Maintaining the Public Sector's Essential Role in Crop Varietal Improvement

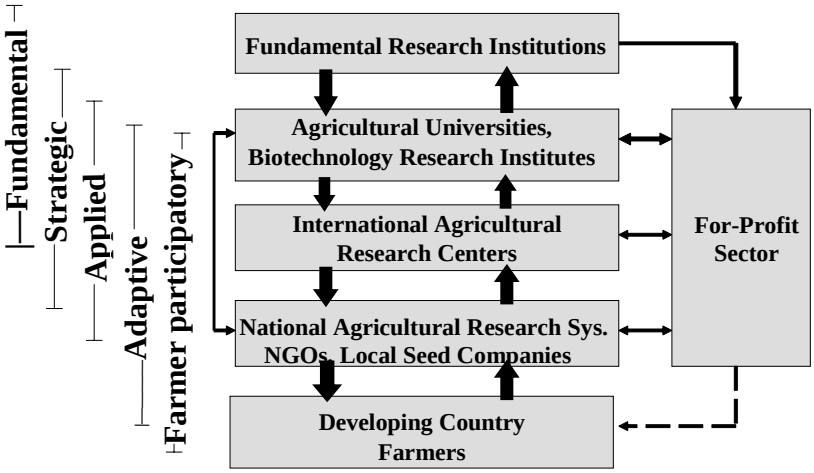
Gary Toenniessen

The Rockefeller Foundation, New York, USA

Seeds form the foundation of all agriculture. Without seeds there is no next season's crop. The genetic traits embodied within seeds reflect and determine the nature of farming systems dependent on them. The prevailing methods of developing, accessing and exchanging improved seeds and other planting materials determine in large measure who benefits from advances in the plant sciences, crop breeding and biotechnology.

As opposed to the health sector, where science now primarily leads to only high-priced end products, we in the agricultural sector are fortunate to still have both a strong public sector international research systems (Figure 1) that can "prime the pump" of crop varietal improvement, and if necessary, deliver affordable end products to poor farmers, and a private sector seed system that can add value to crop varieties and increase the efficiency and sustainability of seed deliver systems. For many years, the public sector and private sector seed systems have functioned in parallel, and sometimes in partnership – often strengthening and seldom impeding each other (Figure 2).

Figure 1. The International Agricultural Research System



Publicly funded agricultural research has traditionally played and continues to play an essential role in developing and disseminating improved crop varieties: 1) for poor farmers who have limited purchasing power, and 2) when and where seed sales are thought to be unprofitable by the private sector. In many regions of the world such "public sector" crop varieties have led to significant increases in farm productivity and profitability.

From 1960 to 2000, over 400 public breeding programs in over 100 countries released over 8,000 modern varieties of staple crops derived in part through this international network (Evenson and Gollin, 2003). As indicated in Table 1, roughly three-quarters of the cultivated land in Asia is now planted to such modern varieties.

Figure 2. Crop Variety Development Pipeline

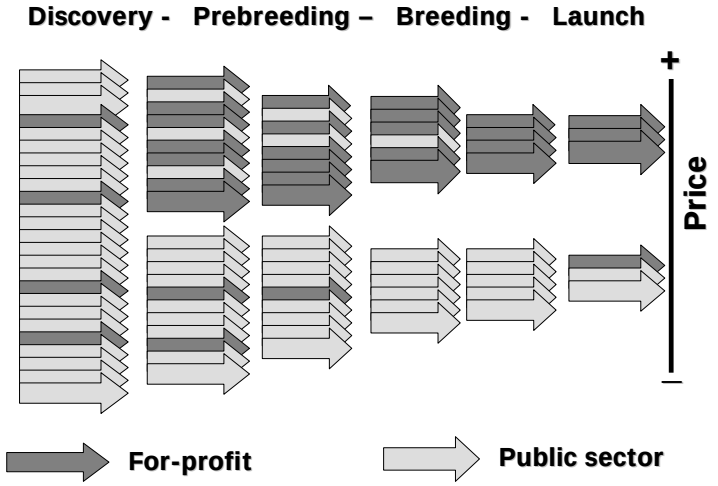


Table 2 summarizes the yield increases achieved in developing countries for the most important of these crops over the last 40 years. For rice, maize and wheat, which together provide more than half of the food energy consumed in developing countries average yields more than doubled. With increased production food prices dropped, average caloric intake rose and there were corresponding gains in health and life expectancy. In Asia the proportion of the population suffering form chronic hunger dropped from 40% to less than 20% while the overall population doubled.

