Scientometrics (2014) 100:261–272
DOI 10.1007/s11192-013-1202-6

Research productivity in soil science in the Philippines

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Received: 10 September 2013 / Published online: 5 December 2013

Abstract Understanding the direction and magnitude of soil science publication in the Philippines is crucial in formulating research priorities and funding allocation. There is no consensus on the current state of soil science publication in the Philippines, thus this study was conducted to elucidate the trend in the soil science publication. We conducted an in-depth analysis on the total number of publications and the total number of citations of soil science publications collected from Thomson ISI database. Results revealed an upsurge in soil science publication from 1970 to 2000 with no indication that this trend is slowing down. Increases in the number of citations with time are consistent with increases in the total number of publications ($r = 0.93$; $p < 0.05$). Results further revealed that the soil science publication in the Philippines is biased towards rice research particularly soil water with very few studies were published for plant nutrition and soil chemistry. The present study highlights the need for a paradigm shift in soil science research from mostly rice related research to environmental research. Ways to increase soil science publication among Filipino soil scientist's particularly in academic institutions is proposed. Finally, since only a few government-funded research have been published, future studies should stress on identifying factors that influence scientific productivity of most soil scientists in the Philippines.

Keywords Bibliometric analysis · Scientific publication · Soil science · Web of science

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Introduction

Scientific publication is the lifeblood of science and the center of any scientific activity. It is a process by which research results are communicated, exchanged and verified (Merton 1968). Any scientific activity is not complete until research results, whether positive or negative, is made known to the public through scientific publication sensu *strictu* in a peer-reviewed journal. The process of peer review warrants that only quality manuscripts are published. Because scientific publication is a widely accepted yardstick for scientific productivity, the success of any scientific career is strongly dependent on good publication record (Hartemink 2002). Specifically, the publication is an objective measure for hiring, career promotion, job tenure and justification of annual budget allocation (Fleet et al. 2006; Chirici 2012). Thus, the number of publications and the number of citations of a researcher are crucial information useful in the research productivity evaluation (Hirsch 2005). While most studies on research productivity evaluation through scientific publication in the Philippines have been done in education and psychology (Vinluan 2012) and science and engineering (Lim and Saloma 1998; Valencia 2004), no similar study has yet been reported in soil science. While scientific publication is a major criteria for research productivity evaluation, most researchers in the Philippines focused on giving scientific presentation at conferences or attending conferences to earn points, which is necessary for the promotion, and as such inconclusive because presentations do not pass through the process of peer-review. This is disturbing because academic or research institutions are in principle the training ground of science. According to Lacanilao (1999), the widespread practice of wrong research in the Philippines continues because researchers gain promotion and recognition for producing 'gray literature'.

Exactly 83 years have passed since Pendleton (1930) published his analysis of the state of soil science in the Philippines. Since then our research interests in soil have increased immensely and that scientific understanding of soil has expanded. Because no similar study has been conducted in recent years, we are uncertain as to the magnitude and direction of soil science research in the country. The objective of this study was to evaluate the scientific productivity in soil science research in the Philippines using the Science Citation Index Expanded (SCI-EXPANDED) of the Web of Science (WOS).

Methods

Source of data

Bibliometric data including the number of publications and the number of citations were collected from the Thomson ISI database, previously known as the Institute for Scientific Information SCI-EXPANDED database. The Thomson ISI database is a leading provider of academic-indexing services that covers nearly 7,000 of the world's leading scientific and technical journals across 150 scientific disciplines. The citations received after 2 years immediately following publication is relevant in the field of bibliometrics (Varela 2013).

Search procedure

Journal articles such as full article, research note and review articles were used as the unit of analysis. Books, book chapter and conference proceedings were excluded from the analysis based on the assumptions that these publications were not subjected to rigorous

peer- review. The following search criteria were fed into the search window of the WOS database:

- Topic = {*soil chemistry, soil biology, plant nutrition, forest soils, soil conservation, soil plant analysis, nutrient management, wetland, soil water, soil fertility, soil physics*},
- Address = *Philippines*,
- Year published = *1970–2012*,
- Document type = {*full article*, *research note*, *review*}

