The citation impact of Open Access Agricultural Research: a comparison between OA and Non-OA publications

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Abstract

We used three methods to estimate whether there is a citation advantage to open access (OA) agriculture research. At the article level, we compared the citation counts of self-archived with non-OA articles based upon a sample of 400 research articles from ISI-indexed agriculture journals in 2005. At the journal level, we compared Impact Factors (IFs) of OA against non-OA agriculture journals during 2005-2007 as reported by the ISI Journal Citation Reports (JCR). We also sought evidence of citation impact based on a random sample of 100 OA and 100 non-OA publications from the Food and Agriculture Organization of the United Nations (FAO) in 2005. We used both ISI and Scopus databases for citation counting and also Google and Google Scholar for locating the self-archived articles published in the non-open access journals. The results showed that there is an obvious citation advantage for self-archived agriculture articles as compared to non-OA articles. Out of a random sample of 400 articles published in non-OA agriculture journals, about 14% were OA and had a median citation count of 4 whereas the median for non-OA articles was 2. However, at the journal level, the average IF for OA agriculture journals during 2005-2007 was 0.29, considerably lower than the average IF for non-OA journals (0.73). Finally, we found that FAO publications which were freely accessible online tended to attract more citations than non-OA publications in the same year and had mean citation count of 1.74 whereas the mean for non-OA publications was 0.28. In conclusion, it seems that OA is an advantage for individual articles but not for whole journals.

***Keywords**: Agriculture, open access, non open access, articles, citation analysis, impact assessment, FAO*

1. Introduction

The Web has introduced new opportunities for academic publishing online that could also be used by the potential users to access research results. Open Access (OA) publishing (e.g., OA journals, preprints / postprints and digital repositories) has rapidly turned into global platform for dissemination the scientific literature. A survey conducted in 1995 discovered only about 100 open access and peer-reviewed journals in the areas of science, technology and medicine (Hitchcock, Carr, & Hall, 1996). In 2004 a study reported that there were 24,000 peer-reviewed research journals worldwide, but that only 5% (1,200 titles) were open access (Harnad et al., 2004). More recently, we can see astonishing

increase in number of open access journals. Currently the Directory of Open Access Journals (DOAJ) indexes more than 4,000 full text and quality controlled scholarly journals, covering various subject areas (DOAJ, 2009). The ISI press release in 2004 also reported that of 8,700 of the highest impact research journals indexed in the ISI Web of Science (WOS) nearly 200 were OA journals (ISI press release, 2004), indicating gradual acceptance of the OA journals in the scientific community.

Open access movement has also influenced agriculture discipline. For instance, significant portion of agriculture researches are only appeared in the OA publications (e.g., OA journals) or subject-based repositories (e.g., digital open access archives). For instance, more than 200 peer-reviewed agricultural journals have been indexed by the Directory of Open Access Journals as of April 2009 (DOAJ, 2009). Some international agriculture institutions have also developed open access repositories to increase the number of potential users which have already been unable to access agriculture research outcomes. *FAO Corporate Document Repository*, for instance, is an open access agriculture databases which the huge numbers of scientific publications are freely accessible through it in electronic format (FAO, 2009).

Although, open access publishing enable users to easily access to the agriculture information, the citation impact of the open access agriculture is not known. Citation counting has been widely applied for research evaluation and is a well-accepted quantitative indicator to explore how an academic work has been explicitly used for scholarly reasons (see Borgman & Furner, 2002; Moed, 2005). It is suggested that there are two major ways to increase the potential research impact of journal articles 1) publish an article in an OA journal ("golden" road) or 2) publish an article in a non-OA journal but also self-archive it in an OA archive ("green" road) (Harnard et. al, 2004). A recent survey of over 10,000 journals indicated that about 10% of journals are gold and over 90% of academic journals let the authors to self-archive their articles through personal websites or institutional repositories and to make it freely accessible to the potential users. However, only about 10–20% of articles have been self-archived by researchers (Harnard et. al, 2008). Moreover, a previous investigation revealed that about 40% of authors have deposited OA version (personal web sites or Institutional OA repositories) of their works for at least one of their articles (Swan & Brown, 2004). Other studies suggested that self-archiving increases citations by 50%+, (Harnard, 2006) and manuscripts deposited to arXiv open access repository in physic tended to attract higher citations than non-OA counterparts (Moed, 2007). Whilst many have reported that online availability considerably increases a paper's impact, a recent study on biomedical sciences journals indicated that the open-access advantage is declining (Davis, 2009).

