Political Economy and Sociology of Agricultural Biotechnology

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Introduction

The commercial development of biotechnology in agriculture and the rapid emergence of GMOs (genetically modified organisms) on our tables have caused the severe controversy over food safety as well as adverse effects on the environment. Although I can't evaluate the safety of GMOs properly, and I understand the potential of this technology as a beneficial tool for farmers, consumers, and developing countries, I dare to say, as a social scientist, that we can't say that there is no question about such a potential if we understand the political and socio-economic context of this technology.

The purpose of this paper is to explain how sociologists and political economists discuss the nature and role of science and technology in general, and agricultural biotechnology in particular.

1. Rhetoric of Neutrality Questioned

There are three points of view with the respect to the use of this technology as seen by sociologists and political economists. First, it is discussed that the rhetoric of neutrality embedded in the science and technology should be questioned, because it tends to mask a series of social contradictions. Actually, the current development in biotechnology reflects a decision-making process in which commercial and political interests override various concerns raised by civil society (Figure1) [Hisano 2001].

Figure.1: Major Factors Influencing Innovation

There are some consumers who misunderstand this technology and fear to eat "Frankenstein-foods." However, we should admit that consumers' concerns are getting beyond this simple fear. They've come to recognize the adverse effects on the environment and the institutional failures in risk management as revealed in the U.S. case of Starlink® corn. They also have come to recognize the political and market power behind the commercialization of GMOs pushed ahead without sufficient risk management. Then, what about the claim that GM technology can help to feed the world? If this is true, concerned citizens must accept this technology to some extents, even if some associated risks would be perceived, and even if some political and market interests would be involved behind the working of science and technology. We know that it is necessary to solve the world food problem, and that GM technology is considered as a beneficial tool to address the problem. However, this premise should be questioned here.

2. Can GM Technology Help to Feed the World?

The world population is expected to grow to 8.9 billion by 2050, from 6 billion today. By then, 84% of people will be in the developing countries. Even recent years, around 790 million people go hungry annually［FAO 2000］. There are three possible choices for future agriculture to address the world hunger. **First** is to expand the area of farmland, but with the result of deforestation and loss of biodiversity irrespective of breeding and cropping technology. Thus, we cannot choose this option. **Second** is to increase production in agricultural exporting countries（ex. USA）, so that food can be sold to those who need it. Current GM crops will allegedly contribute to this second option, because they are very suitable to large, mono-cropping, and corporate-style farming in those exporting countries. However, nowadays even in the US, there has been raised a question whether farmers can get enough benefits from GM technology［Benbrook 2001a, 2001b; Duffy 2001］. In some cases, GM crops would enable farmers to increase yield with less chemicals, but in other cases they would cause adverse effects. This is partly because current GM crops are based on monoculture, and they make little difference in problems like a resurgence of herbicide tolerant weeds or insecticide tolerant bugs, with the result that farmers can't get out of "pesticide treadmill" and will continued to be vulnerable to natural disaster. It is also questionable whether food trade will solve world hunger［Lappé et al. 1998］. As a matter of fact, under the expansion and liberalization of world food trade, the situations of food security in third world countries have worsened. Agriculture in those countries is basically not competitive. They have to import their food, and in order to keep stable import they have to earn foreign currency by exporting cash crops instead. This type of "inter-dependency" has prevailed between the north and the south based on the theory of "comparative advantage." But it has just resulted in social and economic deterioration in those countries.

Now, I turn to the **third** option, which is to increase total farm productivity in the countries that most need the food. The question here is "Can GM technology help developing countries to increase their productivity and improve their food security?"

Feeding the World is not a Simple Problem

When advocates of biotechnology support such a discourse as "GM can help to feed the world," they always focus on increasing productivity without thought of distribution problems［AgBio Forum 1999］. Biotechnology may address concerns such as the amount and quality of food available, but it does not deal with issues of access and distribution. Feeding the world is not a simple problem. Although we now actually produce enough food in the world to feed everyone with a nutritious and adequate diet, there are still some 800 million hungry people. An important factor is poverty. People are hungry because they are poor. They simply do not have the money to buy the food they need. Poor farmers cannot afford expensive "modern" technologies. Basically, what they need is an easily available and cheap means to improve their farms and livelihoods, as well as lands to cultivate by themselves for themselves. FAO's report admits this fact: "World food security, therefore, is not an essentially technical, environmental or demographic issue in the short term: it is first and foremost a matter of grossly inadequate means of production of the world's poorest peasant farmers who cannot meet their food needs. It is also a matter of insufficient purchasing power of other poor rural and urban consumers" [Mazoyer 2000:193].

