The Reinforcement of External Seed Dependency

- Will the agricultural biotechnology feed the hungry? -

Masako Yoshida
A0151241

International Relations Minor
Department of English Language and Studies
Sophia University
Professor Masatsugu Shimokawa

March 7, 2004

Contents

I. Introduction

The industrialization of agriculture, represented by the Green Revolution and the Gene Revolution, has been introduced in the 20th century throughout most parts of the world to increase food production and in consequence, to end hunger. With the growing population, environmental destruction, and natural disasters, it was thought that the advancement in biotechnology to increase food production was the panacea for solving hunger and food issue for the future.

However, the fundamental problem of the hunger is not the productivity. The root causes for the problem of starvation is the inequality of food distribution and the fundamental principles of the market mechanism which makes poor people poorer and rich people richer. There is enough evidence that the world is producing enough food to feed twice its population. Yet, there are about 842 million people in the world suffering from malnutrition, 797 million of them living in the developing countries. One person per second is dying from hunger. Food is in the state of satiation in the developed countries and the upper classes of developing countries whereas the poor people of the developing countries do not have access to food because of poverty or conflicts or some other reason and are suffering from hunger.

What is happening under the industrialization of agriculture is not the miracle increase in food production, but dependence on external input, destruction of biodiversity by monoculture, depletion of natural resources, indebtedness in the developing countries, and the polarization of the rich and the poor. With the invention of Norman Borlaug's hybrid seed in the 1940's, the Green Revolution spread from Mexico to Asia, and to Africa in the 1970's, with the initiative of the United States and the international agencies in the name of food aid. Though the Green Revolution was mainly conducted by the public sector, which aims to reduce poverty and hunger (cf. private sector's objective is the profit of their own firm), it was not successful in addressing the problems of the poor. With the back up of the nature of hybrid seed and regulations that protect intellectual property rights over plant varieties, the role of seed companies changed significantly in 1970's and 1980's, starting a Gene Revolution. Huge conglomerates emerged in the developed countries, with few companies dominating research and development, distribution, and marketing of seeds over the world. Beginning in the 1990's and until now, the major controversy on biotechnology is the genetic engineering. There is still strong opposition to the introduction of genetically engineered food, especially in Europe and Africa. However, the US is forcing GM food aid to the African countries to expand the market for GM food of the US companies.

In the paper, I will observe how the biotechnological revolutions have created and solidified the structure of dependency of the farmers on the commercial seed industry. Without the conversion of agribusiness structure, increasing food production may lead to increased number of hungry people. The spread of new technology to the world by the developed countries in the name of aid may only be damage to the developing countries.

I will first define the term biotechnology, and note the characters of two skills, hybridization and genetic engineering. Next, I will look at how traditional farming was conducted. Then, I will move on to the effects of Green Revolution and the Gene Revolution and how the change in the seed industry transformed the farming system and its risks. The United State's GM food aid that caused damage in Africa will be followed. I will conclude the paper addressing the problems to be solved regarding this seed issue.

II. Definition of Biotechnology

Biotechnology is, in the broad sense, any technique that uses living organisms or substances from these organisms, from viruses to bacteria to plants and animals, to make or modify a product for specific use. Biotechnology includes fermentation, brewing, and plant breeding which have been used throughout history for over millennia. From 2500 to 2000 BC, Egyptians made wine using fermentation techniques based on an understanding of the microbiological processes[1]. Prehistoric ancestors used biotechnology to yeast cells to raise bread dough, to ferment bacterial cells to make cheese and yogurt, and to breed stronger and more productive offspring. Biotechnology includes medical and industrial applications as well as many of the techniques of agriculture and food production.

Plant breeding, Hybridization

Plant breeding, or hybridization, is the process of crossing plant varieties or combining genes from two or more varieties to produce crops with favorable and improved seeds. By plant breeding it is possible to raise and stabilize yields; to improve resistance to pests, diseases and biotic stresses such as drought and cold; and to enhance the nutritional content of foods. Farmers have been responsible in selective breeding of plants to suit diverse climate, disease, and culture for more than 10,000

[1] DuPont HP http://www.dupont.com/

years. These primitive farmers, although ignorant of the natural principles of inheritance, found that they could increase the yield and improve the taste of crops by selecting seeds from particular desirable plants. Already in the 11th century, the emperor of China imported early rice varieties from India and Burma and invented a hybrid to speed up breeding from 180 to 100 days[2]. In the mid-1800s, Gregor Johann Mendel, an Austrian monk and scientist, cultivated and tested pea plants and found principles which are to be later known as Mendel's law of Heredity or Mendelian inheritance. He is known as the father of genetics and his achievement brought about a big impact on the agriculture of the 20th century.

Traditional breeding occurred mostly by the natural phenomena, while modern hybridization is conducted more deliberately. According to Mendel's Law of Dominance, when two types of characters are cross-planted, only the dominant gene appears and the recessive gene will submerge in the F1 generation. Therefore, for example, if high yielding and dwarf parental varieties are cross-planted, the F1 generation variety will be high yielding and low-height (as not to snap) Hybridization can be used to produce preferable varieties artificially, such as high yields, uniformity, early breeding, resistance to disease, and delicacy[3]. Most of our nourishment today is produced by F1 seeds.

However, the negative points about hybridization are that it is very time consuming and that the seed supply will be dominated by the market. It is time consuming in two ways; many generations may be required before the desired combination of traits is found, and to stabilize the preferable character into a variety[4] (Figure1). By Mendel's Law of Segregation and Mendel's Law of Independence, the preferable character of the parental plants will emerge only in the F1 seed, and unfavorable character will be inherited to the F2 seed (the offspring of F1). Therefore producing seed from F1 hybrids is unsuitable and farmers will have to purchase seed every year from seed companies. It will be mentioned later that huge conglomerates are dominating the seed market.

Genetic Engineering

The new kind of biotechnology, genetic engineering, has brought up significant controversy over the past 10 years. The Cartagena Protocol on Biosafety defines

---

[2] P.R. Mooney, *Seeds of the Earth* (Japanese translation rights arranged with Canadian Council for International Co-operation through Japan UNI Agency, Inc, Tokyo, 1979), p.8

[3] CSO Peace Seed HP http://www.peaceseed.org/

[4] Minoru Nishimura, Techno Diagram: Biotechnology(Tokyo: Touyoukeizaishinnpousha, 2001), p.90

biotechnology narrowly as the application of:

a. In vitro nucleic acid technique, including recombinant deoxyribonucleic acid (DNA) and direct injection of nucleic acid into cells or organelles, or

b. Fusion of cells beyond the taxonomic family, that overcome natural physiological reproductive or recombination barriers and that are not techniques used in traditional breeding and selection[5].

The terms “GMO,” “transgenic organism” and “genetically engineered organism (GEO)” are technically different, but are often used interchangeably and will be used as synonyms in this paper. Recombinant DNA techniques, genetic modification, or genetic engineering is “the modification of an organism's genetic make-up using transgenesis, in which DNA from one organism or cell (the transgene) is transferred to another without sexual reproduction[6].”

The advantages of genetic engineering are the potential of producing wide varieties and less time consuming. In hybridization, genes can be transferred through only the same species, whereas in genetic engineering, genetic material can be moved between organisms as well as the host variety. In addition, once the gene to be transferred is decided, the outcome is predictable and it can contribute to short-term research.

Yet, the impact and effects of genetic engineering on environment, biology, and health still needs to be carefully considered, on a case-by-case basis.

III. Traditional Agriculture

Traditionally agriculture was based on self-reliance, diversity, crop rotation, and internal input such as seeds and manure at no cost. Most farmers depended on seed saved from their own crops cultivated in the previous year and did not purchase seed from commercial sources. The seeds possessed dual character, at the both ends of crop production (Figure2). It was the material of production and the ultimate product such as grain. In addition, it was not uncommon for farmers to share surplus seed with friends and neighbors for free, as public common goods. “Agrarian rituals enact a cosmic cycle of gift exchange during which a new crop of rice is offered in return for the original seeds given by the deities.[7]” Biodiversity contributed to survive natural disasters such as floods and droughts, to resist diseases such as pests, and to offer

[5] FAO, “The State of Food and Agriculture 2003-2004”
[6] Ibid.
[7] Vandana Shiva, *Stolen Harvest* (Cambridge, South End Press, 2000), p.84

enhanced taste and biomass for medicine, housing, and food. Agriculture, nature and people co-existed.

