Look at it this way

'Look at it this way' features contributions from distinguished scientists on contentious and current issues in areas such as development, population growth, agricultural production and policy.

Publishing science: past, present and the future

Despite the great importance of publications for individual careers as well as for the prestige of research centres and universities, there seems to be little discussion of this in agricultural scientific journals — as opposed to some other disciplines in which lively debates are held on the pros and cons of the present 'publish or perish' culture. This is somewhat surprising, as scientific careers are increasingly dependent on what one has written and where it is published. Things used to be different, and I will briefly sketch some historical developments and current trends and then consider the future of scientific publishing. The information is slightly skewed towards publishing in soil science, as this is my own discipline, but similar developments have undoubtedly occurred in others.[1]

Past

Scientific journals were first developed in the seventeenth century to systematize the letters and circular letters through which intellectuals interested in science had begun to communicate their discoveries. In January 1665, *Le Journal des Sçavans* appeared in France, and in the same year *The Philosophical Transactions of the Royal Society of England* were first published. *The Philosophical Transactions* were an attempt to deal with the enormous volume of correspondence that the Royal Society had engendered. In the decades that followed, a large number of other journals appeared, and by the nineteenth century the explosion in scientific communication was well under way.[2] Science's exponential growth over the last three centuries has been astonishingly consistent. The number of journals has doubled roughly every 15 years since 1700 and, because existing journals have become larger, the number of papers has doubled roughly every 10 years.[3]

Before the Second World War, there were only a few scientific journals in which agronomic investigations were published. Many journals were established in the years immediately following the war (*Outlook on Agriculture* was established in 1956), and another peak occurred in the 1980s. In soil science, for example, the number of journals has increased dramatically, and five of the eleven current leading soil science journals did not exist in the 1970s. There are currently about 25 journals solely dedicated to publishing soil research, while more than 35 other journals regularly publish soil research papers. There are over 60 national and international journals in which our research and thoughts on soil science can be published.

Present

Estimates of scientific production can be derived from databases of the Institute for Scientific Information (ISI) in Philadelphia. More than one million articles are added annually to their databases, and the number of publications is increasing each year. Some reasons for the continuing increase are: greater pressure to publish; the increased number of journals; the use of computers, facilitating manuscript preparation; and generation through computers of publishable knowledge. Of course, the number of publishing scientists has also increased — both absolutely and relatively.

Even more could be published if all the research that yielded valuable results were to be written up. We do not know how much this unpublished research amounts to, but it is probably decreasing. A colleague

recently made an inventory of unpublished agricultural research in Papua New Guinea, and counted about 400 unpublished manuscripts in research centres, which could potentially yield at least 160 scientific papers.[4] The survey indicated that much of the research had not been published. A similar situation may also prevail in other developing countries where English is not the mother tongue of the research scientists, and pressure to publish and competition are less intense.

One problem that many scientists face is that of keeping abreast of the fast-growing literature, or, as Satchell[5] puts it, 'Who can keep up with all developments in his or her field and have time to read even the slightest minority of these publications?' The answer is strictly personal, but I would like to add to this that accessibility to the literature may be as big a problem as keeping abreast of it. With many journals solely available in electronic form, or no longer available on the library shelf, accessibility may be as problematic as quantity.

Franck[6] questioned whether the increasing number of publications is a proper indication of the advancement of our knowledge, or simply a product of the quest for attention — from peers and the public. This aspect, I think, should not worry us too much, as scientific developments are staggering, and apparently a lot of paper is needed to spread the message. Separating the wheat from the chaff is sometimes difficult, but a journal's reputation still guarantees the quality of a paper. The most important issue is how much science has contributed to society. We all think we make a contribution, but the extent of the contribution is largely unquantified. Counting publications and quantifying the impact on our peers is easier than quantifying the impact on society.