Some NGOs in the developing world insist that they need vitamin M (money) and vitamin L (land), rather than vitamin A in the context of the development of "golden rice," which is genetically modified to contain beta-carotene for poor people suffering from lack of vitamin A (VAD) [MASIPAG 2001]. They also criticize that most of money and resources have been invested in this expensive high-tech solution, while there are many vitamin-rich vegetables, legumes and pulses traditionally grown in those poor countries, which have been abandoned during the Green Revolution [GRAIN 2000]. If poor people cannot be in the market, these "modern" technologies will not make any difference for poor farmers, because these technologies have been developed by transnational corporations whose priority is to seek and maximize their profit, and poor farmers cannot be their customers. Professor Terry Marsden at the University of Wales, a member of the research programme supported by the Economic and Social Research Council, UK, argues that GM technologies are likely to further speed up the structural change in agriculture and food supply, making it more difficult for small and poor farmers to stay on the land. "GM foods could therefore provide another cause of inequality, unemployment and depopulation in rural areas around the world," he says [ESRC 1999:10].

Seeking "Appropriate Biotechnology" is Possible?

Some companies are collaborating with researchers in third world countries to develop poor farmer-oriented GM crops, such as virus resistant sweet potatoes in Kenya [Alvarez 2000]. But, even this is criticized as just a "showcase" for companies' public relations. No one can expect that their patented technologies and resources will continue to be available freely or cheaply to poor countries.

Still, it is fair to say that improvements to farming will arise from GM technology **if** the research is public-funded for the public good [Persley & Lantin 1999]. However, I'd like to remind you of the fact that handful transnational companies, such as Monsanto, DuPont, and Syngenta, control almost all the key technologies and resources (Table1). Other than NGOs, this issue has been warned by international organizations and aid agencies including FAO, UNDP, CGIAR, and several foundations, many of which are basically in favor of GMOs. Take the case of the plan for "terminator technology," in which

Table 1 : Bio-Majors Control Everything

Companies	World pesticide (mil$, rank)		World seed (mil$, rank)		US corn seed (%, rank)		US biotech patent (%, rank)		Bt gene related patent	OECD regist. GMOs	Corn/Soy GMOs in field test
	2000		2000		1997		-1998		-1996.6	-2000.8	-2001.5
Syngenta (Swiss)	6,100	①	958	③	9.0	③	13.0	③	46	5	185
Monsanto (USA)	4,100	②	1,600	②	14.0	②	21.0	①	43	26	1,629
Aventis (France)*	3,400	③	267	⑩	7.0	④	6.0	⑤	22	19	346
BASF (Germany)	3,400	④	-		-		n.a.		4	2	-
DuPont (USA)	2,500	⑤	1,938	①	42.0	①	20.0	②	5	7	848
Dow (USA)	2,100	⑥	350	⑦	4.0	⑤	11.0	④	22	-	113
Bayer (Germany)*	2,100	⑦	-		-		n.a.		n.a.	-	-
Share of Top 7	80%		21%		76%		71%		51%	79%	85%

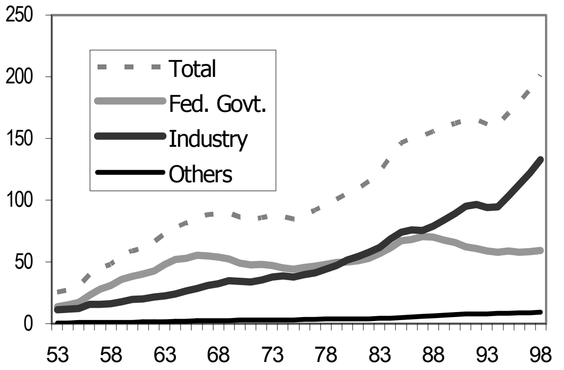
Note: Bayer announced the agreement to acquire Aventis CropScience last year.