In the present study we assess the number of citations open access publications receive and compare it to non-OA counterparts. We examine whether there is a citation advantage between open access and non open access articles appearing in the same non-OA journal. Moreover, it is not known whether there is significant difference between Impact Factors of open access and non-OA journals or how open access publications deposited to the FAO full-text agriculture repository are cited. If it can be exposed that above OA publishing tend to receive more citations than their non-OA access counterparts, then an explanation can be made surrounding the value of OA movement in the agriculture research. No previous study has exclusively investigated evidence of citation impact of the OA agriculture research. Hence, this article may fill this gap and answer some questions addressed in theme of the IFLA Agricultural Libraries Discussion Group. In fact, we think that citation impact assessment of the OA agriculture publications can reveal 1) the role of OA agricultural archives in accelerating research communication 2) the issues surroundings international agricultural research institutes and OA and 3) the advantages and barriers to OA agricultural information against non-open access agricultural publications.

2. Related studies

From the early 1990s, researchers discussed about the potential impact of the OA publishing in the scholarly communication cycle (e.g., Harnad, 1990; Harnad, 1991; Harter, 1996). The next motivating question was to assess the impact of OA publishing using traditional bibliometric techniques (e.g., citation counting). For this purpose, many investigations compared citation advantage of OA vs. non-OA publications (Lawrence, 2001; Antelman, 2004; Harnad & Brody, 2004; Kurtz, 2004; Norris, Oppenheim & Rowland, 2008), suggesting that OA will attract more citations than non-OA works in several subject areas.

Lawrence (2001), for example, showed that free online availability substantially increases a paper's impact and that more highly cited articles and more recent articles in computer science are significantly more likely to be online. He reported that citations to in computer science conference papers were three times higher for open access articles than for non-OA papers.

Antelman (2004) examined whether journal articles in four disciplines—philosophy, political science, electrical and electronic engineering and mathematics—have a greater impact as measured by citations in the ISI Web of Science database when their authors make them freely available on the Internet. The overall result indicated that across all four disciplines, freely available articles do have a greater research impact than non-OA articles. Kurtz (2004) and Shin (2003) also reported same citation patterns for OA articles vs. non-OA articles in the field of astrophysics and psychology respectively.

At the journal level, a study conducted by the Institute for Scientific Information (ISI) compared citation impact of OA and non-OA journals. The result showed that there were no impact differences between the 191 OA journals and the 8,509 non-OA journals indexed by the ISI, (ISI press release, 2004).

Perhaps one of the most comprehensive multidisciplinary research was conducted by Hajjem, Harnad and Gingras (2005). They took a 12-year sample (1992-2003) of nearly 14 million articles from the ISI database to present a more general view of citation impact of open access journals in 10 different disciplines including biology, psychology, sociology, health, political science, economics, education, law, business and, management. They extracted citation data from the ISI database and used robot to crawl the Web for locating OA (self-archived) versions of the articles published in non-OA journals. The overall results showed that OA articles had more citations than non-OA articles in the same journal/year. The citation advantage of OA articles varying from 36%-172% by discipline and year.

Norris, Oppenheim and Rowland, (2008) selected four subjects areas (ecology, applied mathematics, sociology, and economics) and assessed whether there is a citation advantage between OA and toll access (non-OA in this study) journal articles. They found that the citation mean for OA articles (9.04) was considerably higher than toll access counterparts (5.76). However, they found that disciplinary difference is important factor in citation advantage of OA journals.

In contrast to many evidence surroundings the citation advantage of OA publishing, Davis (2009) reported that the citation impact "is considerably overstated for the biological and biomedical literature". In the recent study on biomedical sciences journals from 2003 to 2007 he found that the open-access advantage is declining by about 7% per year, from 32% in 2004 to 11% in 2007 (Davis, 2009).