Topics searched represent the different soil science sub-discipline. Our initial search revealed that no papers were recorded in the Thomson ISI database before 1970, and for this reason, the baseline year of publication search was set at 1970. Also, we did not find publications indexed or recorded in the fields of soil physics and soil biology. The data generated for each sub-discipline search was saved in an Excel file for easy preprocessing. Preprocessing of data, which is done manually, is indispensable to preclude homonyms and duplications arising from overlapping of topics (e.g. soil fertility, nutrient management). When overlapping of topic occurred, we searched and read the abstracts of the articles and an appropriate topic was assigned based on our expert opinion. After preprocessing, the number of publications free of duplications, author and institution, that is changing in status from college to university, related artifacts were reduced from 815 to 546 articles. All 546 articles were subsequently analyzed using the trial version of the HistCite software (http://thomsonreuters.com) to gain information on the research productivity of each author (i.e. number of publications, number of citations), research and academic institutions. In the case of multi-authored papers, the whole counting approach (Okubo 1997) was used and that is a full count was awarded to the author and institution. In this paper, we counted author that has a working address in the Philippines instead of taking consideration the nationality of the author.

Bibliometric indexes

Two bibliometric indexes including the number of publications and the number of citations were used in this study. The number of publications is defined as the number of papers by a given author whether as lead or as co-author or refers to the total number of publications across sub-disciplines, whereas the number of citations is defined as the number of times an article was cited by another author including self-citations. Based on frequency analysis (Vinluan 2012), publication count identified the most productive researchers, institutions, most cited articles and ranking of the top journal outlet of soil science publications in the Philippines.

Results

Number of publications and citations

There was an upsurge in soil science publications during a 4 decade-period from 1970 to 2000 (Fig. 1). Between 1970 and 2012, 546 articles were published of which 513 (94 %) were full articles, 24 (4 %) review papers and 9 (2 %) research notes. In the 1970s, only 10 articles (1.8 %) were published, increased to 61 articles (12 %) in the 1980s, and more than doubled to 245 articles (29 %) in the 2000s. The number of publications from 1990 to 2000

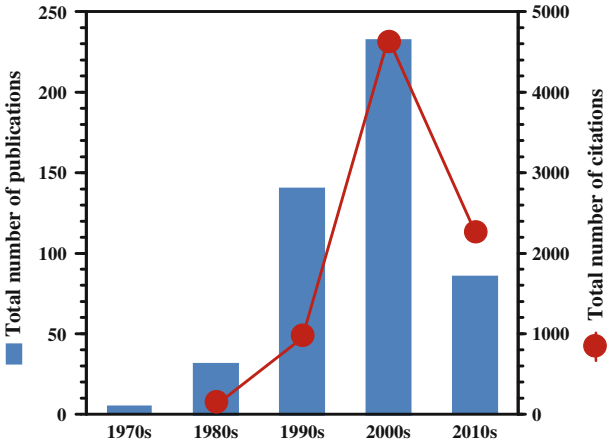

Fig. 1 Decadal patterns in the number of publications and the number of citations in soil science publications in the Philippines

accounted for 404 articles or 73 % of the total number of publications, indicating that this is the most productive period in soil science publication in the Philippines. Although the number of publications was low at the beginning of the 2010s, it was relatively higher compared to the combined number of publications of the 1970s and 1980s.

There were 8,999 citations, including self-citations, between 1970 and 2010 (Fig. 1). Of the 546 articles, 211 articles were cited by more than 8 times and 68 articles were not cited at all. There was a clear increase in the number of citations and is consistent with increases in the number of publications ($r = 0.93$; $p < 0.05$). There were abrupt increases in the number of citations during the period between 1990 and 2000 relative to the 1980 and these increases accounted for 88 % of the total number of citations.

Individual and institutional research productivity

The most productive soil scientists based on the number of published articles are listed in Table 1. The most prolific scientists are JK Ladha with 48 articles followed by BAM Bouman (36), A Dobermann (28), RJ Buresh (24), GJD Kirk (20), TP Tuong (16), SK Dedatta (12), SM Haefele (10) and H Neue (9). The highest number of publications as lead author are A Doberman (11) followed by GJD Kirk (8), and JK Ladha and SM Haefele (7). Of the 546 articles, 203 articles (37 %) come from the 9 soil scientists of which all are foreign scientists (Table 1). Interestingly, these 9 researchers are affiliated with IRRI, a world-renowned rice research institute based in the Philippines.