Source: Compailed by author from various source of information.

seeds are engineered to die after one year so that farmers cannot save these seed and use it again. Will this really benefit the two billion people in developing countries currently relying on unimproved agricultural system? Thus, it is natural that Rockefeller Foundation President Gordon Conway persuaded Monsanto not to commercialize this technology [Conway 1999]. Apart from the "terminator technology," current policy to strengthen and harmonize intellectual property rights globally should be also taken into consideration. It is needless to say that developing countries will be at a disadvantage in such a institutional condition.

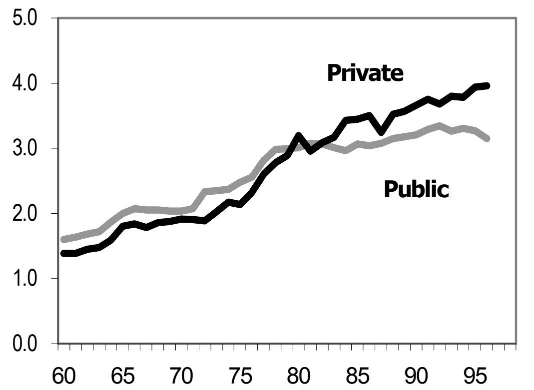
Additionally, in recent years, public institutions and universities, whether located in the north or the south, are suffering from lack of financial resources and cannot but depend on external funds from these companies (Figures2&3, Table2). Therefore, even if researchers in these public institutions and universities want to focus on biotechnology for the benefit of all countries and farmers, not just those who can afford it, they would only notice they don't have enough funds available to them for this kind of research.

Figure 2: U.S. R&D Expenditure, by source of funds (US billion $, 1992)



Source: National Science Board. 2000. Science & Engineering Indicators 2000. Arlington, VA:National Science Foundation.

Figure 3: U.S. Agricultural Research Funding (US billion $, 1996)



Source: USDA, Current Research Information System.

Table 2: R&D Expenditures at U.S. Universities, by source of funds

(US million $, %)

Source	1975		1980		1985		1990		1995		1999	
Land-Grant Universities and Colleges												
Federal Govt.	138	*31.0*	262	*34.2*	369	*32.8*	516	*32.4*				
State/Local Govt	285	*63.7*	456	*59.5*	678	*60.2*	950	*59.7*				
Industry	24	*5.4*	48	*6.3*	79	*7.0*	127	*8.0*				
Public and Private Universities and Colleges												
Federal Govt.	2,288	*67.1*	4,098	*67.6*	6,604	*64.6*	9,638	*59.2*	13,326	*60.1*	16,047	*58.4*
State/Local Govt	332	*9.7*	491	*8.1*	752	*7.4*	1,324	*8.1*	1,689	*7.6*	2,028	*7.4*
Industry*	113	*3.3*	236	*3.9*	560	*5.5*	1,127	*6.9*	1,488	*6.7*	2,048	*7.5*
Institutional Funds*	417	*12.2*	835	*13.8*	1,617	*15.8*	3,006	*18.5*	4,046	*18.3*	5,366	*19.5*
All other sources	259	*7.6*	403	*6.6*	694	*6.8*	1,191	*7.3*	1,613	*7.3*	2,000	*7.3*
Total	3,409	*100.0*	6,063	*100.0*	10,227	*100.0*	16,286	*100.0*	22,161	*100.0*	27,489	*100.0*

Note: Industry R&D support is limited to grants and contracts for R&D activities from profit-making organizations. Total industry funds excludes research funded through unrestricted accounts and from corporate foundations, endowments, and fellowships to students; those funds would be included in an institution's funding totals. Please remark that an increasing number of institutions have linkages with industry and foundations via sobcontracts.

Source:Weatherspoon, D.D., J. Ohemke, and K.C. Raper. 2000. An Era of Confusion: The Land Grant Research Agenda and Biotechnology. Staff Paper 2000-26. Dept of Agricultural Economics, Michigan State University; National Science Foundation, Academic Research and Development Expenditures: Fiscal Year 1999, Arlington, VA: National Science Foundation.