Table 1. Cultivated Land in Modern Varieties(%)

	1970	1980	1990	1998
Asia				
Wheat	19	49	74	86
Rice	10	35	55	65
Maize	10	25	45	70
Sorghum	4	20	54	70
Cassava	-	-	2	12
S-S Africa				
Wheat	5	22	32	52
Rice	-	2	15	40
Maize	1	4	15	17
Sorghum	-	8	15	26
Cassava	-	-	2	18

Source: UNDP

Small scale farming thus became the engine of national economic development. And, as the purchasing power of farmers increase, they are able to afford even better crop varieties marketed by the private sector. This process has benefited literally billions of poor people and is one of science's greatest accomplishments.

Table 2. Increases in Developing Country Yields from 1962 - 2002

	1962 t/ha	2002 t/ha	% Rise
Wheat	**0.9**	**2.7**	**200**
Rice	**1.8**	**3.9**	**117**
Maize	**1.2**	**3.0**	**150**
Sorghum	**0.7**	**1.1**	**57**
Potato	**8.6**	**15.2**	**77**
Cassava	**7.5**	**10.7**	**43**

Source: FAO

The advent of biotechnology now presents a number of challenges (proprietary property, regulations, public acceptance) to these established seed systems, particularly to the public sector's ability to deliver inexpensive improved crop varieties. Increasingly, enabling technologies and information used to produce improved varieties are protected as proprietary property by both the private and public sectors.

Industrial countries have made intellectual property rights (IPR) an important component of international trade negotiations, using them to exploit their competitive advantage in research and development. Countries joining the World Trade Organization, for example, must have IPR systems that include protection of crop varieties, according to the Trade Related Aspects of Intellectual Property Rights (TRIPS) provisions. The least developed countries have only until January 1, 2006, to implement such IPR systems.

Because poor farmers cannot afford to purchase new seed for each planting, it is important that developing-country IPR laws are modeled on plant variety protection systems that include provisions allowing farmers to save and replant seed and plant breeders to use varieties for further breeding. This is in contrast to the utility patent system that extends protection to the seed and progeny of patented plants so breeders cannot legally use protected varieties as breeding material.

Ironically, a major IPR change that is threatening the operations of the international agricultural research system comes from public, not private sector research institutions. To promote technology transfer and product development in the United States, the 1980 Bayh-Dole Act gave universities and other public funded research institutions the right to obtain patents on and commercialize inventions made under government research grants. Similar arrangements have emerged in most other industrialized countries. The result is that while many biotechnology discoveries (e.g., pathogen-derived plant resistance to virus infection) and enabling technologies (e.g., *Agrobacterium* and biolistic transformation methods) are generated with public funding in research institutions and agricultural universities, these discoveries are no longer being treated as "public goods". Rather, they are being patented and licensed, often exclusively, to the for-profit sector (Graft, et al., 2003). Such discoveries now primarily flow from the public sector to the for-profit sector and if they flow back out usually come under material transfer agreements (MTAs) that significantly restrict their use, usually for research purposes only and often include reach-through provisions to capture results of future research.

Since crop genetic improvement is a derivative process, each incremental improvement made through biotechnology now comes with a number of IP constraints, with new IP added with each transfer or further improvement (Barton and Berger, 2001). To deal with this

predicament, the private sector is becoming greatly centralized through a large number of mergers and acquisitions.

The publicly funded agricultural research community, for the most part, lacks “freedom to operate”. Leading academic researchers are primarily interested in research competitiveness. They readily sign research MTAs to gain access to the latest tools but are then restricted from further transferring their research products. Many universities now have “technology transfer offices” where maximizing licensing and royalty income is just as important as technology transfer, and often achieved by granting exclusive licenses. The net result is that improved plant materials produced by academics are highly IP encumbered and commercially useful only to companies having an IP portfolio covering most of the technologies used.

The international agricultural research system does not have a significant IP portfolio and as a consequence the traditional flow of materials through the system is breaking down, particularly where useful new technologies and improved plant materials had flowed from public sector researchers in developed countries to international centers and national crop improvement programs in developing countries. Africa, in particular, is being short changed of the benefits of biotechnology because, unlike Asia and Latin America, its public sector has little capacity to use biotechnology for the benefit of poor farmers, even in countries where the IP is not protected. Africa is much more dependent on partnering with others but publicly funded researchers in industrial countries are no longer partners who can freely share their most important discoveries and products.