Scientific careers are increasingly dependent on what a scientist has written (and where it has been published), but not so much on what he or she has read. Being seen to be widely read and erudite used to be extremely important in academia, but it seems that publication record is now the most important evaluation criterion. In the majority of job interviews, there will be questions about the applicant's publication record, whereas questions such as: 'What is the latest (science) book you have read?' are not asked. The answer would probably be something like, 'I have little time to read a whole book; I am more likely to write one.'

So, is the increasing number of publications a sign that people read more? One could argue the opposite — that those who write a lot have little time to read. Reading and conducting cutting-edge science are of course mutually exclusive. The leisurely days of conducting science without prolific writing have long gone. More and more is being published and there is no reason to assume that this trend will reverse.

Maintaining quality

Is the increasing number of publications affecting the quality? Some have found that many more errors are appearing in international journals. Most of these may be trivial, but technical errors too are on the increase. Production standards are more difficult to maintain, and authors are less careful and editors and reviewers less thorough. This is related to increasing complexity and technical sophistication, which make it easier for errors to escape the attention of authors, reviewers and editors.[7] Also, many large publishers have decreased their degree of intervention. Sub-editors, in-house editors and proofreaders have disappeared from the publisher's office in order to cut costs and boost profits.

It has been noted that the reader-friendliness of some science journals has declined over time.[8] This may be attributable to a decline in the

standards of writing and in the ability to present an argument professionally and clearly. This has been a gradual process that first became apparent at least 20 years ago. But there are also positive signs. In some disciplines the quality of papers has improved over time, and papers that were published 30 or 40 years ago would probably not be accepted today.[9] Standards of acceptance for publication become more rigorous as the pressure on journal editors is increased by the greater numbers of submissions. These factors suggest that quality improves with an increasing number of publications.

The most important aspect of quality control in scientific publishing is dealing with scientific fraud. Three types of fraud, generally abbreviated as FFP,[10] can be recognized: fabrication (or the construction of data and the matching up of results); falsification (manipulating, changing or omitting data in order to represent the results); and plagiarism (appropriating another's work without credit). Misrepresentation (making false statements or omitting material) and misuse of another's work (intentional presentation as the presenter's own without attribution of the ideas or work of another) are also considered as fraud.[11]

What causes fraud? I suppose it requires a rather disreputable and lazy character in combination with high-pressure circumstances, such as intense competition for research funds, pressure to publish, the struggle for recognition, and the rushing into print. Outliers of data and the frustration that follows failed attempts to have a theory recognized[12] may be other factors encouraging the abuse of research information. The fact that the barriers between industrial and academic research are diminishing, with possible conflicts of interest arising between funding agency and researcher, or ethical tensions deriving from private research funding in public institutions, could also cause scientific fraud.[13] Institutional circumstances that favour fraud are a strong hierarchical structure (in which the leader is able to get away with things through lack of accountability), and extreme competition (which tempts some weak-minded scientists to turn to fraudulent practices). Many experiments cannot be repeated because of lack of funds, so that results cannot be verified. Fraudulent authors know this.

Commercial publishers

Many publishing houses, for example Oxford University Press, Iowa State University Press and PUDOC (Wageningen Agricultural University), originate from the publishing activities of universities. In the past decades most universities have privatized the publishing of their scientific achievements and have handed it over to commercial publishers. Many of these publishers have been very successful, and publishing science has become big business. The number of scientific journals has doubled in the past 25 years: there are currently about 160,000.

Most journals are published by commercial publishers or by professional societies, and some society journals are published by commercial or not-for-profit publishers. In the past decade, there has been increasing criticism of commercial publishers following excessive price increases, which were meant to compensate for the declining number of journal subscriptions. Journals from commercial publishers are, on average, more expensive — both absolutely and per printed page, than journals published by scientific societies. In soil science, however, the largest annual price increases occur in the society journals.

The criticism of commercial publishers has yielded various initiatives, varying from total boycotts to free-publishing Websites. Commercial publishers are feeling the pressure. A recent initiative of the World

Health Organization (WHO) and six commercial publishers to give free access to their medical journals to scientists in developing countries should be much praised. It can only be hoped that the real benefits for medical scientists in developing countries exceeds the PR value for the commercial publishers.