We Need Paradigm Shift

It is relatively easy to point out negative aspects of GM technology. But, if we simply assess GM crops and foods against conventional agricultural practices, i.e. industrialized and unsustainable agriculture, we would feel no reluctance in approving the benefits of this new technology. What is needed, however, is to evaluate various different vision for agriculture and the place of GM technology with that [ESRC 1999]. It doesn't make sense to assess new technology in comparison with conventional agriculture. It is time to consider a "paradigm shift" in the direction of agricultural development. Actually there are a lot of projects for sustainable agriculture all over the world. According to Professor Jules Pretty at the University of Essex, who surveyed more than 200 projects of sustainable agriculture from 52 countries, the proportional yield increases were remarkable [Pretty 2001]. Besides food increases, he also shows that these projects could make better use of locally-available natural resources, and that they have improved human capital building through education [Pretty 2000].

In spite of such advantages, these activities for alternative agriculture have been falling behind in research and investment when compared to the progress being made within the agricultural biotechnology sector. In my opinion, if we change the allocation of money and resources, even only a small portion of them, from big science and technology to these local-farmer-oriented projects, we can solve many problems. I'm not saying that we should stop all research and development of GMOs. I'd like to say that keeping balance is important. Clearly, a sustainable agricultural system can be economically, environmentally, and socially viable, and contribute positively to local livelihoods.

In order to realize the potential of such a practice, we need appropriate support from policy makers and academics. It is not easy for academic researchers to consider a "paradigm shift" because these alternative ideas are still unlikely to be a favorable target for competitive funds. But, these discussions about the need of alternative paths are not confined within the literature of Sociology and Political Economy, but also made in the international negotiating processes such as Earth Summit in 1992, FAO's World Food Summit in 1996, the Biosafety Protocol to the Convention on Biological Diversity in 2000, and so on.

3. Limitations of "Sound-Science" Approach and Economic Approach

The second viewpoint of the Sociology and Political Economy is that we should recognize the limitation of "sound-science" approach, which is characterized by the widespread assumption that the safety and acceptability of commercial GM agriculture can be settled by science alone [Wynne 1999]. This is because there remains a great deal of uncertainties associated with the potential impacts of this new technology. For example, scientists are able to analyze the chemical composition of GM crop and compare it with the chemical composition of conventional counterpart. But, we are now talking about enormously complex interactions among a number of systems from gene, cell to living organism, from human body to ecosystem. Current sciences can address each part of these systems precisely, but there remain a lot of unknown mechanism as a whole. Standard risk assessments currently prevailed, which is based on the idea of "substantial equivalence," are unable fully to evaluate uncertainties about fundamental, multiple, or long-term effects.

It is often discussed that we can utilize economic approach to assess a new technology and make a decision whether we should adopt it or not beyond scientific uncertainty. However, we should also recognize the limitation of economic approach, which is characterized by cost/benefit analysis. This is because any decisions about which "cost" and/or "benefit" to whom ought to be considered, as well as any interpretation of how technical risk/benefit analysis will work into economic values, are made by some actors without any objective, universal measure. As in the case of environmental assessment of big construction projects, economic assessment of new technology is likely in favor of actors who have economic and political power. In short, no scientific method can create an absolute and objective criteria or one decision rule to cope with these uncertainties.

4. Democratization of Science and Technology

If there is no one decision rule, what should we do? In European countries, a new principle, called the precautionary principle, has been emerging during the past decade. It is summarized as follows: When an activity raises threats of harm to human health or the environment, precautionary measures should be taken even if some causes and effect relationships are not fully established scientifically. But, this principle is not a algorithm for making decisions, but a principle on which to base decisions. Based on this principle, how to make a decision or a consensus remains open to discussion and negotiation. Here we can find a political arena of science and technology, and this is the final point discussed in the literature of Sociology and Political Economy. Democratization of science and technology through citizens' involvement in the decision-making processes is important, because many areas of science and technology directly influence the general public. Decisions must be accomplished through a process of debate and negotiation in which all stakeholders have a voice.