IV. The Green Revolution

Introduction of green revolution changed the farming system, to intensification of credit, external outputs (seeds, fertilizers, and pesticides), dependence, and uniformity.

History

The major element of the green revolution was the hybrid seed. In the 1920's and the 1930's, University of Connecticut developed high-yielding hybrid corn[8]. At that time, Research and Development (R&D) of improved plant varieties was carried out almost exclusively by the public sector, such as land-grant colleges and universities, and State agricultural experimental stations[9]. A venture between the Rockefeller Foundation of the United States and the Mexican government set up a scientific mission to assist in the development of agriculture technology in Mexico in 1943. The next year, they invited Norman Borlaug from Dupont to the plant breeding program in Mexico. By the middle of the 1950's, Borlaug had invented 'miracle seeds' of dwarf wheat varieties which later on spread worldwide. In 1970, Borlaug won the Nobel Peace Prize for "great contribution towards creating a new world situation with regard to nutrition.[10]" He is considered to have saved more than billions of people from starvation from the invention of hybrid seed. On the basis of Rockefeller Foundation and the Mexican government program, a research center was made in Mexico, which in 1961 became to be known as CIMMYT, International Maize and Wheat Improvement Center or Centro International de Mejoramento de Maiz Y Trigo). Impressed with the impact of 'miracle' wheat, the Rockefeller Foundation and the Ford Foundation established the IRRI (International Rice Research Institute) in the Philippines, which by 1966 produced 'miracle' rice. The 'miracle' wheat of CIMMYT and the 'miracle' rice of IRRI are the two major players of the Green Revolution. In 1971, with the initiative

---

[8] Ohno, Tatsumi, *Biobusiness Saizensen* (Japan, Jijitsuushin Corp., 1986).
[9] Jorge Fernandez-Cornejo (et al.), *The Seed Industry in U.S. Agriculture: An Exploration of Data and Information of Crop Seed Markets, Regulation, Industry Structure, and Research and Development* (Washington DC: U.S. Department of Agriculture. Agriculture Information Bulletin Number 786, 2004), p25.
[10] Vandana Shiva, *The Violence of the Green Revolution* (Malaysia, Third World Network, 1991), p37.

of Robert McNamura, the former president of the World Bank, CGIAR (Consultive Group on International Agricultural Research) was established to finance the network of IARC (International Agricultural Research Centers). Funded by multilateral agencies, private foundations, governments of both industrialized and developing countries, CGIAR have since then played a major role in the research and development as the public sector.

Green Revolution was promoted as part of the international food aid by the United States and the international agencies such as the World Bank. It was recognized internationally that the peasantry were incipient revolutionaries in the decades of the Cold War and to improve the conditions in rural areas were means of defusing the communist appeal[11]. The American-controlled strategy was to simultaneously create material abundance in agricultural societies and reduce agrarian conflicts.

Green revolution began in Mexico in the 1940's, brought to Asia in the late 1960's and in the 1970's it spread in Africa, covering most of the developing world.

Features and Effects

The technological transformation of seed used in the Green Revolution brought 2 major changes of the meaning of seed. That is, the hybrid seed does not 1) reproduce itself 2) produce by itself. As mentioned above, when second generation crops are produced from seeds made from the F1 generation, it will result in poor yield or defective crops. Therefore farmers will have to depend on purchased seed. In addition, for high yielding outcome, hybrid seeds need adequate environment and external input such as chemical fertilizers, pesticides and water irrigation. These two features, often called the industrialization of farming[12], changed the agricultural farming system, from the harmony with nature's processes, self-reliance, diversity, and internal input at no cost, to disharmony with nature, dependence, uniformity, and external input (seeds, fertilizers, pesticides, irrigation) at high cost.

①High Yields, but Short Term

Borlaug's 'miracle' seeds were called the HYVs (the High-Yielding varieties). Proponents of the Green Revolution claimed that increasing production itself has a major impact on the poor, raising the incomes of the farmers. In fact, the yield potential and yield per hectare for the major cereals continued to rise at a steady rate.

[11] Shiva(1991), p.51
[12] Collins, Moore, Rosset, p69.

Between 1960 and 2000 in the developing countries, yields rose 208% in wheat, 109% in rice, 157% in maize, 78% in potato, and 36% in cassava[13]. However, the increase in food production was not sustainable. In many parts of the developing countries where Green Revolution was introduced, rice yields grew steadily during the 1970's, peaked in the early 1980's and have been dropping gradually ever since[14]. This is due to the degradation of soil for the overuse of chemical fertilizers and heavy irrigation. Comparing 1970 and 1990, the total food available per person rose by 11% in the world, while the estimated number of hungry people dropped 16%. But if you eliminate China from the analysis, which reduced the number of malnutrition significantly, the number of hungry people in the rest of the world increased by more than 11%[15]. Even after the Green Revolution was introduced, food imports to India prolonged at a nearly equivalent amount as the past (Table1)[16]. This means the failure to address unequal access to food. Even in Asia, where the new seeds contributed to the greatest success in high yields, it is home to two-thirds of the undernourished in the world.

②Intensive Agriculture

The HYV seeds are not high-yielding by themselves. The distinguish feature of the seeds is that they are highly responsive to certain necessary inputs, such as fertilizers and irrigation. Without the additional and appropriate inputs, the new seeds will not perform as expected. Thus, some people claim that the seeds are "High-Responsive Varieties(HRVs)[17]", instead of HYVs. The hybrid seeds resulted in high-yields because the shorter, and stiffer stems of dwarf varieties were efficient in the mass use of fertilizers and water. The consumption of fertilizers in India increased 10 times, compared between 1960 and 1975 (Figure3). In Central Luzon, Philippines, rice yield increased 13% during the 1980's but at the cost of a 21% increase in fertilizer use. In west Java, a 23% yield increase was virtually canceled by 65% increase in fertilizers and 69% increase in pesticides[18]. The new seeds also required intensive water use and irrigation. The Green Revolution brought a shift from water prudent crops such as millets and oilseeds to new wheat and rice variety monocultures which require 3 times in water use than traditional farming. By the 1970's new seeds accompanied by chemical fertilizers, pesticides, and irrigation had replaced the traditional farming practices of the third world agriculture.

---

[13] FAO, "The State of Food and Agriculture 2003-2004"
[14] Collins, Moore, Rosset,p.70
[15] Ibid, p.61
[16] Shiva(1991), p.54.
[17] Shiva(1991), p.72
[18] Collins, Moore, Rosset, p.69

③External Input

The HYV seeds, chemical fertilizers, and irrigation indispensable to the intensive agriculture were provided externally. The developing countries had to import most of their fertilizers, pesticides, irrigation equipment, and machinery, thus benefits leave the country. R&D of seeds was carried out by the public sector, mostly by the CGIAR, and the seeds were disseminated "freely as public goods"[19]. The farmers had 2 choices for the use of seeds; to use the F2 generation and come out with lower yields, or to renew seeds every year. In developing countries, where seed renewal is infrequent, depending on external seed is a major problem. The increased use of chemical fertilizers brought dependence on import from chemical companies in the industrialized countries, and at high cost. In the 1970's India, 20% of the cash earned by export was used for chemical fertilizer import, and requested financial aid for the same purpose[20]. People shared water as common good at a local level in traditional agriculture. The intensive irrigation needed central control by the government, making a shift of water control.

④Technology for the capable, Labor displacement

Larger farmers were quicker to adopt the new varieties than the poorer ones. Landless farmers could not make use of the new seeds. The larger, wealthier farmers with good-quality farmland and irrigation who were able to purchase high cost inputs were producing more. The increased production resulted in lower grain prices, putting the squeeze on smaller, poorer farmers. In addition, there was tendency for the better off farmers to use herbicides and machines, thus reducing demands for hand weeding. Labor displacement occurred and wages dropped. The 1994 Zapatista rebellion in Mexico was partially because of the growing gap between rich and poor farmers due to the Green Revolution[21]. In the developing countries where labor is abundant, people substitute for capital and infrastructure.

