POLICY FORUM: GENOMICS AND AGRICULTURE

Collaborations in Rice

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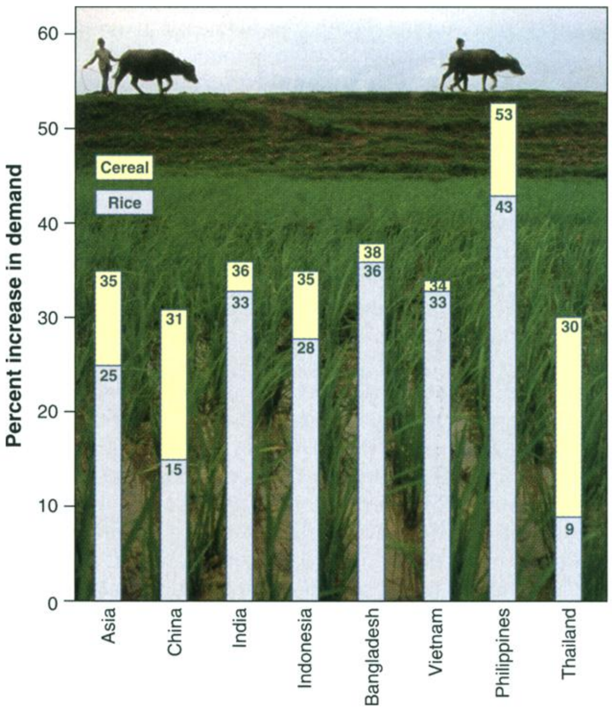
Rice is the largest food source for the poor. It is the staple of Asia, providing 50 to 80% of daily calorie intake. It is also the single most important source of employment and income for rural people (*1*). In Asia, total demand for cereals will increase 35% by 2010 (*2*) (see the figure). This means that the average yield achieved by the 250 million Asian farmers has to be raised from the current 5.0 tons/ha (under irrigation) to around 8.0 tons/ha—a level close to the current maximum achievable yield (*3*). Another challenge is to increase the productivity of lands that do not receive optimal rainfall, which account for 40% of the rice lands in Asia and most of the rice grown in Africa. Poverty and food shortages are widespread in these diverse and unfavorable soil and water environments. If biotechnology is to have an impact on the lives of the poor, it must focus on the problems of too much and too little water, soil toxicity, and low soil fertility, as well as on inadequate grain quality and nutrition (*4*).

Rice, having one of the smallest genomes among the food crops, has been a target for basic research in many countries, and will be the first food crop to be completely sequenced. The sequencing of rice was spearheaded by the Rice Genome Research Program of Japan (*5*). This has now expanded to an International Rice Genome Sequencing Project (IRGSP) (*6*). This effort, largely supported by government funds, has been boosted by a doubling of the rice genomics budget in Japan, and the recent $12.3 million commitment of the United States (*7*). Monsanto recently announced the release of the first "working draft" of the rice genome and will provide the data to IRGSP to enable the international community to complete the genome sooner and at lower cost (*8*).

Because of the conservation of gene sequences in plants, complete sequencing of rice has broad practical implications for many other economically important plant species (*9*). However, there is a growing concern that the poor will not be adequately served by the new science (*10*, *11*). For rice, many of the products with high potential for alleviating poverty will not be those that attract the necessary private sector investment. We propose a model that can serve the poor and encourage investment and innovation by both the private and public sectors.

Public and Private Innovation in Rice

For decades, almost all rice research was done by the public sector through national and international agricultural research centers. In 1984, the Rockefeller Foundation began the International Rice Biotechnology Program, which made rice a model and attracted scientists to conduct basic research. The private sector has played a small role in the development and delivery of rice technology in the tropics, in contrast to what it has done for other crops. However, advances in biotechnology and large investments by industry mean that the balance between the public and private sectors may change.



Future needs for rice and cereal. Projected percent increase in the demand for rice and cereals in 2010 over 1993 (*2*).

Currently, public institutions for rice research are the major source of genetic diversity and biological knowledge. An example of their value to innovators in gene discovery is U.S. patent 5,859,339 granted to the Regents of the University of California for a gene that enhances resistance of plants to *Xanthomonas*. The basic biological assets used to discover the gene (*Xa21*) were the original germplasm collection from Mali and the near-isogenic lines developed at the International Rice Research Institute (IRRI) (*12*). These were freely shared with research partners and used to further innovation leading to the successful cloning of *Xa21* (*13*). This product is now being made available to developing countries at zero royalty.

In forging public and private sector collaboration in rice genomics, the expectations of both communities must be recognized. In the case of the private sector, the ability to obtain patents on gene or plant products is crucial. Almost all private-sector plant breeding depends on a proprietary position that permits recovery of research costs. The classic example is hybrid maize in the United States, for which biological proprietary protection is derived from the farmer's inability to use the harvested crop as seed. This has encouraged private breeding that has increased yields by more than fivefold since 1930 (*14*). As developing-world seed markets are becoming significant to the multinational biotechnology community, some patents are likely to be sought in larger developing nations, which could deny access to the poor.

