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Challenges and responsibilities for public sector scientists

Review

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Current agriculture faces the challenge of doubling food production to meet the food needs of a population expected to reach 9 billion by mid-century whilst maintaining soil and water quality and conserving biodiversity. These challenges are more overwhelming for the rural poor, who are the custodians of environmental resources and at the same time particularly vulnerable to environmental degradation. Solutions have to come from concerted actions by different segments of society in which public sector science plays a fundamental role. Public sector scientists are at the root of all the present generation of GM crop traits under cultivation and more will come with the new knowledge that is being generated by systems biology. To speed up innovation, molecular biologists must interact with scientists from the different fields as well as with stakeholders outside the academic world in order to create an environment capable of capturing value from public sector knowledge. I highlight here the measures that have to be taken urgently to guarantee that science and technology can tackle the problems of subsistence farmers.

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The challenges

Public research institutions have always been engaged in innovations and developments aimed at ameliorating human living conditions. In the field of agriculture, thanks to the dedicated plant breeding scientists, the Green Revolution could make use of improved crop varieties that allowed food production to keep pace with worldwide population growth. The success of Norman Borlaug and the CIMMYT team in producing wheat and, later, rice high yield varieties, together with innovative cultivation methods, increased the grain yield at levels that led to the notion that the world hunger could be solved. This was true in the short run, however the on-going population growth and the eagerly anticipated industrialisation of developing countries have to be taken into account in the long run. These factors besides being energy and water demanding also compete for land and will ultimately exert pressure on global food production.

The media have always considered it *bon ton* to make anecdotal criticism of Malthus. We often read in the news about the arrogant intellectuals who keep quoting Malthus whilst the man has been wrong for more than 200 years. Indeed, while the world population tripled during the 50 years after the second World War, agricultural production increased by a factor of 3.5. But the scenario has now changed. The yield increase through classical breeding programs has reached a plateau and food production has

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to take into account the global pollution, a concept not considered in Malthus's time. We now realize that, unfortunately, Malthus's prediction of risks finally materialises. Current agriculture faces the challenge of doubling food production to meet the food needs of a population expected to reach 9 billion by mid-century whilst maintaining soil and water quality and conserving biodiversity. The task becomes particularly tough when it has to be accomplished with limited land. It is estimated that by the time the world's population passes the threshold of 8 billion people, there will only be 1.4 ha of arable land per capita [1].

These challenges are more overwhelming for the rural poor, who make up an estimated 80% of the world's 1.4 billon hungry people [2]. No segment of humanity depends more directly on environmental resources and services than the rural poor. They use soil and water for farming and fishing, forests for food, fuel and fodder, and the biodiversity of a wide range of plants and animals, both domesticated and wild. Their lives are interwoven with the surrounding environment in ways that make them both particularly valuable as custodians of environmental resources and particularly vulnerable to environmental degradation. When population pressure grows and food is scarce, hunger can drive them to plough under or overgraze fragile rangelands and forest margins, threatening the very resources upon which they depend.

The solutions

Solutions have to come from concerted actions of different segments of society. It will require political will and strong commitments on the part of the nations as it will lead to a full revision of the way we perceive our society and our interaction with the environment. In this context, science and technology alone obviously does not have the power to overcome the challenges, but it is a very relevant and essential instrument of the orchestra. The range of science and technology opportunities now available can mitigate the greater constraints imposed on poor farmers. As international organisations have stated repeatedly, there is a *moral imperative* that technologies that are pro-poor, pro-environment and pro-economy find their way to those who need them the most.