Successful example of the Green Revolution is only in some areas of Asia that had relatively low levels of inequality traditionally[22]. In those areas, there is a long history of communally managed irrigation systems that successfully left the land holdings relatively equal. However, irrigation is often out of the reach of the poor in other parts of the developing countries. Where agricultural workers are well organized,

---

[19] FAO, "The State of Food and Agriculture 2003-2004"

It is not sure whether the term "freely" here means that the seeds were gratuitous or sold at a low price without patent.

[20] Mooney, p.55

[21] Mooney, p.65

[22] Ibid, p.65

such as the state of Kerala in India, real wages of farm workers rose, retrieving many people out of poverty[23].

⑤**Monoculture, Uniformity, Less Biomass**

The Green Revolution favored monoculture because of the external seed input and the massive use of water and chemical fertilizers. In the Philippines, small peasants used to cultivate thousands of traditional rice varieties. But by the mid-1980's, only 2 Green Revolution varieties occupied 98% of the entire rice growing area[24]. The monocultures of rice and wheat excluded rich diversity of food grown by small farmers, such as pulse, legume, maize, millet, straw and oilseed, which were nutritionally and economically important for lower-income farmers. The developing countries depend on edible legume for half of their protein intake. High-protein legumes were substituted for low-protein cereals, and between 1961 and 1972, the legume yields dropped by 38% in India[25]. Whereas the cropped area of cereals increased, percentage of area under other biomass became negligible. Biomass such as straw was used to produce daily goods and as part of people's housing, and biomass constituted a great part of the forage crops. The high-yields of the HYVs were thus achieved at the sacrifice of the loss of diverse biomass.

⑥**Degradation of Environment and Ecology**

The intensive use of chemical fertilizer, pesticides and irrigation, and the monoculture brought new degradation of the environment and ecology. Soil fertility was decayed from the chemical fertilizers killing diverse plants and animals that played an important role in bringing nutrition to the soil. The overuse of irrigation resulted in waterlog, salinity, and desertification. The monoculture of rice and wheat were derived from a very narrow genetic base created at the agricultural centers, and thus created vulnerability to pests and diseases. Planting the same crops over large areas and for many years, and using pesticides repeatedly, have built pesticide resistance in pests. Insects and pests which were considered to be insignificant before the Green Revolution caused various epidemics of bacterial blight, virus, rust, powdery, and downy mildew, one after another. The new seeds also brought genetic contamination. Once the new external seeds are mixed into the native cropping fields, the genetic diversity will be contaminated through open pollination, and the native genetic resources can not be recalled. The degradation of environment and ecology will create difficult conditions for agriculture, and therefore creating dependency on external inputs even

---

[23] Mooney, p.67
[24] Shiva(2000), p.80
[25] Mooney, p.59

more.

⑦Public Sector

The public sector research was responsible for creating the high yielding varieties of wheat and rice that launched the Green Revolution. The private firms were involved in the development and commercialization of some seeds, but were rather restricted and were concentrated on the chemical equipments[26]. Chemical companies and development institutions collaborated in the promotion of Green Revolution technologies. The CGIAR was established specifically to generate biotechnology spillovers to the developing countries. The public sector's objective is to develop and provide sufficient and enough food at low cost for the sake of the poor and the hungry. Therefore, their R&D was concentrated on major cereals. However, the R&D expenditures of the CGIAR, which is the largest international public sector, has a total budget of less than $300 million for plant improvement, whereas the world's top 10 transnational corporations spend nearly $3 billion in R&D[27]. In the Green Revolution, the public sector was not successful in addressing the problems of the poor, and with the march of time, the public sector started to depend on the private sectors in the second biotechnology revolution for increased productivity.

V. The Gene Revolution

In contrast to the Green Revolution, most of the R&D and commercialization in the Gene Revolution is driven by private firms based in industrialized countries. With the contribution of the public sector's research in basic agricultural biotechnology, today the private sector is expanding explicitly, utilizing hybridization and genetic engineering. The major objective of the private firms is the profit of the firm itself. Therefore private firms dominating the world food supply raise concern that poor farmers may not benefit, because the new technology is not available or too expensive. The external seed dependency created in the Green Revolution is intensified in the next step of the biotechnology revolution.

Emergence and Domination of Multinational Seed Companies

The incentive for private sector's entry into the seed industry is in the hybrid seed structure *per se*. The hybrid seed does not reveal its lineage by simple

[26] FAO, "The State of Food and Agriculture 2003-2004"
[27] Ibid

observation, therefore if the lineage is kept secret, the technology will not be stolen by other companies or farmers. Besides, the enhanced trait of hybrid seed will not be inherited to its offspring, thereby farmers will have to buy new seed in order to keep preferable yields. These characteristics within the hybrid seed guarantees company's profits.

Until the beginning of the 20th century, most commercial seed companies' role was to multiply and sell seeds of varieties developed in the public sector. The situation gradually changed when the first Plant Patents Act was enacted in 1930, drawing seed companies to carry out R&D activities. Beginning in 1930, 150 new companies were formed to produce hybrid corn seed, some 40 existing seed companies expanded their business to include production of hybrid seed, and by 1944, U.S. sales in the seed corn market reached $70 million[28]. After the Second World War, chemical companies in the industrialized countries involved in the war industry started selling agrichemicals. In the late 1960's, those pharmaceutical and petrochemical firms were in a deadlock. The agrichemical market had reached maturity, there were rising criticism of its negative effects on human, environment, and ecology, and the profits in that sector were declining[29]. Thus, the agrichemical firms entered the seed industry. It was manageable for the firms with basic knowledge about agrichemicals to develop seed that best suits their own agrichemicals. Selling seeds and agrichemicals in a package was killing two birds with one stone (Table2). In 1970, The Plant Variety Protection Act was put into force, promoting the mergers and acquisitions of small seed firms by large pharmaceutical and petrochemical firms, and creating a new seed industry structure. Expanding R&D costs led to a further M&A.

In 1998, global commercial seed trade was estimated at $23 billion, top 10 bio-majors sharing $7 billion, or 30%[30] (Table3). As for U.S. corn seed market, DuPont/Pioneer and Monsanto held 72% of the share in 2000[31]. DuPont and Monsanto divide the U.S. industry in seed, pesticide, food, pharmaceutical, and veterinary products. To benefit from the economy of scale of R&D, DuPont and Monsanto, as well as the other large seed companies, became huge conglomerates by numbers of M&A (Figure4 and 5). Between 1995 and 1998, Monsanto spent over $8 billion buying seed

---

28 Jorge Fernandez-Cornejo (et al.) p.25
29 Jorge Fernandez-Cornejo (et al.) p.26
Mooney, p.77
30 Action Group on Erosion, Technology, and Concentration HP http://www.etcgroup.org/
31 Rachel A. Schurman, Dennis Doyle, Kelso Takahashi (eds.), Engineering Trouble –Biotechnology and its Discontents – (CA, University of California Press, Ltd, 2003), p.27

companies, in order to control the production and sales of corn, wheat, and cotton seed[32]. Monsanto also bought seed companies operating in the developing countries, such as MAHYCO of India, and Cargill's operation in Central and Latin America, Asia, and Africa. Monsanto holds a controlling interest in Calgene, a firm that launched the first GM variety, "Flavr-Savr" tomato to the market[33].

Regulations Related to Intellectual Property Rights to Plant Varieties

Regulations that assure the rights of plant breeders are important factors in providing incentives for private firms to enter and invest in the seed industry. The assignment of intellectual property rights (IPR) to living organisms is a relatively new concept. In the U.S., the first IPR legislation passed by Congress was the Patent Act of 1790, which protects the intellectual property rights of inventors, discoverers, and innovators, and establishes a framework through which they can obtain financial rewards[34]. This legislation excluded biological innovations from protection, regarding that new plant varieties are products of nature.