3. Research questions

We address three questions below to compare the citation advantage of OA and non-OA research in the agricultural scholarly communication. For instance, if self-archived agricultural research could receive more citations than non-OA counterparts, then it is suggestive to encourage researchers, institutions and other organization in the field of agriculture to deposit or self-archive their pre-print post prints works to increase both the citation impact and the potential users' access to the research.

1) At the article level, is there significant difference between citation counts of OA and non-OA articles appearing in non-OA journals index by ISI?

2) At the journal level, is there significant difference between Impact Factors of OA and non-OA journals as reported by ISI Journal Citation Reports?
3) Do OA publications deposited online by FAO tended to attract higher citations than its non-OA publications in the same year?

3. Methods

In order to compare the citation advantage of open access against non-open access agricultural research, we applied three methods (see below). Ultimately, the methods may shed lights on the value of OA publishing in the field of agriculture.

3.1. Journal and Article Selection

Many authors are willing to deposit an open access version of their papers online, even though the papers have not been published in an open access journal. It is investigated that over 90% of scholarly journals let the authors to self-archive their articles (Harnard et. al, 2008). Hence, we can compare the citation impact of self-archived and non-OA articles appearing in the same non-OA journal in the specific subject area and the year. This approach is very useful, since the results are not influenced by other factors such as journal Impact Factor (IF).

For the first research question, we retrieved all research articles (omitting reports, editorials, book reviews, etc.) published in 27 ISI-indexed journals in "Agriculture, Multidisciplinary" subject category in the year 2005. Hence, both OA and non-OA articles would have similar time window to be cited and this approach eliminates the potential factor of time on citation increase. As shown in Table 1, we retrieved 3,186 research articles published in 27 agriculture journals indexed by ISI. Since, we were interested in how self-archiving and open accessibility of articles could influence the citation impact of agricultural research, we excluded four open access journal titles in the sampling process (see bold titles in Table 1). Moreover, we found that "*Journal of Agriculture and Food Chemistry*" which is published by the *American Chemical Society (ACS)* consists about 46% (1,480 articles) of the whole papers in this study and it is loosely related to agriculture research and is more related to chemistry (see Table 1). Consequently, we decided to omit this individual journal title in order to give broader view of impact assessment of OA agricultural research.

Ultimately, we had 1,407 articles from 22 non-OA journals indexed by ISI for the study. In order to manage the project in the proper time, we took a random sample proportional to the total number of articles in each journal. Hence, journals with more published articles had more articles in our final sample of 400 research articles (Table 1).

Table 1. ISI-indexed agriculture journals, accessibility and sample collection of articles

ISI-Indexed Journals	No. of articles in 2005	Accessibility	Sampled articles
AGRICULTURAL AND FOOD SCIENCE	17	Non-OA	5
AGRICULTURAL HISTORY	12	Non-OA	3
AGRICULTURAL SYSTEMS	61	Non-OA	17
AGRICULTURE AND HUMAN VALUES	26	Non-OA	7
AGRICULTURE ECOSYSTEMS & ENVIRONMENT	207	Non-OA	59
AGROCIENCIA-MEXICO	70	**OA**	Ignored
ANNALS OF APPLIED BIOLOGY	59	Non-OA	17
AUSTRALIAN JOURNAL OF AGRICULTURAL RESEARCH	108	Non-OA	31
AUSTRALIAN JOURNAL OF EXPERIMENTAL AGRICULTURE	97	Non-OA	28
BERICHTE UBER LANDWIRTSCHAFT	16	Non-OA	5
COMPUTERS AND ELECTRONICS IN AGRICULTURE	48	Non-OA	14
INDIAN JOURNAL OF AGRICULTURAL SCIENCES	107	Non-OA	30
JAPAN AGRICULTURAL RESEARCH QUARTERLY	22	**OA**	Ignored
JOURNAL OF AGRICULTURAL & ENVIRONMENTAL ETHICS	18	Non-OA	5
JOURNAL OF AGRICULTURAL AND FOOD CHEMISTRY (JAFC)	1433	Non-OA	Ignored
JOURNAL OF AGRICULTURAL SCIENCE	30	Non-OA	9
JOURNAL OF AGRICULTURE AND RURAL DEVELOPMENT IN THE TROPICS AND SUBTROPICS	17	Non-OA	5
JOURNAL OF SUSTAINABLE AGRICULTURE	46	Non-OA	13
JOURNAL OF THE FACULTY OF AGRICULTURE KYUSHU UNIVERSITY	86	Non-OA	24
JOURNAL OF THE SCIENCE OF FOOD AND AGRICULTURE	329	Non-OA	94
NEW ZEALAND JOURNAL OF AGRICULTURAL RESEARCH	45	Non-OA	13
NJAS-WAGENINGEN JOURNAL OF LIFE SCIENCES	5	Non-OA	1
OUTLOOK ON AGRICULTURE	21	Non-OA	6
PESQUISA AGROPECUARIA BRASILEIRA	150	**OA**	Ignored
PHILIPPINE AGRICULTURAL SCIENTIST	37	Non-OA	11
RENEWABLE AGRICULTURE AND FOOD SYSTEMS	15	Non-OA	4
SCIENTIA AGRICOLA	78	**OA**	Ignored
Total	**3,160**		**400**
Total articles without OA journals and JAFC	**1,407**		