The future

The personal computer has brought us things we could not have dreamt of 20 years ago. Personal computers are not so personal any more, because they are hooked up to networks in offices and eventually across the entire world. The paradox is that society is becoming more 'individualized', whereas people are 'de-individualized' by being connected to the biggest computer network in the world: the Internet. The PC has become the 'people's computer'. The Internet has already caused many changes and its effects will continue to evolve. It will affect the exchange of scientific information, and many traditional modes of communication will be replaced by Internet-based media.

The exchange of scientific information is currently effected via printed paper in journals and via 'soft' copy delivered as e-mail or as downloads from the Internet. This is, however, a transitional period. Ultimately, the printed version of a scientific journal may well disappear. At least, that seems to be the opinion of the major publishers and experts. A chief executive of Elsevier Science, the main scientific publisher in the world, aiming to reinvent itself as an Internet company, thinks that within two years the printed versions of many journals will no longer exist and that articles will be available only on the Internet. Articles will be offered through the Internet, will be reviewed through the Internet and made available on the Internet. This seems likely to reduce subscription prices drastically, and the USA is at the forefront of this technology. Elsevier Science hopes that by 2002 more than 60% of its scientific revenues will come from Internet projects.

Experts believe that the plethora of printed journals is doomed to extinction as it makes no economic sense and is increasingly a hindrance to science itself.[14] Science demonstrates diminishing returns, and one day science's exponential demands on national purses will become excessive, causing the rate of scientific growth to slow.[15] That economic law is likely to affect agricultural science, and to some extent it is already occurring in a number of countries. Second, the current number of journals is too large and too much time is required to keep abreast of developments in any field of interest. Internet journals may postpone a decrease in the number of agricultural science journals, but the effect will be only temporary. Titles will merge and some will disappear.

Journals whose content can command a large readership will, however, continue to exist and flourish in print as their economics are akin to those of the magazine market. The bulk of journals are consulted no more than 50 times a year in a typical library, and only 15% are consulted more than 250 times. Subscribing to a handful of journals only will save several thousand dollars, and the costs of printing will be difficult to justify for most journals. Therefore in a free market, high-cost, low-circulation journals will be forced to go electronic, or disappear.

If we move to electronic publishing, can quality be guaranteed, will we write differently, and is peer review going to be abolished? Will it affect the way we conduct science, and how will impact or citation be measured? It is likely that electronic publishing will affect the style of scientific writing. The length of online articles will be less restricted, and it will be possible to use hypertext and to connect to supplementary

material on other Websites or external databases. This enables a reduction in the length of the main text and the chance to make it less technical, moving the details to linked sections. The use of hypertext in papers raises the issue of whether authors will be free to modify linked material on their own Websites, or whether the content related to a paper should be frozen on submission, which is especially relevant to refereeing.[16]

Will Internet publishing affect peer review? New systems may develop by which manuscripts are put in an Internet archive of unreviewed papers for some months after a first quick screening by a specialist. Other specialists in the field may give comments; the author will consider these and will resubmit the manuscript to an editor to make the final decision. The paper may then either be removed or put in the peer-reviewed archive. Will it work? I don't think so: few people will voluntarily look for papers to review, and those who do so and give their comments may not be the busy specialists whose opinion is crucial. Moreover, such systems will not be easy to maintain and editors will still be needed. Such 'open' systems avoid the publisher, but their introduction requires a drastic change of culture in publishing science. A more radical approach would be to break the link between publishing and peer review altogether. In effect, the journals would then merely act as service bureaux providing peer-review and editing services. Printing, publishing and distribution would be done on the Internet, via a distributed global database, which is currently being established under the banner of the Open Archives initiatives. Journal subscriptions would be irrelevant, and the review process would be financed by fees paid directly by scientific institutions, using money that would otherwise have been paid for journal subscriptions. This plan, which has long been championed by the University of Southampton in the UK, is likely to work if all institutions in the world can save on the large number of subscriptions to publishing houses. The system is based on page charges — those who publish pay for refereeing and everyone has free access to all information.