It was in the 20th century that plant varieties became the object of IPR. The first IPR legislation enacted to specifically address issues of plant breeding was the U.S. Plant Patent Act (PPA) of 1930. PPA provides patent protection over asexually or vegetatively reproduced plant varieties for 17 years, excluding others from reproducing their plants. This act did not include the protection of sexually reproduced plants, reflecting the perception at that time that such varieties were not identifiable, uniform, or stable enough to provide patent protection[35]. The Patent Act of 1952 extended patent rights to "any new and useful process, machine, manufacture, or composition, of matter, or any new and useful improvement thereof," including agricultural machinery, equipment, chemicals, and production processes[36]. In the international IPR context, the International Union for the Protection of New Varieties of Plants (UPOV) was established under the International Convention for the Protection of New Varieties and Plants (international headquarter in Geneva) and put into force in 1968. Its objective was to provide IPR to the breeders of new varieties and plants aiming to encourage the development of new varieties. Today there are 59 member states in the UPOV, and not

---

32 Shiva(2000), p.81
33 Ibid
34 Jorge Fernandez-Cornejo (et al.), p.18
35 Jorge Fernandez-Cornejo (et al.), p.20
36 Ibid, p19

many developing countries from Asia and Africa have ratified yet[37]. The 1970 Plant Variety Protection Act (PVPA) brought exclusive rights for breeders to market a new variety including sexually reproduced plants for 18 years from the date of issuance. The 1994 amendment to the PVPA brought PVPA into conformity with the international standards set by UPOV. The amendment extended the length of protection from 18 years to 20 years, prohibits farmers from selling saved seed, and extended the number of plants to be protected. Thus the IPR regulations are making seeds, which used to be products of nature and accessed freely, into a possession by the major-bio firms in the industrialized countries. If the IPR regulations incorporate other developing countries, poor farmers may be neglected of the right for access to plant varieties.

Features and Effects

①High Cost Package

The new seeds focus mainly on 4 traits, herbicide tolerance, insect resistance, virus and bacterial resistance, and nutrition enhancement. Of these, herbicide tolerance and insect resistance are predominant. The seeds are genetically engineered to work only with certain herbicides, and pesticides, thus farmers have to buy the whole package. Herbicide tolerance for various crops developed under the name of Roundup Ready (RR) by Monsanto is well-known. It was estimated that in 2001, the RR soybeans brought benefits of $652 million to consumers worldwide for lower prices, $421 million to seed firms as technology revenue, $445 to RR soybean producers in the U.S. and Argentina, whereas producers in other countries without the access to the RR soybeans faced losses of $291 due to the lower price in world market prices[38]. This indicates that the parties who benefit from the new technology are the consumers, firms, and farmers of industrialized countries, leaving the developing country farmers with low income.

The International Fertilizer Industry Association works closely with the World Bank and the Food and Agriculture Organization to promote increased fertilizer use of the package[39]. In India, 20% of the farmers were subsidized for the new seeds, and the fertilizers were subsidized as well for the primary year. With the three to sixfold rise in seed prices, most of the farmers were not capable of the continued use of the new seeds.

---

[37] UPOV HP http://www.upov.int/index.html
[38] FAO, "The State of Food and Agriculture 2003-2004"
[39] Collins, Moore, Rosset,p.64

Ecological and environmental risks associated with biotechnology are the possible escape of herbicide tolerance and insect resistance genes to wild relatives of crops, creating superweeds and pests that are resistant to control[40]. Since herbicides and pesticides are effective to specific weeds and insects, the promising results by genetic engineering of the decline in the use of herbicides and pesticides were not acheived. In fact, total herbicide use has increased to control superweeds[41].

②Terminator Technology

Monsanto also owns the patent for "terminator technology," a method of creating sterile seeds. The genes are engineered so that the crops can not produce seeds from terminator varieties. In 1998, USDA and the Delta and Pine Land Company jointly announced "Control of Plant Gene Expression," that permits patents on terminator technologies to prevent farmers from saving seeds, and other companies stealing the technology. This secures the profits and monopoly of the seed companies. However, as a result of international opposition, Monsanto announced to abandon its plans to commercialize terminator technology the next year. If the terminator technology persisted, the terminator and related-seeds market could constitute 80% of more of the global commercial seed market by 2010, $20 billion per year[42]. This fact demonstrates the danger of a few companies controlling the world food supply, which would be further difficult for poor people to access.

③Contract

Monsanto forces farmers to sign a contract when purchasing the company's products. It is called the Technology Use Agreement (TUA) (Figure 6). According to its terms and conditions, 1) the grower agrees not to save seed produced from Roundup Ready seed for the purpose of replanting nor to sell, give, and transfer, and must purchase seed every year 2) the grower shall purchase Roundup Ready branded herbicide and Roundup Ready seed as a package, 3) the grower grants Monsanto for 3 years the right to inspect, take samples and test all of the growers' owned or leased fields planted with Monsanto seeds or other land farmed by the grower, 4) the grower agrees to pay Monsanto $15 per acre planted with Roundup Ready seed, 5) the grower agrees to deliver to Monsanto any seed containing the Roundup Ready gene resulted from unauthorized use of Roundup Ready seed, 6) the grower must pay Monsanto all costs incurred as a result of the grower breaking and of the terms and conditions of the

---

[40] Collins, Moore, Rosset, p.75
[41] FAO, "The State of Food and Agriculture 2003-2004"
[42] Ibid, p.83

contract, and so on[43]. However, the agreement has no liability clause[44]. Therefore, even if the seeds fail to perform as promised, or if it causes ecological damages, Monsanto does not take responsibility.

④IPR trial

Percy Schmeiser is a Canadian farmer who has been farming for over 55 years, saving and using his own seed, and developing his own varieties tolerant to local farming conditions. In Nov. 1998, Schmeiser received a letter from Monsanto claiming he illegally planted the firm's canola without paying the privilege. However, Schmeiser had never purchased seed from Monsanto, nor had contact with the company. His land was contaminated by Monsanto's Roundup Ready canola through natural breeding, or pollination carried by birds and animals. Monsanto claimed that this was a piracy to their intellectual property right and took the case into court. The final judgement of the Supreme Court in May 2004 was a draw, claiming that Monsanto's patent is valid, but Schmeiser is not forced to pay compensation to Monsanto. The consequences of this case are the contamination of Schmeiser's native seed by Monsanto's variety, making Schmeiser withdraw from canola farming in 2000 and securing the seed companies of their rights over seeds. Monsanto even disorganized the credibility among farmers[45]. The suit broke out from a farmer in the village taking canola evidence to Monsanto. Monsanto has already sued more than 550 U.S. farmers in similar cases. Such cases are not seen in developing countries yet, but it warns the risks of poor farmers unreasonably petitioned in the future by companies for what used to be a common property.

⑤Genetic Contamination

Complete isolation of GM seeds, hybrid seeds, and native variety seeds are impracticable. Therefore genetic contamination occur by cross pollution in the farming fields, and during transpotation through storage, truck, and vessel in the market field. Once the new genes are mixed with the native varieties, the genetic diversity will be contaminated and will not be recovered.

In Soon Vally, Pakistan, farmers depended on imported seed of califlower from a Japanese seed company[46]. From 6 or 7 years ago, the yields dropped significantly. The problem of this case seems to be that different types of seeds were mixed in the

---

[43] Monsanto vs Schmeiser http://www.percyschmeiser.com/
Kawada, Masaharu,"Bio-terrorism Over the World," Alternative, Vol. 332 (Pacific Asia Resource Center, Jan., 2004), p.12

[44] Shiva(2000), p.92

[45] Kawada, p.12

[46] Shimokawa, Masatsugu (International Politics and Economics Seminar miscellany, 2003)

canister somewhere along the distribution process, thus generating genetic contamination, resulting in lower yields. The label on the canister did not indicate the contact of the seed company and the farmers had no measures to solve the problem. The farmers' cooperative was formed in 2002 to manage agriculture problem within farmers. The cooperative invited an expert from Japan and the problem of the Soon Valley seed seems to be heading for improvement.

In September, 2004, the Sakata Seed Corporation, the largest seed company in Japan, anounced to recall cabbage seeds[47]. The yields of cabbage were severe where this variety of seeds were planted. The farmers were notified that the poor outcome was due to the "mistake" during the production of seeds.

Both of these cases occured due to the dependency on external seed. Genetic cotamination is irreversible, and for developing countries facing sever starvation, one "mistake" created by private companies in the industrialized country could be at the cost of many lives.

⑥Privatization of the Genetic Resources

In India, more than 200,000 rice varieties were bred traditionally. Bastami rice was one of them and it has been an important export item of India. A Texas-based company, Rice-Tec, Inc. brought Bastami seed from India to the U.S., crossed with semi-dwarf varieties, and was granted patent on Bastami rice lines and grains in 1997, claiming that it is a novel variety[48]. Such patenting on seeds derived from nature could exclude the farmers from their rightful access to seeds, which used to be their own.