Plant biotechnology has produced numerous breakthroughs that can contribute significantly to alleviating many of the entrenched problems of poor nations, including hunger, malnutrition, diseases and environmental degradation (for review see Farre *et al.*) [3]. Public sector scientists are at the root of most innovations and practical achievements. Indeed all of the present generation of GM crop traits under cultivation can be traced back to discoveries in the public sector. The recent developments in systems biology are generating an explosion of information that public sector scientists are translating into new knowledge (see Figure 1). The next step, the generation of new products out of the knowledge gained, is beyond the scope of public research institutions. In general, the private sector takes charge of the knowledge application. Here stands the gap. Notwithstanding the scientific breakthroughs, the rate of development and commercialisation of new biotech crops is frustrating the expectation.

The responsibilities

Several factors have contributed to the knowledge application gap. One is the fact that the discoveries have not reached the group with expertise to generate innovation. There is a need for better

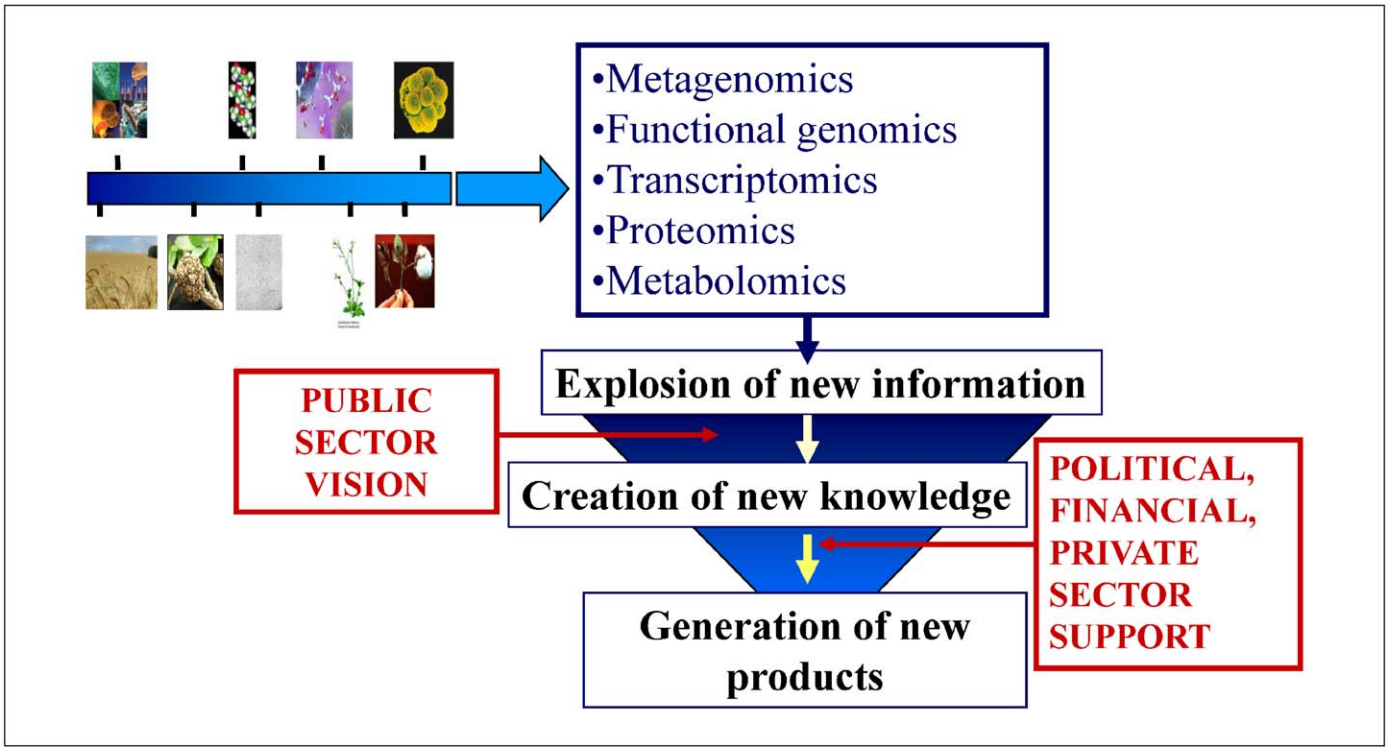

FIGURE 1

The innovation gap. Systems biology is generating an explosion of basic information from which scientists must derive tangible knowledge for the development of new products and services. A critical set of factors – political, financial and private sector support – will determine the rate at which this new knowledge will tackle the problems of subsistence farmers. Dialogue between the different players must be initiated now.