Consensus Conference in Japan

There are several ways of democratizing science and science policy, including public hearings and forum, advisory and oversight panels and councils, public surveys, consensus conference, and science shops ［Lacy 2000:17］. In Japan, for example, the consensus conference on GM crops was held in 2000, following the successful experiences in several European countries. The conference was convened by one of the public research institution, entrusted to by the Ministry of Agriculture ［STAFF 2001］. The objective of a consensus conference is to broaden the range of participants from the general public with diverse backgrounds and also to bridge the gap between the general public and the experts (Figure4)［Joss & Durant 1995］. In the Japan's case, 18 citizen panelists were selected from nearly 500 ap-

Figure 4: Democratizing Process in Consensus Conference

plicants and provided with basic information about the topic. They made "key questions" by themselves based on discussion among the citizen panel. After that, some experts replied to the questions and discussed the related issues. The expert panel was composed of 11 members including both natural and social scientists, government staff, NGO members, and a company manager. According to the review of the conference made by some sociologists [Hirakawa 2001], what was the most impressive for the citizen panel was the discussion of the social scientists especially in respect to its difference from the discussion of the natural scientists and other proponents. For example, scientists engaging in research and development of GMOs were likely to say that its risks and benefits ought to be evaluated independently of the socio-economic conditions. Oppositely, social scientists argued that the evaluation should be based on the context of the ongoing transformation of the agrifood system characterized by monoculture, unfair trade of foods between the south and the north, concentration of the agri-food markets controlled by transnational agribusiness companies, and so on. In their discussion, there remain a lot of unsolved questions apart from the technological or safety aspects of GMOs.

Here we find another form of democratization of science: to bridge the gap between natural science and social science.

Conclusion

The implication I want to derive from these discussions is to show the necessity of interdisciplinary research to evaluate this new technology or the direction of its innovation, as well as the importance to bridge the gap between general public and experts through well-informed democratic debate and negotiations in which all stakeholders are involved and have a voice evenly. As shown in the Appendix, the Declaration on Science and the Use of Scientific Knowledge adopted in 1999 at the UNESCO's Conference emphasizes the same things.

In my opinion, through collaboration between the fields, natural scientists and technologists should acquire "socio-political literacy," while social scientists should acquire "scientific/technical lit-

Appendix: Declaration on Science and the Use of Scientific Knowledge

(Adopted by the World Conference on Science, 1 July 1999, UNESCO)

Preamble

1. ......The nations and the scientists of the world are called upon to acknowledge the urgency of using knowledge from all fields of science in a responsible manner to address human scientific endeavor, that is the natural sciences such as the physical, earth and biological sciences, the biomedical and engineering sciences, and the social and human sciences. While the Framework for Action emphasizes the understand their impact on and relations with society, the commitment to science, as well as the challenges and the responsibilities set out in this Declaration, pertain to all fields of the sciences. All cultures can contribute scientific knowledge of universal value. The sciences should be at the service of humanity as a whole, and should contribute to providing everyone with a deeper understanding of nature and society, a better quality of life and a sustainable and healthy environment for present and future generations.

4. Today, whilst unprecedented advances in the sciences are foreseen, there is a need for a vigorous and informed democratic debate on the production and use of scientific knowledge. The scientific community and decision-makers should seek the strengthening of public trust and support for science through such a debate. Greater interdisciplinary efforts, involving both natural and social sciences, are a prerequisite for dealing with ethical, social, cultural, environmental, gender, economic and health issues. Enhancing the role of science for a more equitable, prosperous and sustainable world requires the long-term commitment of all stakeholders, public and private, through greater investment, the appropriate review of investment priorities, and the sharing of scientific knowledge.......

eracy." This is the indispensable step for academic researchers to fulfill our social responsibilities. Unless there were sufficient and appropriate dialogues among different expertise, especially between natural and social sciences, any attempts to inform citizens and build consensus would be in vain.

References

AgBioForum. 1999. "Special Issue: The Economics of Biotechnology in Developing Countries," *AgBioForum*. 2.3-4.

Alvarez, David P. 2000. "Connecting People to the Promise of Biotech: Update of the ISAAA Fellowship Program in Africa and Southeast Asia," *ISAAA Briefs*. 14. Ithaca, NY: ISAAA.

Benbrook, Charles M. 2001a. "Troubled Times Amid Commercial Success for Roundup Ready Soybeans," *AgBioTech InfoNet Technical Paper*. 4.

Benbrook, Charles M. 2001b. "Factors Shaping Trends in Corn Herbicide Use," *AgBioTech InfoNet Technical Paper*. 5.