The intellectual property rights system is making the farmers' traditional rituals, to save and exchange seeds with neighbors, into crimes. It also forces farmers to use only "registered" varieties[49]. Up until now, farmers' varieties had not been registered, and it is too costly for small individual farmers to register their varieties. There are many instances where farmers had been fined for "seed piracy[50]" cases, such as using uncertified seed or exchanging seeds among farmers. Allowing the use of the only registered varieties will create more genetic uniformity than diversity. The wide patenting of technology and products will also create research dependency. Patenting of crop genes means that farmers in the future may be obliged to pay royalties to foreign companies on varieties bred by their ancestors.

The developed countries are heavily dependent on the developing countries'

[47] Sakata Seed Corporation http://www.sakataseed.co.jp/index.html
[48] Shiva(2000), p.92
[49] Ibid, p.90
[50] Ibid, p92

genetic diversity. Genes from local and wild varieties have contributed an estimated $ 66 billion to the U.S. economy[51]. Free exchange of plant genetic resources has been important to the United States for the need of access to genetic materials beyond U.S. borders. As a result of collection and breeding activities, the U.S. is currently a net supplier of plant germplasm to the rest of the world.

The global area cropped under GMOs skyrocketed from 2.8 million hectare to 67.7 million hectare in 2003. Six countries (U.S., Argentina, Canada, Brazil, China, and South Africa) and four crops (soybeans, maize, cotton, and canola) account for 99% of the GM production[52]. Though the commercial production of GM crops is still restricted to a few crops and concentrated in a few countries, R&D is carried out to create rice, wheat, and other GM varieties and the life science corporations are seeking for new markets to sell seed package. The international agencies insist that public and private sector cooperation is necessary in the field of biotechnology for addressing the problems of the poor, depending on the private sector for R&D and the public sector work to adapt the spillover of technology to the developing countries. The CGIAR, which have played a central role as public sector to achieve sustainability of food security and reduce poverty, focuses on increasing productivity, strengthening national systems, protecting environment, saving biodiversity, and improving policies. However, the public and private sector cooperation will make no difference to the structure of reliance on external input.

VI. Food Aid

Food aid is being used, particularly by the U.S. as a tool for facilitating the export of GM food surpluses, or as a market tool to capture new markets. Out of $1.76 billion Official Development Assistance food aid, $1.13 billion is borne by the U.S. shows how important the food aid is to the U.S[53].

The GM food aid issue arose in 2000 and grew increasingly in 2002. The donor countries were sending food aid including GM crops without advance notice to the recipients. The developing countries are refusing food aid despite the fact that there are food crisis within the country, for the fear of impact of GM food on health and

---

[51] Shiva(2000), p.77

[52] FAO, "The State of Food and Agriculture 2003-2004"

[53] *Association for International Cooperation of Agriculture & Forestry, Outline of Japan's Overseas Cooperation in Agriculture, Forestry, and Fisheries* (Tokyo, Tokyo Inshokan Printing Co. Ltd, 2001)

environment.

The United States Agency for International Development (USAID) and the World Food Program (WFP) were well aware of the problems and controversy over GMOs and food aid. However, the U.S. put pressure on developing countries to force the acceptance of GM food aid, giving only 2 choices; either to accept GM food aid, or watch people starve. Some U.S. officials behave as were to say that "beggars can't be choosers[54]." The U.S. accused the European Union (EU) of being responsible for the African rejection. Africa fears to lose export markets in the EU, where people are rather skeptical about the acceptance of GM food, due to the GM contamination by food aid. There were no prior informed consents about GM food aid, and some food aid did not have appropriate labeling, indicating the lists of ingredients, the name and address of manufacturers, and instructions for use, depriving the recipient countries of the right to know[55]. Thus, the aid is violating the rights of recipient countries.

The first documented complaint about the shipment of GMOs in food aid was denounced in 2000, in India. The aid was conducted by USAID and WFP. The Indian government rejected a large shipment of food aid from the U.S. in 2002 because there was no confirmation that the food aid would not contain any traces of GMOs. Ironically, the introduction of the U.S. food aid was being pushed despite the fact that India has 65 million ton of non-GM wheat or rice surplus derived from the biotechnological revolutions[56]. Between 2000 and 2002, many Latin America and African countries declared "no" to GMOs in food aid.

The 2 major reasons for GMO food aid rejection are the impacts of the GMOs to health and ecology. In 2002, civil society groups in Bolivia found StarLink, genetically modified maize not authorized in the U.S. for human consumption, in food aid from USAID. It was recalled in the U.S. when found in the commercial food market, but no measure was taken in the case of Bolivia. Though genetically engineered food released in the market is being tested and is said to be safe, there is still no assurance that it will not give harm in the long-term, let alone GMOs not authorized for human consumption. Moreover, safety assessment is mainly done in the industrialized countries, where GMOs are only one part of many other diverse food consumptions[57]. The situation in

---

[54] *Playing With Hunger –The Reality Behind the Shipment of GMOs as Food Aid-* (Netherlands, Friends of the Earth International, 2003), p.8
[55] Ibid, p.7
[56] *Playing With Hunger,* p.8
[57] Ibid, p. 10
Conversation with Mr. Kodato, Nobuyuki (Kanagawa Prefecture Agriculture Administration Office), Nov. 9, 2004

the developing country, such as malnutrition, or consumption of only one GMO product for over time, is not taken into consideration. The environmental concern is the genetic contamination of indigenous varieties from GMOs. Even in the state of food crisis, farmers usually save part of the grain for planting the following year. The food aid recipients save GMO seeds, and this could lead to lower yields in the future, due to genetic erosion or contamination of traditional crop diversity through cross-fertilization. The genetic contamination could develop resistance to pests, or herbicide tolerance in weeds. In fact, Zambia is already suffering lower yields of corn due to the genetic contamination from GMO food aid, despite its rejection of both milled and grain GM food aid in 2002[58]. The developing nations are the original birthplaces of most of the crops, and once GMOs pollute the genetic resources, it can not be recalled. If the indigenous varieties are contaminated, farmers will have to buy commercial seed every year, intensifying the dependence of developing countries on industrialized countries for food supply.

The E.U. expressed to provide alternatives to the false choices of only GMO food aid or starvation. EU Community sent financial food aid, of which 90% of them were used to purchase local, regional, and traditional non-GM food in surplus in the recipient countries, as not to disrupt local markets or local consumption habits[59]. Every country's foreign aid is a tool of foreign policy. However, aid that is egoistic, dogmatic, or has potential of harm will not be help in most cases to recipient countries, and must be avoided.

VII. Conclusion

The introduction of high yielding varieties in the Green Revolution created a structure of dependency on external input such as seeds, chemical fertilizer, and irrigation. Later and still now, in the ongoing Gene Revolution, that structure is being intensified, through life science bio major companies in the industrialized countries, and IPR regulations. The traditional agriculture system was based on internal input and the seeds were free of access as common goods. Biodiversity, water, animals, plants, soil, and people all co-existed, creating a cyclical circle. Farmers exchanged seeds freely. Biodiversity and crop rotation helped endure and control pests, diseases. All the factors interacted to contribute to the sustainability and self-reliance of agriculture

---

[58] From NHK BS1 Program, Hunger Business, Zambia, Question to American Food Aid, Feb. 12, 2004
[59] *Playing With Hunger,* p.9

(Figure 7). The biotechnology revolutions industrialized the agriculture. The agriculture system turned from cyclic to lineal. In the Green Revolution, the public sector, private firms, and central government controlled the inputs. The consequences of external input operated mutually to make agriculture unsustainable, thus creating downward control and the vicious circle of dependency (Figure 8). Then the Gene Revolution came along with the emergence of conglomerates, and IPR regulations. The lineal agriculture system was reinforced, with a few companies in the industrialized countries controlling the input, R&D, and genetic resources, making contract with farmers as not to reproduce seeds, and making farmers pay for the patents. Thus the farmers are trapped in the dependency system (Figure 9). The one-sided GM food aid derived from the U.S. is trying to create a dependency system in another way.