communication of the knowledge generated by the fundamental research. The communication channels of molecular biologists cannot be restricted any longer to specialised journals often enigmatic to those who do not belong to the clan. A better sharing of the knowledge and the generation of demand-driven technologies will require changes in the organisational structure of universities and public research institutions. To speed up innovation, molecular biologists must interact with scientists from the different departments that are tackling the same goal, for example departments of agronomy, forestry, tropical agriculture, agricultural economy, ecology, and nutrition. They also have to reach stakeholders outside the academic world, such as curators of seed banks, seed companies and small to medium size enterprises (SMEs). The latter are fundamental players, since they traditionally fill the application gap. Public research institutions have to be immersed into an environment fertile to generate spin-offs. This has been the strategy of the US and Europe and the results are clear. The investments in R&D accounted for 50% of the US economy growth in the last 40 years [4]. Similarly, in Europe, the experience of Flandres shows that when federal investments in universities' R&D increase, there is a corresponding increase in private sector investments, with the flourishing of SMEs in biotechnology.

Agricultural R&D in developing countries also requires the implementation of new organisational structures to promote the public–private partnership and the emergence of SMEs. Such environment is essential for capturing value from public sector knowledge and should be encouraged through policy measures that stimulate investments. Unfortunately the recent surveys [5] show that the trend is going in the opposite direction. The investments in agricultural research have stagnated over time despite the numerous studies showing that improvements in productivity are linked to increased investment in agricultural R&D. The consequences are clear and are already there. A recent review of the world's commercial pipeline of GM crops reveals that the contribution of Latin America and Africa to current and future GM events by 2015 is insignificant. The big actor in emerging countries is China, which will contribute with about 40% of the GM events that will be commercially available by 2015 [6]. Unsurprisingly, the Chinese government is stimulating public–private partnership and the emergence of a SME and start-up culture.

Another important issue must be highlighted. Society must understand that business is as usual everywhere. Commercial interests drive investments of the private sector in R&D both in developed and developing countries. Neglected pro-poor traits and orphan crops will remain as such if the returns of investments are not attractive. It is clear that, in this scenario, large private multinationals opt out. Private companies do not have it as their mission to accomplish the Millennium goals. But I do believe that SMEs in developing countries would invest in pro-poor GM crops because the returns can reach their expectations, provided that they can start with a rather finished product, ready to scale up. In view of the dimension of our challenge to overcome poverty, one may well say that what the private sector cannot do has to be the task of the public sector. Unfortunately this is not going to be so for now. The public sector has underinvested in R&D for smallholder crops and in biotechnology specifically. Public spending on R&D on transgenics is only a fraction of the US$ 1.5 billion spent each year by the four largest private companies [7]. The arguments are that it is not worthwhile to do research on pro-poor plant biotechnology, because the costly and unnecessary overregulation will anyway block the access to those who need it most. Society is then trapped into the loop reasoning that the technology is not worthwhile because the rich countries do not need it and it is not yet proven that it can have any humanitarian impact.

The importance of research developments to tackle the problems of subsistence farmers is acknowledged by governments and international organisations. It is now urgent to take measures to guarantee the accomplishment of this fundamental humanitarian task. I see the need for the following actions. (i) To increase funding for public sector programmes targeted to solve major constraints of poor farmers in trying to provide a sustainable, sufficient and safe supply of foods. They are many: higher productivity, enhanced nutrition, disease and insect resistance, drought tolerance, increased fertilizer use efficiency, and so on (ii) To promote and fund international cooperation to allow the knowledge transfer to developing countries scientists to develop of locally relevant crop improvement programmes. (iii) To support breeding programmes and quality seeds production in developing countries where a strong seed industry is inexistent and where the public sector is the major player. (iv) To develop mechanisms to empower developing country scientists so that they can participate in – and contribute to – the emerging global knowledge-based bio-economy. And last but not least, (v) to promote regulatory frameworks that are science-based, avoiding a costly overregulation that will halt pro-poor GM crops.