The public sector needs access to the new technology for further research, innovation, and use in noncommercial environments. In the *Xa21* example, these are being negotiated after the research phase. In the future, access for use of the products by the public sector should be agreed upon at the beginning of the collaboration.

The challenge is to develop a shared vision for rice research that will provide the public sector access and freedom to use modern tools and sufficient incentives for the private sector to innovate, develop, and deliver new rice technologies. In the human genome project, 10 pharmaceutical companies and the Wellcome Trust have agreed to fund and create a publicly available archive of human genetic variation (*15*). A similar pattern of collaboration is needed in rice functional genomics.

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Public Resource Platform

The demand for diverse genetic resources and expertise in functional genomics requires a common platform where information and genetic resources can be broadly shared to accelerate trait discovery. The key elements of this collaborative platform are public access to sequence data, abundant genetic resources for functional assignment, capacity for biological evaluation, and incorporation of genes and traits into varieties. The recent announcements on the release of rice sequence data and donation of proprietary technologies for the production of provitamin A rice are encouraging signs that the private sector is willing to share their products of investment and make them available to developing countries (*16*).

Different processes, resources, and expertise are needed to reach the final objective of rice improvement. Diverse resources held by rice-growing countries and public institutions are crucial to success, and these include mutants, germplasm, near isogenic lines, pedigrees, populations for mapping, and breeding lines. Furthermore, a tight coupling of the processes involved in assigning gene function, identifying beneficial alleles, and generating improved varieties is essential to ensure that discoveries are put to practical use (*17*).

Therefore, IRRI proposed the formation of an international working group on functional genomics (*18*). It was agreed that the following activities are of high priority: (i) create an information node to deposit and disseminate information on rice functional genomics; (ii) build a public platform to promote access to genetic stocks and phenotypic information; (iii) develop databases on phenotypes and mutants with linkage to sequencing laboratories; and (iv) initiate partnerships to develop resources for microarray analysis.

Intellectual Properties

The pattern of rights envisioned is that genetic resources for functional genomics will be made available to the public and private sectors under a material transfer agreement (MTA). This agreement permits recipients to obtain patents on genes discovered through use of the material, but requires them to make available rights under those patents at a reasonable royalty for application in commercial markets of the developing world, and at zero royalty for application in noncommercial subsistence farming.

In addition to ensuring the possibility of use in the developing world, it is also essential that data and materials are freely available for research. Hence, the envisioned MTA will have provisions permitting free use for research purposes of any of the patents, as well as provisions ensuring that recipients cannot obtain any form of intellectual property protection on the genetic stocks per se. The information gained from research with such genetic resources must be provided back to the public, albeit after an appropriate delay to allow patenting. Public institutions engaged in developing and studying these genetic resources must agree among themselves to supply materials and to exchange all the information developed and maintained in a common database. They must also follow the same rules as those imposed on the private sector through the MTA.

The public and international research institutions cannot sort out the legal technicalities involved at the marketing stage. The planned MTA requires those who obtain materials and patents to commit themselves to negotiate with, and grant licenses directly to the ultimate users of the developing world. The MTA also requires these patent holders to commit themselves to arbitration, should there be a dispute in defining or interpreting the license terms.

Action Plan

The International Functional Genomics Working Group has prepared a three-point action plan for initiation in 2000:

Information node: A Web site has been created where progress on rice functional genomics can be communicated (www.cgiar.org/irri/genomics/index.htm). It will serve as the entry point for finding and sharing information and provide a link to individual laboratories or organizations. The site will also serve as a clearinghouse of information on genetic resources and their availability. We encourage laboratories to contribute summaries of their research activities and experimental systems, as well as suggestions to improve the site.

Genetic resources: IRRI has begun to share genetic stocks through MTAs that will support the common goals. This includes genetic materials—mutants, isogenic lines, and mapping populations—specifically created for gene identification. Germplasm collected from different countries are shared under conditions specified by the convention on biological diversity.

Microarray resources: A nucleus of laboratories has agreed to contribute expertise and resources essential for making microarrays. We will work toward printing a common set of DNA sequences and developing mechanisms for sharing microarrays and data generated.

The proposed collaborative agenda is not unique. For example, the Maize Gene Discovery project, with support from the U.S. National Science Foundation, is committed to collaborations between government-supported laboratories and industry (*19*). In this project, all gene sequences and mutant lines are to be made available to the public. As in the proposed rice collaboration, users of the materials provided through the project are encouraged to patent their inventions.

What we advocate in rice that is unorthodox, however, are the arrangements for specific rights in new inventions derived from the biological assets held by the public sector. In addition to public access to information on gene function in rice and public access for research to any proprietary product derived from the biological assets, we seek access for limited use of the products in developing countries. Such a collaboration in gene discovery in rice, if fully embraced by the public and private sector, can bring the benefits of innovation and modern science to solve intractable problems for both commercial and subsistence rice farmers.

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