Traditionally 300,000 plant varieties grew in the agriculture system and the places of origin for most plants were what are now developing countries. Human beings consume 95% of energy from only 30 plants. The controlled and uniform agriculture brought by the biotechnological revolutions and its effects on genetic contamination are destroying the diverse genetic resources of the earth and putting them into the hands of the limited. International Treaty on Plant Genetic Resource for Food and Agriculture (ITPGR) was approved in 2001 under the supervision of the Food and Agriculture Organization of the United Nations (FAO). The treaty aims to ensure free and equitable access to genetic materials, conservation, sustainable use, and exchange of the world's plant genetic resources. However, Japan and the U.S. did not approve, due to its ambiguity of the IPR[60]. The genetic materials available through ITPGR are limited to plants that are out of date of IPR. There are arising issues, such as compensating farmers, particularly in developing countries for their contributing to past plant genetic improvements. If the external seed dependency persists, the seeds that were formerly common property of people in the developing countries must be purchased, with the royalties on the seeds, from the industrialized countries.

There have been movements by some NGOs in the developed countries, such as Seed Savers Network and International Seed Saving Institute, to review the importance of saving seeds, mostly to farmers and horticulturists in the developed countries. They also launch programs in the developing countries to support farmers to save seeds and preserve genetic resources. The Japan International Cooperation Agency (JICA) also launches agricultural technical assistance to developing countries, with the objective to raise productivity of crops and maintain sustainability. However, some of the

[60] Japan approved ITPGR in June, 2004.

programs are based on dependency of external inputs, such as programs of building research centers outside of the farming area, and technology assistance for irrigation to fit the hybrid seeds. The best way to conserve diverse varieties is to ensure the continued use of the seeds in the field, not in the storage of research centers or private firms.

However, there are still some questions to be addressed regarding the seed problem. To name a few, the first question is; can the local farmers make use of the F1 seed technologies or any other biotechnology to conserve and manage their own seeds? To make F1 seed, as mentioned above, takes many years and work. Biotechnology requires knowledge and facility. If these technologies can be dispersed without too much hardship, developed countries and institutions, such as JICA, can give technological assistance for the local farmers to improve the quality of the seeds to match the local agriculture system. If not, farmers in the developing countries may not be able to afford money, time and labor on the research of new seeds.

The second question is; can organic agriculture, agro forestry, or seed saving movements that are being re-evaluated today, feed the world? With more complex situation for sustainable agriculture, such as growing population, environmental destruction, climate change, and depopulation of farming lands, whether or not the world can produce and feed its population without the use of latest biotechnology by the conglomerates is a question.

Another question is; is public-private sector cooperation in the seed R&D going to work and end hunger? International agencies emphasize on the need for cooperation to increase production and eliminate hunger. If R&D of high quality seeds is too technological for the local farmers to manage themselves, public sector may need to depend on the private sector for R&D. Then, the public sector must ensure that the technology be available to the poor. However, there still needs caution to the current situation of public-private cooperation because there is risk of the biotechnology becoming a tool for limited population.

The reinforcement of external seed dependency will not address the problems of the poor and hungry. Empowering farmers to analyze and cope with their own problems for sustainability and self-reliance may be an alternative to the external seed dependency trap.

References

Association for International Cooperation of Agriculture & Forestry, Outline of Japan's Overseas Cooperation in Agriculture, Forestry, and Fisheries (Tokyo, Tokyo Inshokan Printing Co. Ltd, 2001)

FAO, "The State of Food and Agriculture 2003-2004" (Food and Agriculture Organization, 2004)

Collins, Joseph, and Lappé, Frances Moore, and Rosset, Peter, *World hunger: twelve myths* (New York, Grove Press, 1998)

Cornejo,Jorge Fernandez (et al.), *The Seed Industry in U.S. Agriculture: An Exploration of Data and Information of Crop Seed Markets, Regulation, Industry Structure, and Research and Development* (Washington DC: U.S. Department of Agriculture. Agriculture Information Bulletin Number 786, 2004)

Doyle, Dennis, Takahashi, Kelso, Schurman, Rachel A., (eds.), *Engineering Trouble –Biotechnology and its Discontents –* (CA, University of California Press, Ltd, 2003)

Hisano, Shuji, "Political and Sociology of Agricultural Biotechnology" (Seoul National University - Hokkaido University the 4th Joint Symposium, Seoul, October 22-23, 2001)

Japan International Cooperation Agency, International Cooperation (Tokyo, JICA, 2004)

Kawada, Masaharu "Bio-terrorism Over the World," Alternative, Vol. 332 (Pacific Asia Resource Center, Jan., 2004)

Nishimura, Minoru, *Techno Diagram: Biotechnology* (Tokyo: Touyoukeizaishinnpousha, 2001)

Mooney, P.R., *Seeds of the Earth* (Japanese translation rights arranged with Canadian Council for International Co-operation through Japan UNI Agency, Inc, Tokyo, 1979)

Ohno, Tatsumi, B*iobusiness Saizensen* (Japan, Jijitsuushin Corp., 1986)

Playing With Hunger –The Reality Behind the Shipment of GMOs as Food Aid— (Netherlands, Friends of the Earth International, 2003)

Shimokawa, Masatsugu, "Japanese Seed" (International Politics and Economics Seminar miscellany, 2003)

Ohno, Tatsumi, B*iobusiness Saizensen* (Japan, Jijitsuushin Corp., 1986)

Vandana Shiva, *The Violence of the Green Revolution* (Malaysia, Third World Network, 1991)

Vandana Shiva, *Stolen Harvest* (Cambridge, South End Press, 2000)

Wieglele, Thomas C., *Biotechnology and International Relations: the Political Dimensions* (U.S.A., University Press of Florida, 1991)

Yoshida, Masako, *Starvation and Satiation* (2004)

Action Group on Erosion, Technology, and Concentration HP http://www.etcgroup.org/

Consultative Group on International Agricultural Research HP
http://www.cgiar.org/index.html

CSO Peace Seed HP http://www.peaceseed.org/

DuPont HP http://www.dupont.com/

Food and Agriculture Organization of the United Nations HP http://www.fao.org/

Ministry of Agriculture, Forestry, and Fisheries of Japan HP http://www.maff.go.jp/