Of the 8,999 citations (Fig. 1), 1,339 citations or about 15 % of the total number of citations was contributed from the 12 articles listed in Table 2. The number of citations per author, including self-citations, ranged from 90 to 186 with the highest citations from the paper of Bouman and Tuong (2001) and the lowest from Tabbal et al. (2002). On the other hand, the average citation per year, including self-citation, ranged from 5.1 to 17.8 with the paper by Bouman and Tuong (2001) had the highest citation, whereas the paper of Denier van der Gon and Neue (1995) had the lowest citation.

Among research institutions, IRRI was at the forefront of ISI-grade publications (71 %) followed by the Philippine Rice Research Institute (PhilRice: 4 %) and the Bureau of Soils and Water Management (BSWM: 1.4 %). Among academic institutions, the University of the Philippines at Los Banos (UPLB) had the highest number of publications (11 %)

Table 1 List of authors having the highest number of publications

Author	Institution	No. of papers as first author	No. of papers as co-author	Total number of papers
Ladha, JK	IRRI	7	41	48
Bouman, BAM	IRRI	4	32	36
Dobermann, A	IRRI	11	17	28
Buresh, RJ	IRRI	4	20	24
Kirk, GJD	IRRI	8	12	20
Tuong, TP	IRRI	4	12	16
Dedatta, SK	IRRI	5	7	12
Haefele, SM	IRRI	7	3	10
Neue, H	IRRI	2	7	9

IRRI International Rice Research Institute

followed by Visayas State University (2 %). This result indicates that the publication output of IRRI significantly outnumbered those from the academic institutions combined (Table 3).

Distribution of studies and journal use

Figure 2 shows the distribution of publications across soil science sub-discipline. While soil water is a well-studied soil science sub-discipline with 226 articles, very few studies were published for plant nutrition (19), forest soils (18) and soil chemistry (4). No publication was indexed or recorded in the fields of soil physics and soil biology, which is expected since only few Filipino soil scientists specialized in these fields. About 81 % of all publications were related to lowland rice research and only a small percentage of the remaining 19 % of all publications were related to understanding the nature and characteristics of degraded soils.

The journal, Field Crop Research (Elsevier) topped as the frequent publication outlet with 78 articles (14 %) (Table 4). This was followed by Plant and Soil (Springer) with 45 articles (8 %). Nutrient Cycling and Agroecosystems (Springer), Soil Science and Plant Nutrition (Taylor & Francis) and Agricultural Water Management (Elsevier) had 29, 28 and 20 articles, respectively. Eleven papers (2 %) were published in Agricultural Systems (Elsevier) and Communications in Soil Science and Plant Analysis (Taylor & Francis), respectively. The Philippine Agricultural Scientist (18 articles) published by UPLB was the only journal published locally and the most preferred journal among Filipino soil scientists.

Discussion

Publication productivity

Scientific publications at IRRI is rigorous compared with the various academic and research institutions in the Philippines (Table 3). Specifically, high publications at IRRI can be explained with the fact that (i) publication is an important justification for research funding, job tenure and promotion, (ii) scientific infrastructure for conducting scientific research are equipped with cutting edge research tool, and (iii) recruitment of international

Table 2 Top 12 highly cited soil science publications

Authors	Title of the article	Total citation	Average citations/ year
Bouman and Tuong (2001)	Field water management to save water and increase its productivity in irrigated lowland rice	186	17.83
Cassman et al. (1998)	Opportunities for increased nitrogen-use efficiency from improved resource management in irrigated rice systems	155	10.33
Gyaneshwar et al. (2002)	Role of soil microorganisms in improving P nutrition of plants	129	11.73
Witt et al. (1999)	Internal nutrient efficiencies of irrigated lowland rice in tropical and subtropical Asia	114	8.14
Kronzucker et al. (1999)	Nitrate-ammonium synergism in rice. A subcellular flux analysis	101	7.21
Belder et al. (2004)	Effect of water-saving irrigation on rice yield and water use in typical lowland conditions in Asia	99	11.22
Dobermann et al. (2002)	Site-specific nutrient management for intensive rice cropping systems in Asia	99	9
Denier van der Gon and Neue (1995)	Influence of organic matter incorporation on the methane emission from a wetland rice field	92	5.11
Cassman et al. (1996)	Nitrogen-use efficiency in tropical lowland rice systems: Contributions from indigenous and applied nitrogen	92	5.41
Bronson et al. (1997)	Automated chamber measurements of methane and nitrous oxide flux in a flooded rice soil. 1. Residue, nitrogen, and water management	91	5.69
Bouman et al. (2005)	Yield and water use of irrigated tropical aerobic rice systems	91	11.62
Tabbal et al. (2002)	On-farm strategies for reducing water input in irrigated rice: case studies in the Philippines	90	8.18