Conway, Gordon. 1999. "Remarks to the Monsanto Board of Directors," *Foundation News*. June 24, Washington D.C.

Duffy, Michael. 2001. "Who Benefits from Biotechnology?" a paper presented at the American Seed Trade Association Meeting, December 5-7, Chicago, IL.

ESRC Global Environmental Change Programme, *The Politics of GM Food: Risk, Science and Public Trust*. Brighton: University of Sussex.

FAO. 2000. *The State of Food Insecurity in the World 2000*. Rome: FAO.

GRAIN. 2000. "Engineering Solutions to Malnutrition," *GRAIN Briefing*. Available on the web site http://www.grain.org.

Hirakawa, Hideyuki. 2001. "Provisional Report on the GM Crops Consensus Conference in Japan," a paper presented at the workshop of the European Association for Studies of Science & Technology, February 8-9, Lisbon.

Hisano, Shuji. 2001. "Political Economy of Industrialization of Agricultural Biotechnology," a doctoral dissertation at Hokkaido University, written in Japanese.

Joss, Simon, and John Durant, eds. 1995. *Public Participation in Science: The role of consensus conferences in Europe*. London: Science Museum.

Lacy, William B. 2000. "Empowering Communities Through Public Work, Science, and Local Food Systems: Revisiting Democracy and Globalization," *Rural Sociology*. 65.1, pp.3-26.

Lappé, Frances M., Joseph Collins, Peter Rosset. 1998. *World Hunger: Twelve Myths*. NY: Grove Press.

MASIPAG. 2001. *Grains of Dulusion: Golden rice seen from the ground*. Available on the web site http://www.grain.org.

Mazoyer, Marcel. 2000. "The Socio-economic Impact of Agricultural Modernization," in FAO, *The State of Food and Agriculture: Lessons from the Past 50 Years*. Rome: FAO, pp.171-198.

Persley, Gabrielle J., and Michael M. Lantin, eds. 2000. *Agricultural Biotechnology and the Poor*. Proceedings of an International Conference on Biotechnology, convened by CGIAR and U.S. National Academy of Sciences, 21-22 October, 1999, Washington D.C.,

Pretty, Jules. 2000. *Genetic Modification: Overview of Benefits and Risks*, a paper posted on the web site of Centre for Environment and Society, University of Essex.

Pretty, Jules. 2001. "Against the Grain," *The Guardian*. January 17.

Society for Techno-innovation of Agriculture, Forestry and Fisheries. 2001. *Brief Report: Consensus Conference on Genetically Modified Crops*. Tokyo: STAFF.

Wynne, Brian. 1999. "Bitter Fruits: The issue of GM crops is too important to leave to science alone," *Guardian Science*. 16 September.

This paper is based on the presentation made at the Seoul National University – Hokkaido University 4th Joint Symposium, October 21-23, 2001, Seoul: S.Korea.

Figure 4: Democratizing Process in Consensus Conference

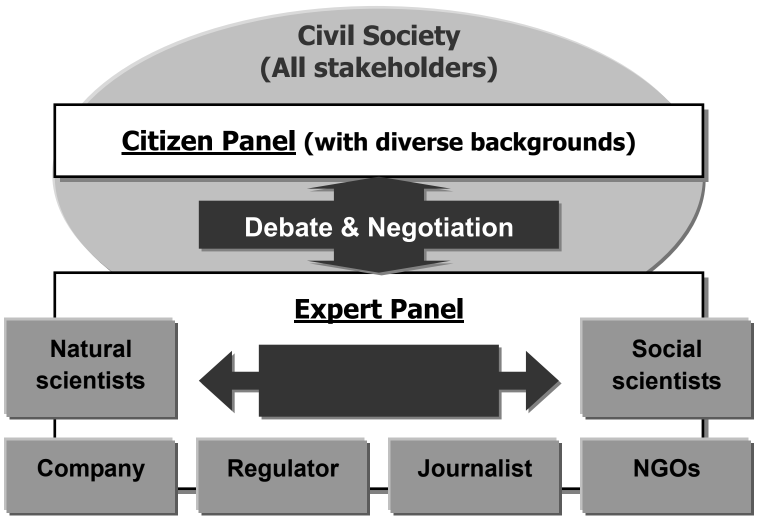


Figure 1: Major Factors Influencing Innovation