3.2. Locating Self-archived Articles Published in Non-OA Journals

We looked for the self-archived version of articles published in the non-open access journals both through Google and Google Scholar searches (see below). Note that we used Google Scholar (http://scholar.google.com) because it has wider coverage of OA Web documents including postprint and preprint repositories and documents which would not be indexed by search engines such as Google (Kousha & Thelwall, 2008). Google was also selected because previous investigation showed that it is the most comprehensive Web search engine (Bar-Ilan, 2004)

For both Google and Google Scholar searches, we manually searched the exact titles (taken from ISI search results) of all 400 sampled articles as phrase searches. Sometimes it was necessary to add more citation information for articles. For instance, we also added extra bibliographic information to our query (e.g., first author name, journal name) with very general or common titles (e.g., *Livestock production in Germany*) to eliminate false matches. Consequently, we usually conducted several searches and manually browsed and checked retrieved results to locate possible self-archived papers published in non-OA journals. The above technique is very similar with Web citation extraction method applied in the previous studies (Vaughan & Shaw, 2003; Kousha & Thewall, 2007).

Below is an example of a Google Scholar search for an article originally published in non-OA journal (*Agricultural and Food Science*), but its OA version was also deposited online at the time of this study.

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"Forward hedging under price and production risk of wheat" Liu
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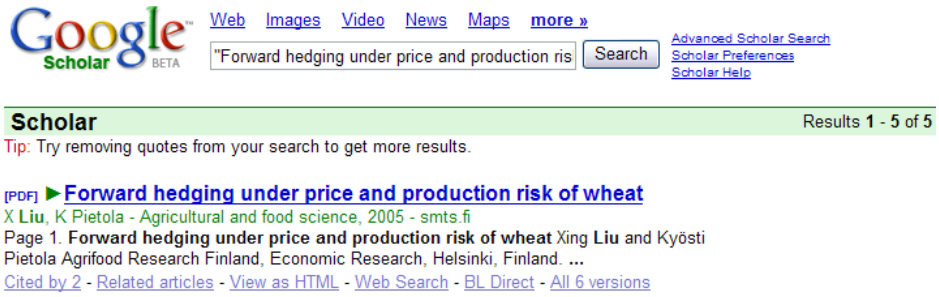
After conducting both Google and Google Scholar searches, we checked the open accessibility of articles. For instance, we generally checked “view as HTML” or “cached” options below each retrieved

record in the Google or Google Scholar results. Below is an example of Google Scholar search result. It shows that the article published in a non-OA journal was available online in PDF format.



3.3. Citation Impact of OA vs. Non-OA

We used ISI as the main source of scientific citation data which are commonly used for research evaluation. Hence, we used ISI citation data to assess the citation advantage of OA publishing both at the article and journal level.

For the first research question we recorded number of citations to both self-archived and non-OA articles published in 2005 as reported by ISI Web of Science (WOS). Then, we examined whether there is significant citation impact difference between two groups, OA and non-OA articles appearing in non-OA journals. For the second research question, we compared the Impact Factors (IF) for the four OA journals against 23 non-OA journals as reported by ISI Journal Citation Reports (JCR) during 2005-2007. The journal impact factor is calculated by each year by Thomson Reuters for those journals which it indexes within subject categories, and the factors are reported in Journal Citation Reports. This metric is usually calculated by dividing the number of citations to papers published in a journal during two preceding years to all papers that were published during the same period by a journal. Note that our initial study revealed that there was few OA agriculture journals (four journals) indexed by ISI in the Agriculture, Multidisciplinary subject category at the time of this study. This low number of OA agriculture journals is a limitation of our study and is discussed again.

