5

China

Beyond Technology: Initiatives to Popularize Genetic Modification

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Over the past years, China's agriculture has been facing enormous challenges resulting from limited resources and environmental changes. Scarce water resources, frequent natural disasters, climate change, and population increase have posed huge challenges to China's agricultural development. Arable land is declining every year, by year, and has now approached the "Red Line" (1.8 billion *mu*[1] or 121 million hectares). Arable land per capita is only 1.3 *mu* or 0.087 hectare, accounting for 40% of the world's average level. From 1998 to 2008, growth rate of food output was only 2.5. The aggregate grain consumption surpassed the total output for seven consecutive years, thus, threatening grain supply.

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[1] *mu* equals 666.6 sqm or 0.067 hectare

COUNTRY PROFILE

China, located on the eastern part of Asia and the west coast of the Pacific Ocean, borders on 14 countries and adjoins eight countries along the shoreline. Despite being ranked third largest in the world with a territory of about 9.60 million square kilometers, China has arable land of only 1.826 billion *mu* or 1.217 million square kilometers. The country is also the most populous nation with 1.328 billion people, accounting for 20% of the world's population and 33% of Asian people. Those in the rural areas make up 57% of total population.

Over the past 50 years, China produced 25% of the world's grain on only 7% of global arable land yet feeding 20% of the world's population – a feat considered as a miracle in man's development history. As a large agricultural country, China produces grain crops such as rice, wheat, maize, sweet potato, potato, and soybean, and economic crops including cotton, oil seed, sugar, tobacco, bast fiber, and medicinal plants.

In the light of this situation, the government and its leaders attach much importance to the development of crop breeding technology including the use of genetic modification (GM). They expect to mitigate grain shortage through the use of biotechnology. Deng Xiaoping, Chief Designer of China's Reform and Open-up Policy said: "Biological engineering and advanced technology should be the ultimate solution to China's agricultural problems." Chinese Premier Wen Jiabao specifically said: "I have much faith in GM engineering, and worldwide food shortage further intensifies my faith." With the strong support of the Chinese government, biotechnology including GM technology witnessed fast growth and resulted in remarkable achievements.

Scenario for Biotechnology Research and Development

China embarked on biotechnology research in the 1980s. It launched the High-tech Industry Development Plan in 1986 which included modern biotechnology into its core technological development sectors. The government issued a specific implementation guideline: "Regard high-efficiency agriculture as the key, take new medicine, vaccine, and gene therapy as tools to achieve breakthroughs in new medical technology, and use protein engineering and applied fundamental research in agricultural and medical biotechnology as technological reserves for biotechnology's development in the beginning of the 21st Century." Under this guideline, China's biotechnology research and industry achieved rapid growth and development. Through a series of 7th to 10th Five-Year Plans for Technological Programs, "863" High-tech Program, "973" Fundamental Research Program, and GM Special Project, the government invested tens of billions of Yuan for scientific endeavors in biological science, with more than 100 agencies engaged in GM research. It is noteworthy that in the *National Guideline on Medium- and Long-Term Program for Science and Technology Development (2006-2020)* and the *11th Five-year Plan (2006-2010)*, breeding and development of new genetically modified organisms (GMOs) was listed as one of 16 significant technological projects identified to contribute to China's future development.

Government's Role in Biotechnology Development

Unlike developed countries, GM research is done by the public sector and receives significant funding and policy support. The government, thus, plays a crucial role in the development of biotechnology.

As early as the mid and late 1980s, many scientists like Fan Yunliu embarked on GM rice and cotton research. The government implemented special projects to support GM research. In 1986, the National "863" High-tech Program was set up and involved biotechnology including GM breeding among its important research projects. The State Council launched the five-year National GM Plants Research and Industrialization Special Project in 1999. The Central Finance allotted 510 million Yuan[2] (US$76 M) while relevant departments, local governments and social institutions invested 320 million Yuan (US$47 M) in the project. This is to support new GM product development and commercialization including plant safety evaluation and research and development (R&D) capacity building.

[2] Yuan Renminbi 6.7 = US$1.00 (as of October 2010)

In addition, the Ministry of Science and Technology obtained 610 new genes and consequently produced many high quality crop varieties that were resistant to pests and diseases, and tolerant to drought, salt, and herbicides. The *Breeding and Cultivation of New GM Varieties* project launched in 2008 was recognized as the most significant and largest technological investment since the founding of China, with a total investment of 20 billion Yuan (US$3 B). Research on important crops like rice, wheat, maize, cotton and soybean aims to integrate GM technology with traditional methods to cultivate new crops with excellent quality, high yield, and tolerance to abiotic and biotic stresses. The project also promotes research on functional gene clone technology and large-scale and high-throughput plant transformation. In 2009, crop biological breeding was included in the Development Framework of China's Strategic Burgeoning Industries. The government explicitly pointed out in 2010 that efforts to commercialize new GM varieties should be boosted on the basis of "Scientific Evaluation and Law-abiding Management" principle to promote technological innovation, develop modern agriculture, and ensure food security.

Crop Development

After more than 20 years, China has developed a GM crop breeding system making it one of a few countries with independent R&D capacity, and globally recognized research outputs. As of 2009, GM crops that are being commercialized are cotton, tomato, poplar, petunia, papaya, and pimiento. GM insect-resistant cotton is extensively commercialized and yields are remarkable. Also gaining acceptance is GM insect-resistant poplar and papaya ringspot virus-resistant (PRSV) papaya. Other GM crops, however, did not fare as well due to inefficient match between research and application. It is worth pointing that GM rice and GM maize were awarded Production and Application Biosafety certificates in 2009 (See Appendix 1 for highlights of GM crops).