Closely related to the question of how the Internet will affect scientific publishing is the question of whether it will affect the way we conduct science. It seems to be occurring in other disciplines. For example, in bioinformatics, using intelligent search engines and a large number of databases on the Web, new combinations of information can be made. 'Surfing on DNA' yields novel insights or information on functions of unknown genes. Could something similar be done in agricultural science, say on soil degradation, using items of information published on the Web to create something new? It all depends on the quality and quantity of that material. It also depends on the availability of databases, soil information systems and metadata and the willingness of institutes to put information on the Web. In a rapidly commercializing world where information is valuable, that willingness may be limited. There is no doubt, however, that the free availability of information of good quality would be beneficial for the advancement of agricultural science.

What about developing countries?

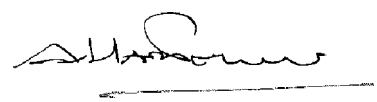
Three-quarters of the earth's population does not have a telephone, let alone access to the Internet. In addition, the Internet is not evenly spread over the world. Of some 360 million users worldwide, only 3.1 million are thought to be in Africa, and most of those are either in South Africa or north of the Sahara. Nigeria probably has 100,000 users and Kenya has even fewer. In 1997, something like 84% of global expenditure on information and communication technologies took place in North

America, Western Europe and Japan. Such spending encourages what has been called the 'digital divide'. Therefore, some fear that electronic publishing will affect the availability of scientific literature to developing countries, where telephone lines are unreliable and Internet connections are either not available or slow. It will exclude them from access to information as well as from contributing, because submissions would also need to be electronic. The fear is certainly justified in many countries, but it is questionable whether it remains valid for the long term. First, scientific literature is currently problematic in developing countries because many libraries have had to cut their subscriptions to scientific journals in view of extraordinary price increases. Cheaper electronic journals will increase the potential availability of scientific literature in developing countries. The remaining hurdles relate to telephone lines, optical-fibre cables, bandwidths and Internet providers. Perhaps satellite connections are the solution.

The Internet is spreading fast in Africa and usage tripled in 1999. In August 2000, Somalia became the latest African country to offer local access to the Internet, and for the first time surfers can use the net in Kiswahili. Internet cafés have been springing up in African cities wherever people have the money to use them. On a larger scale, an East African company, Africa Online, based in Nairobi, works in eight countries. The UN has put its faith in the Internet as a means for poor countries to leapfrog stages of development. The Internet could provide a solution to one of Africa's greatest weaknesses — its feeble infrastructure — but it will remain affected by uncertain power supplies and bad telephone lines, although satellite transmission of services obviates the need for land lines and traditional supply routes for communications.

Concluding remarks

Scientific publishing is at the centre of scientific activity. Although it was primarily developed to exchange information and ideas, it has become big business. The total publishing market is worth some $10 billion and is hugely profitable. Citation analysis and impact factor ratings combined with publishing records are increasingly being used as evaluation tools for individual scientists and institutes. The number of scientific publications is increasing each year, and there is no reason to assume that the rate of expansion will decline. Quality control will remain of the utmost importance and responsibilities should be shared by authors, reviewers and the publishers. Electronic publishing will replace paper copies and will create a new system of information exchange. The Internet is also spreading rapidly in many developing countries and this may enhance the availability of scientific information. Since we are currently in a transitional period it is to be hoped that improvements in the reliability and availability of the Internet keep pace with the speed at which journals go out of print.



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Notes and references

[1] This article is based on a series of papers by the author published in the *Bulletin of the International Union of Soil Sciences*; copies of the papers can be obtained from the author (Hartemink@isric.nl) or downloaded from www.soils.org.uk/porp/iuss-porp.htm.

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