Ministry of Health, Labor and Welfare HP http://www.mhlw.go.jp/

Monsanto vs Schmeiser HP http://www.percyschmeiser.com/

Sakata Seed Corporation HP http://www.sakataseed.co.jp/index.html

UPOV HP http://www.upov.int/index.html

The Asahi Shinbun
NHK BS1

Appendixes

Figure.1 Hybridization

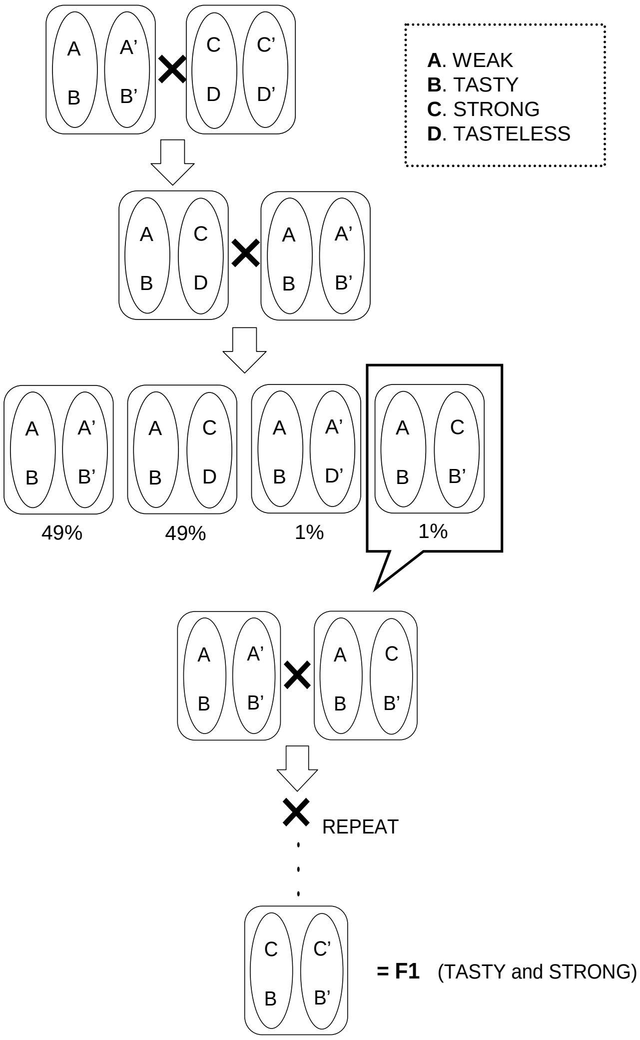


Figure.2 Traditional Agriculture System

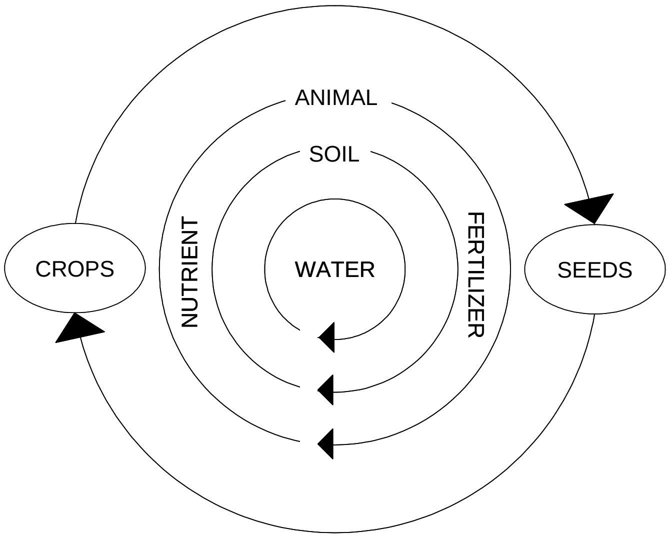


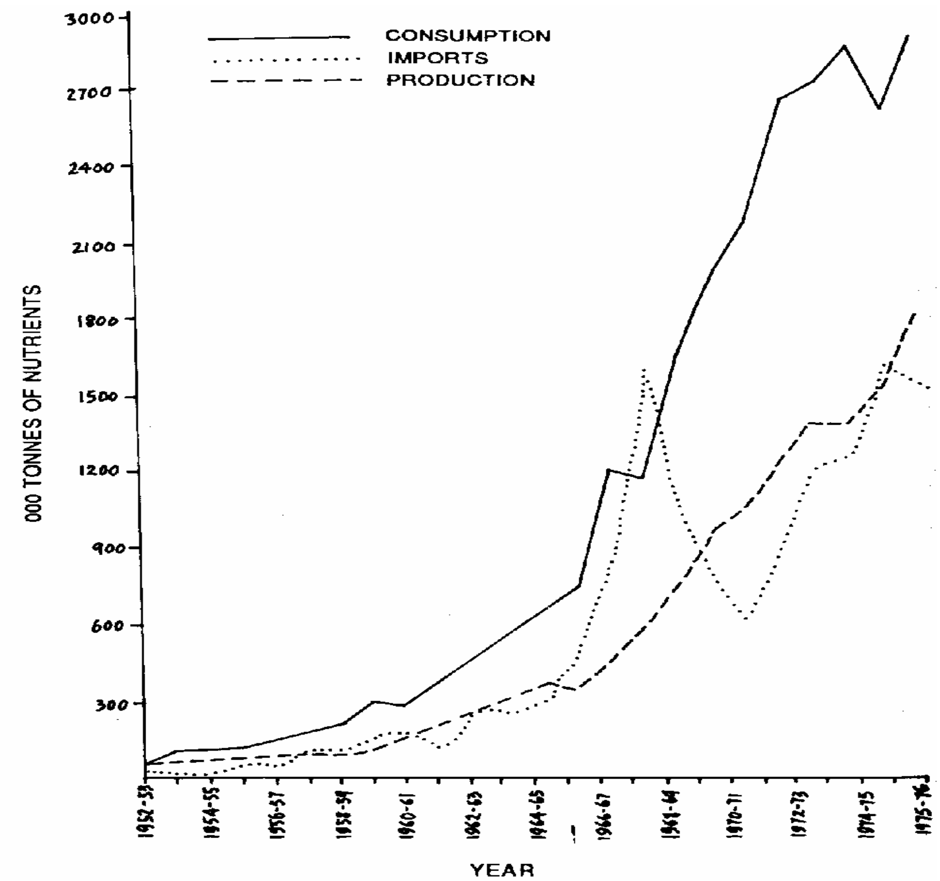
Table.1 Imports of Foodgrains in India

Year	Quantity in 1,000 tonnes
1950	2,159
1955	711
1960	5,137
1965	7,462
1970	3,631
1975	7,407

Source: Directorate of Economics and Statistics, New Delhi

Vandana Shiva, *The Violence of the Green Revolution* (Malaysia, Third World Network, 1991), p.55

Figure.3 Production, Imports and Consumption of Fertilizers in India



Source: Vandana Shiva, *The Violence of the Green Revolution* (Malaysia, Third World Network, 1991), p.106

Table.2 Agrochemicals and Seeds Package

Companies	World pesticide (m$, rank) 2000		World seed (m$, rank) 2000		US corn seed (%, rank) 1997		US biotech patent (%, rank) -1998		Bt gene related patent -1996.6	OECD regist. GMOs -2000.8	Corn/Soy GMOs in field test -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%

Source: Hisano, Shuji, "Political and Sociology of Agricultural Biotechnology"

Table. 3 The World's Top 10 Seed Corporations

Company	Revenue (US million)	Comment
1. DuPont/Pioneer (US)	$1,800+	DuPont owns 20% share in Pioneer
2. Monsanto (US)	$1,800	Total sales volume of all Monsanto M&A Made by October 1988
3. Novartis (Switzerland)	$928	Former Ciba Geigy and Sandoz
4. Groupe Limagrain(France)	$686	
5. Advanta (UK,Netherlands)		
6. AgriBiotech, Inc. (US)	$437	Owned by Astra Zeneca and Royal VanerHave
7. Grupo Pulsar/Seminis/ ELM (Mexico)	$425 $375	Complete 30 M&A since 1995
8. Sakata (Japan)	$349	Vegetable/Flower/Turfgrass
9. KWS AG (Germany)	$329	Major sugar-beet seed company
10. Takii (Japan)	$300	Privately-held