young talents through postdoctoral position. These reasons have largely contributed to the upsurge in the soil science publications from the 1990 to 2000 (Fig. 1).

Comparing publication trends in soil science between the Philippines and selected Southeast Asian countries including Indonesia, Malaysia and Vietnam, where soil science research is strong, the Philippines had an edge among these countries in terms of number of soil science publications (Fig. 3). Nevertheless, there is reason to believe that other countries had increased their publication output in the past 2 decades. The number of citations linearly increases with time and is consistent with increases in the number of publications, indicating that the more publications indexed in the Thomson ISI database the more chances a paper will be cited in the future by other authors. Nevertheless, despite the considerable numbers of publications, only a few of these publications are being cited (Table 2) and consistent with the global trend in soil science citations that there are many soil science publications but few are being cited (Hartemink 2002). According to Merton (1968), citations of published work are an important validation of scientific contribution to the advancement of science since it reinforces the value of past research.

To enhance publication output, some private (e.g. Ateneo de Manila University) and public (e.g. University of the Philippines System) universities in the Philippines has recently initiated monetary incentive schemes for its faculty for every ISI journal article published. For example, at the University of the Philippines, the amount received for every article published in an ISI journal is equivalent to $1,000 dollars. There is a strong

Table 3 Comparison of the number of publication between research and academic institutions

Institution	TNP	%
Research institution		
International Rice Research Institute	404	74.0
Philippine Rice Research Institute	23	4.2
Bureau of Soils & Water Management	8	1.5
Department of Agriculture	3	0.5
Department of Environment & Natural Resources	3	0.5
Others	9	1.6
Academic institution		
University of the Philippines, Los Banos	62	11.4
Visayas State University	11	2.0
Central Luzon State University	4	0.7
Mindanao State University	3	0.5
Mariano Marcos State University	3	0.5
Others	13	2.4
Total	546	100

TNP Total number of publication

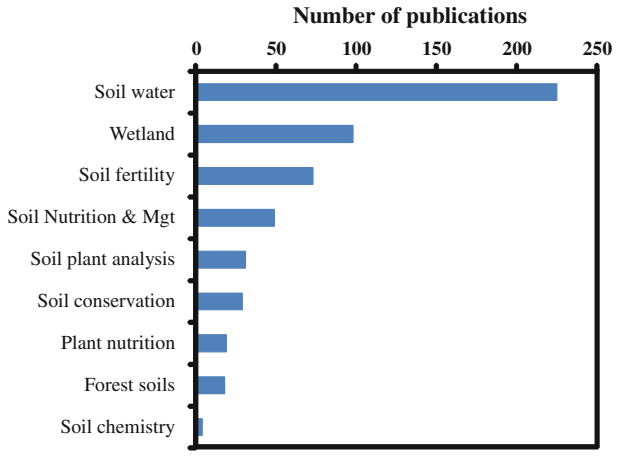

Fig. 2 Distribution of publications according to soil science sub-discipline

indication that this scheme is promising in the soil science field considering that in the last 5 years, publication output of academic institutions accounted for 32 % of the total number of publications (data not shown). Nevertheless, it is perceived that this inducement scheme is not a long-term solution for improving soil science in the country, because most of the articles are published only by a few scientists. We found, for example, that the same authors (data not shown) published in the last 5–10 years, indicating that scientific productivity is highly skewed towards small prolific group of soil scientists. Alternatively, it is perceived that the use of the publication as the basis for tenure and promotion among academic institution will result in arduous competition to publish. At Harvard University, for example, hiring of assistant professor is decided based on 5 publications and the promotion to full professor needs 10 publications (Culliton 1988). The use of publications