3.4. Citation Impact of FAO OA Publication

In order to understand how the agricultural OA repositories have influenced the research communication, we compared the citation impact of OA and non-OA English publications (e.g., research reports, technical papers, working papers) published by FAO in 2005. For locating OA publications published by FAO, we used *FAO Corporate Document Repository*, a full-text electronic database of FAO OA publications available at: http://www.fao.org/corp/publications/en/. Out of 680 OA English publications exclusively published by FAO in 2005, we took a random sample of 100 documents. For locating non-OA publications also published by FAO, we used *FAO Catalog Online* and also restricted our search to English publications in 2005. We again select a random sample of 100 non-OA publications, after checking they are not freely available online. Consequently, the method helped us to assess the citation advantage of the OA and non-OA publications both published by FAO in the same year.

Since, there is major technical problem using *"Cited Reference Search"* option in the ISI Web of Science for citation counting of the FAO's publications, we used Scopus (http://www.scopus.com) as an alternative source of citation data. Although, Scopus does not index many of the FAO's publications (e.g., research reports, technical /working papers and monographs), it is possible to use the *"Reference Search"* facility in the Scopus to retrieve citations to FAO's publication in the references of other journals indexed by the Scopus. For this purpose, we manually searched the exact titles of FAO's publications as phrase searches in the main Scopus search interface and selected "references" option to locate possible citations to FAO's full-text publications appeared in articles covered by Scopus.

Figure 1 is an example of Scopus search based on the exact title (*Agricultural Workers and their Contribution to Sustainable Agriculture and Rural Development*) and the first author name

(*Hurst*) searche of an OA research report published by FAO.

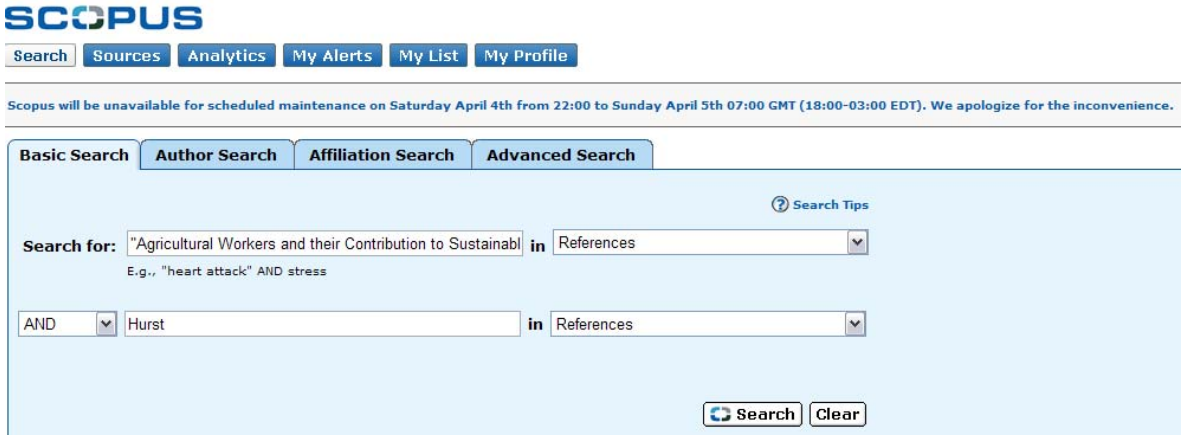


Figure 1. Locating citations to FAO's OA research report based upon Scopus citation database

Figure 2 is search results of the Figure 1. It shows that the above OA research report which was deposited online by FAO in the year 2005 could attract three citations from other journals indexed by the Scopus. Note that we manually checked the cited references through selecting "Abstract +Refs" below each retrieved results to remove possible false matches.

