of performance based monetary and innovative non-monetary incentives may be introduced to sustain achievement motivation of scientists in general and Principal Scientists in particular. Either a re-stratification of the existing scientific career hierarchy or opening up further promotional opportunities for the Principal Scientists will help in overcoming stagnation of their productivity growth. Although necessary financial and other forms of support from the organization is crucial for carrying out research projects, the scientists should strive for securing fund through externally funded research projects, enhance their involvement in such projects and improve upon personal research competencies to harness optimum research productivity.

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