Indeed, the cumbersome and costly regulatory infrastructures constitute a major obstacle that adds to the chronic underinvestment in science and technology. Many public sector scientists cannot afford the regulatory compliance costs, which ranges from tens of thousands to millions of dollars [8]. The public sector scientists must be more actively involved in on-going biosafety regulation negotiations if we are to breach the present impasse that prevents many of the most promising pro-poor technologies reaching the farmers. Until recently, the public research sector has not provided scientific input in these negotiations, with the result that there is a misperception that biotechnology is only the domain of a handful of multinationals.

Critics of plant biotechnology have mounted a campaign of misinformation that warns that GM crops are the monopoly of the multinationals and will enslave the third world even more. The detractors go on saying that GM crops will lead to a loss of biodiversity and they have not been sufficiently tested. This is not the case. Despite the claims, no adverse effects of GM crops have been reported for consumer health or the environment; on the contrary, a number of health and environmental benefits have been reported. Sadly, the result of the present 'anti-GM' environment is that, currently, GM crops are one of the most overregulated technology sectors in existence. Only the multinationals can afford to pay the costs associated with regulatory filings and bring new biotech products to market. No SME or third world country can develop and market such technology. Whilst decision making continues to ignore a science-based rationale, threats to food security and health problems will remain in the developing world, and the brain drain will continue in parts of the industrialised world. The public sector needs an improved understanding of the impact of the emerging regulatory framework on the

delivery of the public goods R&D agenda, it needs a better understanding of the consequences of the regulations on the total costs of research projects and needs to rethink research project definitions and funding criteria accordingly. Until then, regulatory policy that is poorly structured and implemented will continue to have a disastrous impact in Europe and all countries seeking to trade with Europe.

The public sector has taken steps to fight for the establishment of a regulatory framework less counterproductive in different countries. National regulations are strongly influenced by international agreements, such as the Cartagena Protocol on Biosafety (CPB). During the development of these international agreements, the public research sector, which numbers tens of thousands of researchers in several thousand research institutes in developing and developed countries, has until 2004 not been represented in an organised way. Aiming at filling this gap, public sector scientists involved in biotechnology research for the public good initiated, in 2004, a worldwide initiative – the Public Research and Regulation Initiative (PRRI) [9]. The objective of the PRRI is to offer public researchers involved in modern biotechnology a forum through which they participate in and/or are informed about relevant international discussions such as the Meetings of the Parties of the CPB (MOPs). The goal of participation in such meetings is to inform negotiators about the objectives and progress of public research in modern biotechnology, to bring science to the negotiations, and to inform the negotiators about concerns public researchers may have.

Another mechanism public sector scientists must use to reduce the unnecessary regulatory burden that halts the innovation chain is to engage in the dialogue with society. Regulatory policy is a political issue and as such sensitive to public opinion. Public sector scientists have to create channels to share with the different stakeholders the facts and information, as well as to discuss the concerns, potential and opportunities related to this new technology. We must convey this important message to society: agriculture, be it classical or organic, is very detrimental to the environment and biodiversity. GM agriculture is our biggest opportunity of having a less environmentally damaging agriculture and still meet the food needs of an ever-growing population. Actually biotechnology brings us as close as possible to the ideal agriculture system: a high yielding organic agriculture. Only through cooperation and mutual understanding will it be possible to capture and develop the true potential of this exciting technology to create a more livable and environmentally stable society.

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