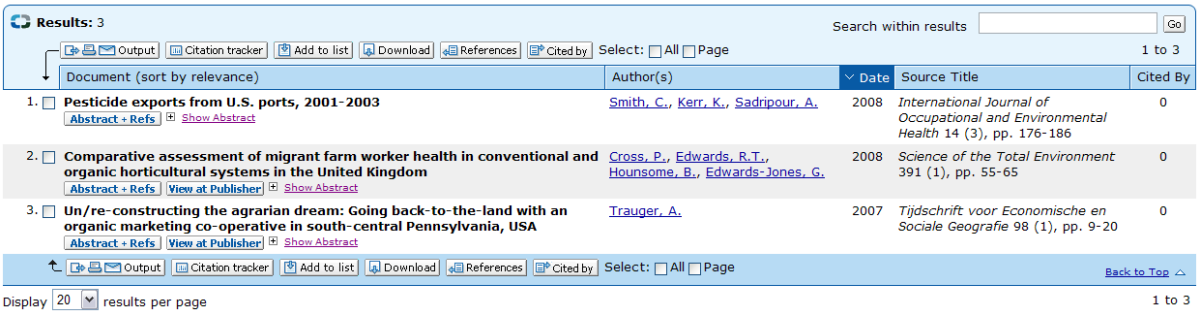


Figure 2. The search result for locating citations to FAO's publications

4. Findings

4.1. Citation Advantage of OA Articles vs. Non-OA Articles

Harnad and Brody (2004) discussed that "the way to test the impact advantage of Open Access (OA) is not to compare the citation impact factors of OA and non-OA journals but to compare the citation counts of individual OA and non-OA articles appearing in the same non-OA journals. Such ongoing comparisons are revealing dramatic citation advantages for OA." Table 2 reports a similar idea for agriculture subject area. It shows that of 400 sampled articles, 55 (about 14%) articles were open access and 345 (86.25) were not open access based upon the Google and Google Scholar searches (see method). Table 2 also shows that the mean (5.76) and the median (4) of citation counts to self-archived OA agriculture articles were considerably higher than the mean (3.03) and the median (2) of non-OA articles in the sample. In other words, articles which were self-archived through open access practices tended to attract about two times more citations than their non-OA counterparts.

Table 2. Statistics for citation counts of self-archived and non-OA articles in agriculture

Descriptive statistics	**Self-archived / OA articles**	**Non-OA articles**
Number (%) of articles	55 (13.75%)	345 (86.25)
Citation Median	5.76	3.03
Citation Median	4	2
Standard Deviation	5.15	3.68

In order to examine whether the above difference between citation counts of open access and non open access articles appearing in the same non-OA journal is statistically significant, we preformed Mann-Whitney Test. Note that we applied Mann-Whitney Test instead of independent samples T-test, because the frequency distributions of both OA and non-OA citation counts in the sample were highly skewed and parametric test is not appropriate for statistical analysis. The null hypothesis is that there is no difference between OA and non-OA citation counts. The research (alternative) hypothesis is that there is statistically significant difference between OA and non-OA citation counts. Results showed that the OA agriculture articles could attract more citations than non-OA counterparts and this difference is statistically significant (p-value=0.000; n=400; Mann-Whitney U score=5520.5). Because the calculated p-value (0.000) is less than 0.05 we can conclude that the difference between OA and non-OA is statistically significant.

4.2. Citation impact of OA journals vs. non-OA journals

The second research question investigates citation impact of open access against non open access agriculture journals. Although, this method might be less effective for exploring whether open accessibility of agricultural research substantially increase citation impact, it is helpful approach to compare OA and non-OA publishing at the journal level. For this purpose, we compared the Impact Factors (IF) of OA and non-OA journals during 2005-2007 as reported by ISI Journal Citation Reports (JCR). One limitation of this part of research is that there were very few OA agriculture journals indexed by ISI. Consequently, we could only compare four OA journals against 23 indexed by ISI during 2005-2007 in Agriculture, Multidisciplinary subject area.