Table 4 Ranking of journals based on the number of publication

Name of journal	Publisher	Frequency	%	Impact factor[a]
Field Crop Research	Elsevier	70	15	2.474
Plant & Soil	Springer	34	7	2.733
Nutrient Cycling in Agroecosystems	Springer	29	6	1.792
Soil Science & Plant Nutrition	Taylor & Francis	24	5	1.017
Agricultural Water Management	Elsevier	16	3	1.998
Philippine Agricultural Scientist	UP Los Banos	16	3	nd
Biology & Fertility of Soils	Springer	15	3	2.319
Soils & Tillage Research	Elsevier	13	3	2.425
Agronomy Journal	American Society of Agronomy	12	3	1.794
Agricultural Systems	Elsevier	12	3	2.899
Communications in Soil Science & Plant Analysis	Taylor & Francis	12	3	0.506

[a] 2011; *nd* no data

as a basis for hiring will streamline hiring process and will warrant that only highly qualified applicants are being hired. Furthermore, it is argued that the academic institutions in the country should conform the 'publish or perish' culture adapted in American and European academic institutions to increase publications.

Most governments funded research has concluded as a terminal report simply because funding agencies do not demand publications (Lim and Saloma 1998; Alcala 2004). These terminal reports are not available to the public and importantly not strictly subjected to peer-review, and as such, considered as 'gray literatures'. Lim and Saloma (1998) made a comprehensive survey of scientific publications from the faculty of the College of Science, UP Diliman from 1988 to 1998. Their results revealed that no academic unit in the College of Science has at least one international publication per faculty per year, suggesting that even the top university in the Philippines had a poor publication record. Furthermore, Alcala (2004) surveyed 131 concluded biodiversity projects in the Philippines and revealed that 22 or 17 % of the projects reported publication of their research in books, conference proceedings and refereed journals. This indicates that many government-funded research have not been published and certainly, more could have been published if all research, which have yielded good results, has been written up for scientific publications (Lim and Saloma 1998; Alcala 2004).

The high numbers of publication by foreign soil scientists based in the Philippines (Table 1) can be explained by the fact that the first period of soil science development as an academic field in the Philippines was influenced by foreigners particularly by the Americans (Pendleton 1930). Among the important soil scientists during this period were CW Dorsey, HS Walker and RL Pendleton. In 1903, CW Dorsey, a soil surveyor working for the Philippine Bureau of Agriculture at that time, made the first soil survey of the Batangas area in Southern Luzon (Pendleton 1930). The soil chemist, HS Walker, published a book detailing the various analyses of soils used for sugarcane production in Negros Island from 1908 to 1909 (Walker 1910). Also, RL Pendleton, was one of the pioneers of soil science at UPLB, who taught soil science to students of agricultural sciences from 1923 to 1935. The second period of soil science development was mostly contributed by soil scientists working at IRRI (see Table 1).

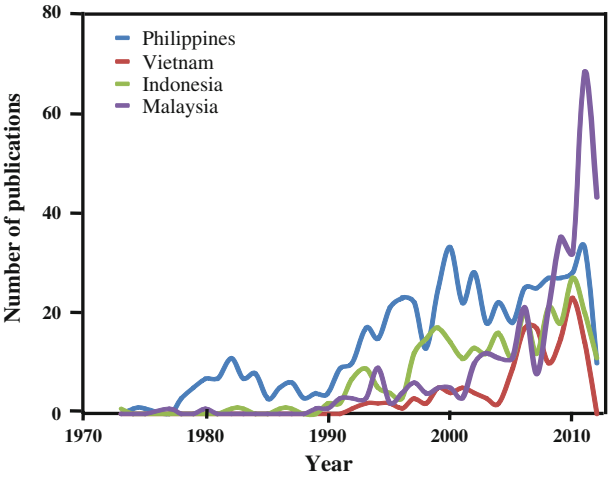

Fig. 3 Trends in soil science publication in selected Southeast Asian countries

Research and publication biases

Our study revealed research biases among soil science sub-discipline and within research and university institutions (Fig. 2). One possible reason for this bias is that published scientific research is disproportionately conducted in areas with internationally funded field stations (e.g. IRRI), wherein intellectual and scientific infrastructure for conducting scientific research is equipped with the state-of-the art research facilities. While universities across the country also get international funding, scientific infrastructure such as laboratory and scientific equipment is not suitable for research, and thus should cause a major concern. According to Villalino and Cagasan (2012), given a favorable research environment, which is characterized by low workload in instruction, availability of research funding and research facilities and availability of publication incentives, faculty members of academic institutions in the Philippines can be productive in research and in publishing research results.