Source: RAFI Action Group on Erosion, Technology, and Concentration HP

Figure.4 Evolution of Dupont

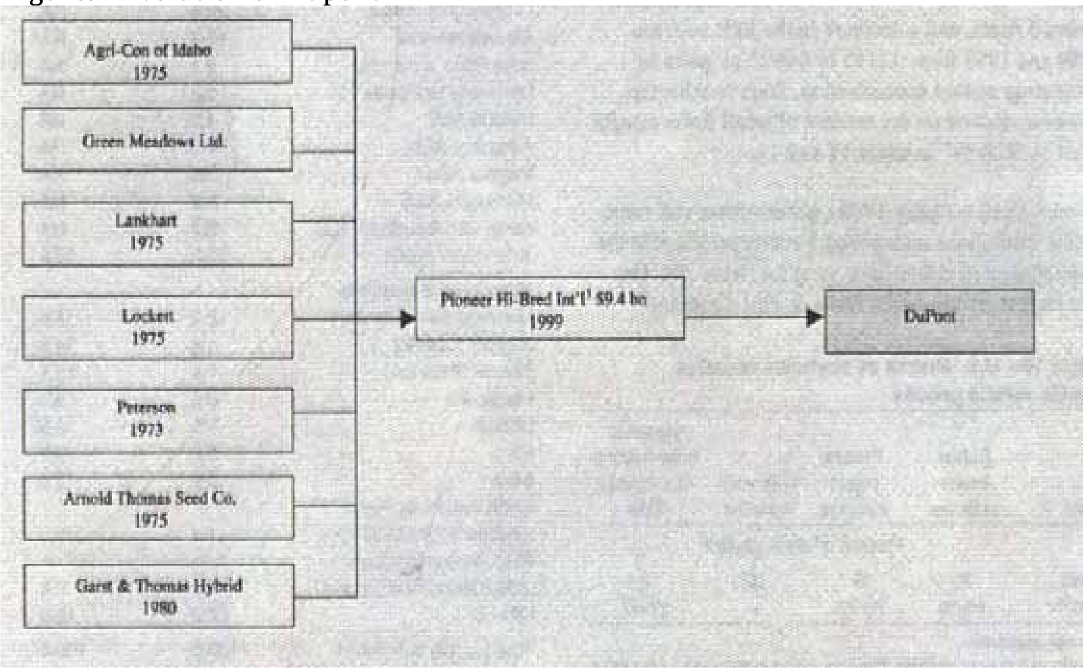
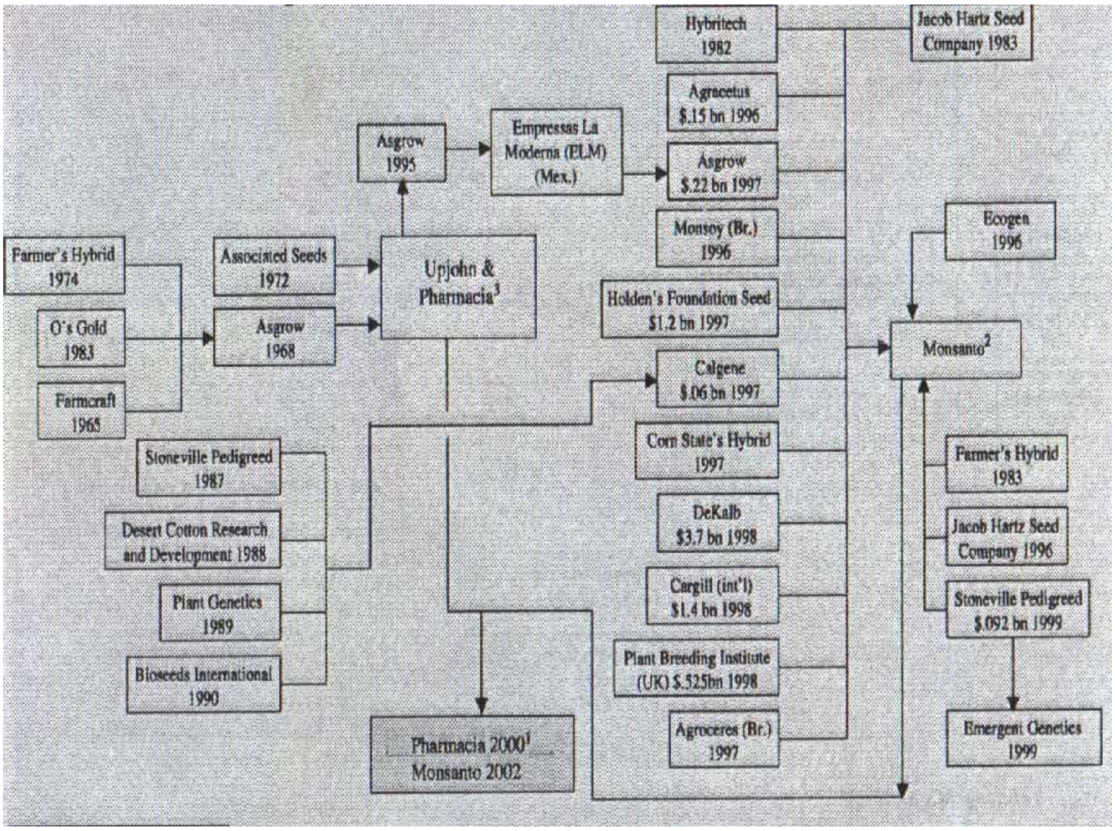


Figure.5 Evolution of Monsanto



Source: Jorge Fernandez-Cornejo (et al.), *The Seed Industry in U.S. Agriculture: An Exploration of Data and Information of Crop Seed Markets, Regulation, Industry Structure, and Research and Development* (Washington DC: U.S. Department of Agriculture. Agriculture Information Bulletin Number 786, 2004), p.33, 34

Figure6. Technology Use Agreement of Monsanto

Figure.7 Traditional Agricultural System

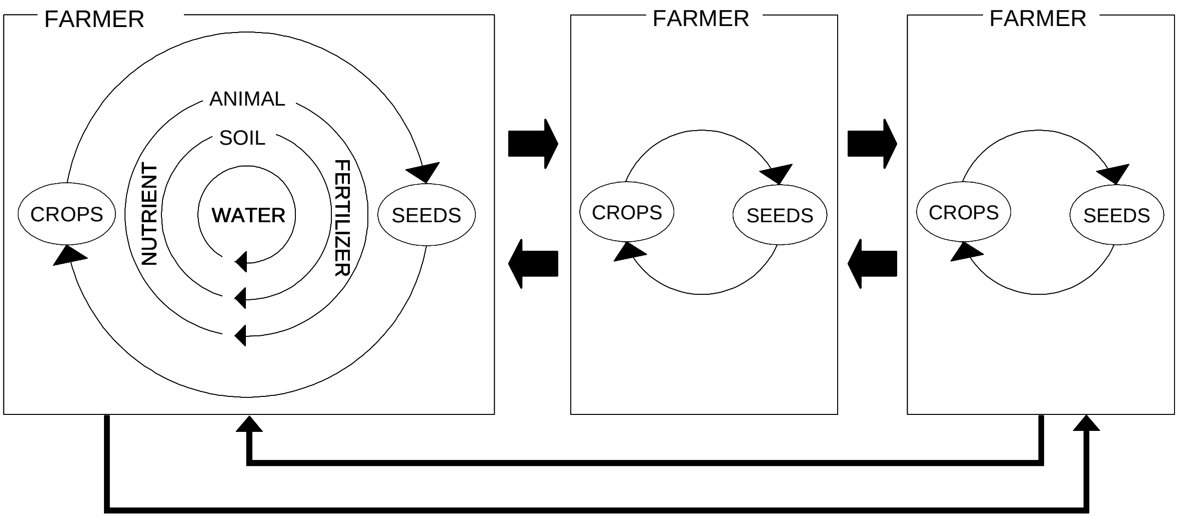


Figure.8 Green Revolution Agriculture System

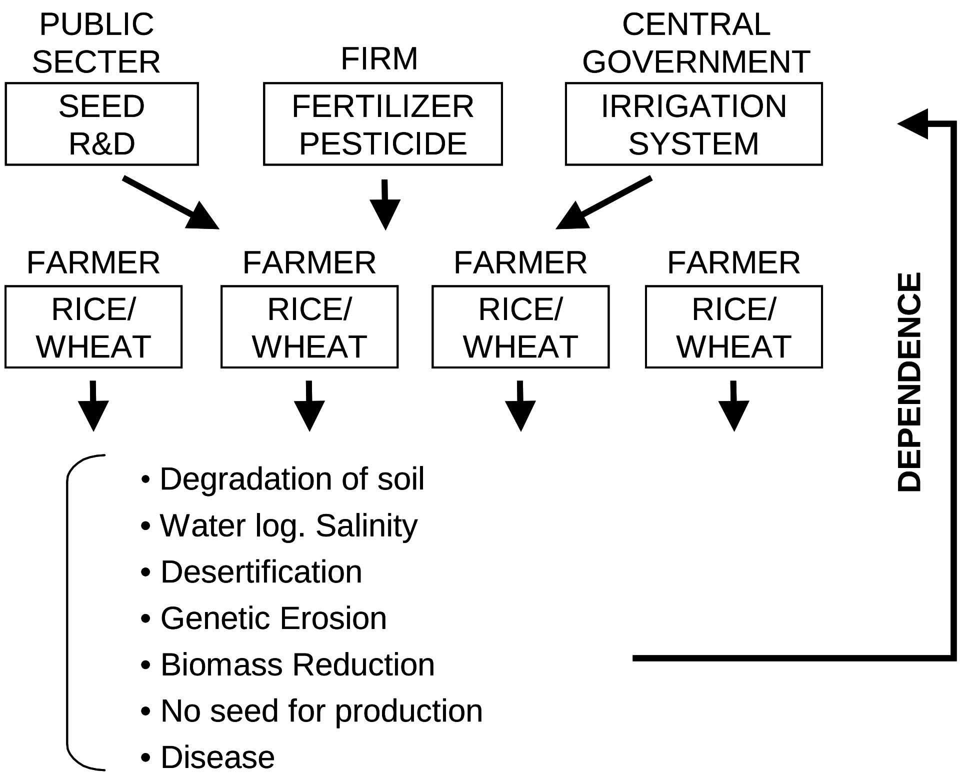


Figure. 9 Gene Revolution Agriculture System