Table 3 shows the ranking for all 27 agriculture journals indexed by ISI (OA journals are highlighted) based upon the average Impact Factors (IF) during 2005-2007 (the sixth column). It reports that the four OA journals including *Scientia Agricola, Japan Agricultural Research Quarterly, Pesquisa Agropecuaria Brasileira and Agrociencia-Mexico* have relatively low Impact Factors comparing to non-OA journals. As shown in Table 3, the four OA agriculture journals are ranked as 14, 16, 21 and 25. Thus, it is seems that OA journals have significantly lower citation advantage than non-OA journals.

Table 3. Impact Factor (IF) of 27 agricultural journals as reported by ISI Journal Citation Reports (2005-2007)

Rank*	ISI-Indexed Journals	Impact Factor 2005	Impact Factor 2006	Impact Factor 2007	Average Impact (2005-2007)
1	JOURNAL OF AGRICULTURAL AND FOOD CHEMISTRY (JAFC)	2.507	2.322	2.532	2.454
2	AGRICULTURE ECOSYSTEMS & ENVIRONMENT	1.495	1.832	2.308	1.878
3	ANNALS OF APPLIED BIOLOGY	1.06	1.379	1.752	1.397
4	AGRICULTURAL SYSTEMS	0.937	1.378	1.677	1.331
5	AUSTRALIAN JOURNAL OF AGRICULTURAL RESEARCH	0.993	1.133	1.352	1.159
6	JOURNAL OF THE SCIENCE OF FOOD AND AGRICULTURE	0.996	1.026	1.304	1.109
7	COMPUTERS AND ELECTRONICS IN AGRICULTURE	0.802	0.851	1.242	0.965
7	JOURNAL OF AGRICULTURAL SCIENCE	0.636	0.861	1.093	0.863
9	AUSTRALIAN JOURNAL OF EXPERIMENTAL AGRICULTURE	0.676	0.861	0.948	0.828
10	JOURNAL OF AGRICULTURAL & ENVIRONMENTAL ETHICS	0.778	0.74	0.833	0.784
11	AGRICULTURE AND HUMAN VALUES	0.571	0.672	0.614	0.619
12	NJAS-WAGENINGEN JOURNAL OF LIFE SCIENCES	1.02	0.5	0.242	0.587
13	NEW ZEALAND JOURNAL OF AGRICULTURAL RESEARCH	0.547	0.53	0.618	0.565
14	**SCIENTIA AGRICOLA****	**N/A**	**0.298**	**0.62**	**0.459**
15	RENEWABLE AGRICULTURE AND FOOD SYSTEMS	0.308	0.404	0.564	0.425
16	**JAPAN AGRICULTURAL RESEARCH QUARTERLY**	**0.165**	**0.395**	**0.439**	**0.333**
17	OUTLOOK ON AGRICULTURE	0.421	0.31	0.242	0.324
18	JOURNAL OF SUSTAINABLE AGRICULTURE	0.376	0.323	0.238	0.312
19	JOURNAL OF THE FACULTY OF AGRICULTURE KYUSHU UNIVERSITY	0.447	0.12	0.239	0.269
20	AGRICULTURAL AND FOOD SCIENCE	0.255	0.354	0.161	0.257

21	**PESQUISA AGROPECUARIA BRASILEIRA**	**0.181**	**0.286**	**0.274**	**0.247**
22	BERICHTE UBER LANDWIRTSCHAFT	0.316	0.226	0.085	0.209
23	AGRICULTURAL HISTORY	0.032	0.118	0.267	0.139
24	PHILIPPINE AGRICULTURAL SCIENTIST	0.154	0.09	0.173	0.139
25	**AGROCIENCIA-MEXICO**	**0.091**	**0.123**	**0.185**	**0.133**
26	INDIAN JOURNAL OF AGRICULTURAL SCIENCES	0.084	0.106	0.122	0.104
27	JOURNAL OF AGRICULTURE AND RURAL DEVELOPMENT IN THE TROPICS AND SUBTROPICS	0.065	0.147	0.094	0.102

*Journals were ranked based upon the average Impact Factors during 2005-2007
** Highlighted titles are open access journals

Table 4 compares that the average Impact Factors for 22 non-OA journals with four OA journals during 2005-2007. Result indicates that in all studied years the average Impact Factors for non-OA journals are considerably higher than OA journals. The sixth column reports that the average citation impact of 22 non-OA journals is 0.73 which is two times more than the average citation impact of four OA journals (0.29). Hence, it is suggestive that open accessibility is not the only factor that can influence the increase of citation impact. In fact, other factors (e.g., peer-review process, quality and topic of papers) may influence the Impact Factors of journals.