Large uncertainty remains in our understanding of degraded upland soils because limited studies have been conducted on these problematic soils (Asio et al. 2009). Continued use of these problematic soils for agriculture have resulted in unsuitable crop production resulting in low crop yield (Garrity 1993), failure of the government on its massive forest rehabilitation projects (Alcala 1997) and widespread soil degradation (Asio et al. 2009; Navarrete et al. 2009, 2011, 2013). Also, various crop production technologies developed for marginal areas have failed to alleviate crop production (Cramb 2001), suggesting that basic information about soil, which can be done through pedological studies, is the key to sustainable land-use of these problematic soils (Asio et al. 2009; Navarrete et al. 2009, 2013). Together our results justify the need for more pedological studies on Philippine soils since suitable land-use and management of these soils require detailed information on their soil properties (Asio et al. 2009; Navarrete et al. 2013).

Caveats of datasets

Datasets used in the present study were selected based on a stringent criteria (see Methods). While extra care was done to select these data sets, interpreting these results from this

study should be taken with extreme caution. First, despite several databases available including Google Scholar, SCOPUS and SCIMAGO the present datasets were collected and compiled solely from Thomson ISI database. Because this database covers nearly 7,000 of the world's leading scientific and technical journals across a wide discipline, we assumed that it indexed all published soil science publications in the Thomson ISI database. Second, it is conceivable that some publications have not been indexed by Thomson ISI despite they are published in an ISI journal (Varela 2013). Together these results suggest that the number of publications and the number of citations presented in this study are both lower limits, indicating that the number of publications and the number of citations could be even higher than what we actually reported here. This problem is inherent when using only one indexing database, thus we recommended that a comparative analysis of the trends in soil science publication in the Philippines in combination with other databases such as Google Scholar and Scopus. Such a comparative analysis may apply the search procedure used in the present study.

Implications and outlook

Our study revealed a strong scientific publication in soil science in the Philippines as indicated by exponential increases in the number of publications with no indication that this tendency is slowing down (Fig. 1). Nevertheless, the apparent research biases across soil science sub-disciplines highlights the need for a paradigm shift in research priorities from dominantly rice nutrition research to environmental research particularly in understanding the nature and properties of degraded soils, quantifying changes in soil carbon stocks with land-use change, estimating anthropogenic greenhouse gas fluxes, soil pollution and bioremediation. Specifically, the poor understanding of the nature and properties of degraded soils (Asio 1997; Asio et al. 2009; Navarrete et al. 2009, 2011) help explains why until now soil degradation is a major agricultural and environmental problem in the Philippines (Asio et al. 2009; Navarrete et al. 2013).

Since foreign soil scientists contributed largely to increases in soil science publication in the Philippines, we propose four important points that will likely increase publication output among Filipino soil scientists. First, universities that offered a Ph.D. degree in soil science (e.g. UPLB) should require at least one scientific article in an international peer-reviewed journal as prerequisite for graduation. Second, since scientific publication is a widely accepted yardstick for scientific productivity, it must be a benchmark for research productivity evaluation in universities and must be the basis for job tenure, promotion and awards. It is perceived that this will result in an arduous competition to publish. Third, funding institutions should require at least one article published in an ISI journal for each funded research or Ph.D. scholarship grants. Fourth, because of limited research facilities in the country, building an international network of collaborators will likely increases publication productivity. Finally, because not many funded studies ended up as scientific publication, future studies should focus on identifying factors that influence scientific productivity of most Filipino soil scientists in the Philippines.

Acknowledgments The Alexander von Humboldt Foundation (Bonn, Germany) has granted a research fellowship to Dr. Ian A. Navarrete during the course of this study. We thank Dr. Rotacio Gravoso who reviewed an earlier version of this manuscript.

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