New mechanisms are needed to re-establish and re-invigorate the linkages between universities and the international agricultural research system, and to build new linkages to the expertise and resources of the private sector.

Progress is being made. In the public sector, twenty-five of the leading agricultural universities and plant research institutes in the United States have established a consortium called the Public Intellectual Property Resource for Agriculture (PIPRA) (Atkinson, et al., 2003). These universities have generated much of the intellectual property in crop biotechnology, but they have also entered into exclusive licensing agreements for this IP with the private sector. These agreements often eliminate their ability to share their technologies with other public-sector institutions such as national and international research centers that are working on new crop varieties for poor framers in developing countries.

For many public universities, the practice of exclusive licensing has also constrained their ability to generate specialty crops for farmers of their own states and countries – a mission that is often part of their charters. There are dozens of new transgenic varieties of crops like strawberries, apples and lettuce in university greenhouses; plants that can grow without pesticides, that would benefit both local farmers and the environment, and that were paid for with taxpayer dollars, but are not being brought to market (Gianessi, et al., 2002). Neither universities nor small companies have sufficient IP rights to commercialize them, and the companies that hold the rights are only interested in major crops like corn, soybean and cotton.

The irony is that, collectively, the universities originally obtained IP rights but have exclusively licensed away rights to the enabling technologies they themselves now need. To correct this problem, the universities involved in PIPRA will promote licensing strategies that favor retention of some of the rights to their own technologies, while still realizing a return on licensing the major market rights to the private sector. The licenses they grant will therefore no longer be exclusive. The universities will retain and share rights to use their technologies for humanitarian purposes, and also for the development of specialty crops for which markets are small and which do not compete with the large private companies. By maintaining a public database, PIPRA will also provide information about technologies that are now available to the public sector without IP constraints. It will also explore IP pooling

mechanisms designed to help scientists develop new crops that can truly reach those that are most in need (see www.pipra.org).

The African Agricultural Technology Foundation (AATF) is a new institution designed to promote public-private partnerships that benefit African agriculture. The AATF is an African-based and African-led facilitative organization that will operate by creating partnerships with existing organizations. The AATF will not be aimed primarily at distributing finished products. Rather, it will be a focal point where Africans can access new materials and information on which technologies can be built. It is a way of giving very poor nations the tools to determine what new technologies exist in the public and private sectors, which ones are most relevant to their needs, how to obtain and manage them, and how to develop nationally appropriate regulatory and safety regimes within which to introduce these technologies.

The AATF will transfer materials and knowledge, offering its partners access to advanced agricultural technologies that are privately owned by companies and other research institutions, usually on a royalty-free basis. In exchange for access to these technologies, the AATF will identify partner institutions that can use them to develop new crop varieties that are needed by resource-poor farmers, conduct appropriate biosafety testing, distribute seed to resource-poor farmers, and help create local markets for excess production. Most of the major international seed companies and the US Department of Agriculture have expressed serious interest in working with the AATF to accomplish its goals. The AATF will provide the organizational stimulus to bring together the elements of the public-private partnerships. The existence of new technologies with great potential, not only for food security but also for income generation by resource-poor producers, and the willingness of companies to collaborate make this the right time to bring these elements together (see www.aftechfound.org).

Hopefully new organizations like PIPRA and the AATF will enable millions of the world's farmers with limited purchasing power to continue to be provided with affordable improved crop varieties that can help make their farms more profitable and build their purchasing power. Over time they too can then become important customers of private seed companies. The key to such success is for the public sector and private sector to work together to maintain and strengthen the parallel crop variety development system depicted in Figures 1 & 2.

References

Atkinson RC, et al. (2003). Public sector collaboration for agricultural IP management. *Science* 301: 174 - 175.

Barton J, Berger P (2001). Patenting agriculture. *Issues in Science and Technology* 17: 43 – 50.

FAO (2002) FAOSTAT. Food and Agriculture Organization of the United Nations. Rome.

Gianessi L, Silvers C, Sankula S, Carpent J (2002). Plant biotechnology: current and potential impact for improving pest management in US agriculture: an analysis of 40 case studies. National Center for Food and Agricultural Policy, Washington, D.C.

Graff DG, Cullen SE, Bradford KJ, Zilberman P and Bennett AB (2003). The public-private structure of intellectual property ownership in agricultural biotechnology. *Nature Biotechnology* 21: 989-995.

UNDP (2002) Human Development Report 2001: Making new technologies work for human development. United Nations Development Programme. New York.