Table 4. The average Impact Factors for OA and non-OA ISI-indexed journals in the field of agriculture during 2005-2007

Type of Accessibility	Number of Journals	Average Impact Factor 2005	Average Impact Factor 2006	Average Impact Factor 2007	Average Impact during 2005-2007
Non-OA Journals	22	0.67	0.71	0.81	0.73
OA Journals	4	0.15	0.28	0.38	0.29

4.3 Citation Advantage of FAO's OA Repository

The third research question assesses citation impact of FAO's OA repository (e.g., research reports, technical papers, and working papers). For this purpose, we compared citation counts of the English OA publications against non-OA counterparts both published by FAO in 2005. Table 5 reports the citation counts of a random sample of OA and non-OA publications based on Scopus searches. It shows that 100 sampled OA publications could attract 173 citations whereas sample of 100 non-OA publications received only 28 citations from articles indexed by Scopus. The mean and median of citations for FAO OA publications are 1.74 and 1 respectively which is considerably higher than the mean (0.28) and median (0) of non-OA documents published by FAO in the same year.

Table 5. Citation counts of FAO's OA and non-OA publication in 2005

	OA Documents	Non-OA Documents
Sampled publications	100	100
Citation mean	1.74	0.28
Citation median	1	0
Total citations	173	28

We again preformed Mann-Whitney Test to examine whether there is statistically significant difference between the above citation means for sampled 100 OA and 100 non-OA publications. Results showed that the OA publications deposited online by FAO could attract more citations than non-OA counterparts in the same year and this difference is statistically significant (p-value=0.000; Mann-Whitney U score=3393; n=200). Because the calculated p-value (0.000) is less than 0.05 we can conclude that FAO open access publications could attract more citation impact than non-OA publications.

Conclusions

In answer to the first research question, results indicate that self-archived research articles published in the non-OA agriculture journals could attract nearly two times more citations than their non-OA counterparts and this difference was statistically significant. Therefore, the result supports previous findings in different subject areas that self-archiving and open accessibility substantially increase the citation impact (e.g., Lawrence 2001; Kurtz 2004; Hajjem, Harnad & Gingras, 2005; Norris, Oppenheim & Rowland, 2008). Hence, an important corollary from this study is that self-archived agricultural research through personal or institutional initiatives can relatively increase citations. This finding discloses remarkable citation advantage for open access research vs. non-OA in the field of agriculture and suggests that launching open access repositories and encouraging authors to self-archive their research can not only maximize user access to the agriculture research but also potentially increase their research impact.

In answer to the second research question, we found that the Impact Factors of open access journals was considerably lower than non-OA journals during 2005-2007. In other words, although at the article level self-archiving could considerably increase articles' citation impact in the same non-OA journal, this does not imply that open access journals themselves have a higher Impact Factors than non-OA journals. Thus, it seems that open accessibly is not sufficient for attracting citation and other factors may also influence research impact.

The third research question assesses the citation impact of OA publications deposited online by FAO website. We found that the citation mean for the sampled FAO's OA publications is relatively higher than non-OA publications in the same year. The result might be motivating factor for academic institutions, research centers or other organizations in the field of agriculture to launch open access agriculture archives and to increase research impact and the number of potential users which have already been unable to access their research outcomes.

Limitations: This study has several practical limitations. We only selected OA journals indexed in ISI Web of Science in the Agriculture, Multidisciplinary subject category. Hence, the results should be cautiously generalized to other related disciplines to agriculture science. Moreover, we found relatively low number of OA agriculture journals. Thus, it would be insufficient to use them to compare non-OA journals. Another limitation is that some of the OA journals in the study have only recently shifted to open access; therefore it would be unfair to compare them with many long established and high impact non-OA journals. Moreover, we only used Google and Google Scholar for locating the self-archived version of articles published in the non-open access journals; however both above databases have partial coverage of web. Finally, we took a random sample of 100 OA and 100 non-OA publications published by FAO. Hence, future studies may test similar pattern on wider sample size or examine other OA repositories in the field of agriculture.

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