China has now completed the approval of a troika of key biotech crops in a logical chronology – first was Fiber (GM insect-resistant cotton), second was Feed (GM phytase maize) and third was Food (GM insect-resistant rice). Over 7 million small cotton farmers are already increasing their income by approximately US$220 per hectare (equivalent to US$1 billion nationally) due to, on average, 10% increase in yield and a 60% reduction in insecticide application. China is the largest producer of cotton in the world, with 68% of its 5.6 million hectares successfully planted with Bt cotton in 2008. Bt rice offers the potential to generate benefits of US$ 4 billion annually from an average 8% increase in production and 80% decrease in the use of insecticides. China is planting 30 million hectares paddy (Huang et al., 2005), and is the biggest rice producer in the world (178 million tons).

Bt rice will increase productivity of more affordable rice at the very time when China needs new technology to maintain self-sufficiency and increase food production to overcome drought, salinization damage, pest damage and other yield constraints associated with climate change and dropping water tables. China, after USA, is the second largest producer of maize in the world (30 million hectares grown by 100 million agricultural work families); it is principally used for animal feed. Maintaining self-sufficiency in maize and meeting the increased demand for more meat in a more prosperous China is an enormous challenge.

China's efforts towards global leadership in approving biotech rice and maize will likely result in a positive influence on acceptance and speed of adoption of biotech food and feed crops and can serve as a model for other developing countries. James (2009) says: "The approval by China of the first major biotech food crop, Bt rice, can be the unique global catalyst for both the public and private sectors from developing and industrial countries to work together in a global initiative towards the noble goal of "food for all and self sufficiency in a more just society".

GM Biosafety Management System

China is one of the earliest countries to enact and implement GM regulation. In December 1993, the former National Committee of Science and Technology promulgated the *Gene Engineering Safety Management Measure*, based upon which the Ministry of Agriculture (MoA) enacted the *Procedures for the Safe Administration of Agricultural Biological Gene Engineering* in July 1996. Five years later, the State Council promulgated the *Safety Management Regulations on Agricultural GMO* to implement the whole management process of research, production, processing, operation, import and export. Six management systems are in place for safety evaluation, production license, operation license, labeling, import and export management, and processing examination and approval.

GM Biotechnology Enterprises

Compared to developed countries, China's biotechnology industry is small scale, and lagging in sales revenue, R&D investment, and technical equipment. At present, biotechnology seed companies with strong competitiveness include Biocentury Transgene (China) Co., Ltd., Beijing Origin Seed Technology Inc., and China National Seed Group Co., Ltd. Appendix 2 lists additional information about these companies. China's market economy has a short history and its capital market is not yet fully developed. As an emerging strategic industry, commercialization of GM crops is still at the takeoff phase. The country has to address problems regarding investment and financing channels, policy and legal environment, management and technological innovation systems, as well as communication concerns.

Awareness, Acceptance of, and willingness to buy GM food

Stakeholders' concern and attitude toward GM technologies and products exert direct influence on the development of the GM industry. Consumers are the biggest interest party to GM food, and their attitude will influence decisions of policy makers, enterprises, and research institutions.

Findings from several consumer surveys in China are mixed and confusing due to restriction in size of interviewees and survey methods. On one extreme, a study in Guangzhou, Shanghai, and Beijing by Greenpeace (2004) claimed that GM foods were generally not accepted by consumers. On the other hand, other surveys showed that consumers were willing to pay a premium for GM food. Some surveys showed that the majority of consumers in Tianjin City were willing to pay up to 20% extra (Li et al., 2003). A survey in Beijing concluded that consumers were willing to pay a 38% premium for GM rice over non-GM rice. Recent surveys in different locations in China also showed a large variation of consumer acceptance of GM food, ranging from about 50% in Tianjin and Nanjing to about 80% in Beijing.

In 2002 and 2003, Jikun Huang from the Center for Chinese Agriculture Policy, Center for Agricultural Science and his research team conducted an in-depth survey on consumers of 11 cities in East China's five provinces. They also made a comprehensive research on urban consumers' awareness, acceptance of, and willingness to buy GM food. Results showed that compared to consumers in developed countries, Chinese consumers had less information on GM food, but two-thirds of them have heard of GM food. Such proportion is low when compared with developed countries, but it is considered relatively high in China considering low knowledge level and few information dissemination channels. After the in-depth analysis, Huang found that consumers' concern regarding GM food was closely associated with gender, education, income, and the type of city. Generally, male respondents' degree of concern is higher than female respondents, and those with higher education level have higher degree of concern about GM food. In addition, the income and city scale are also in direct proportion to the degree of concern (Huang et al., 2006a).

The research also showed that consumers had limited knowledge of biotechnology, and their degree of acceptance of GM food was far higher than other countries. The 2002 survey revealed that 57% of consumers approved GM food. About 24% of consumers were neutral and 9% did not have an opinion. Huang considered neutral as acceptance because respondents were indifferent to either GM or non-GM food. Hence, it can be said that Chinese consumers differed slightly in terms of attitude toward GM food. However, high degree of acceptance of GM food does not mean high willingness to purchase. The decision to purchase GM food is also subject to external factors like price. Huang believed that the survey was targeted at developed cities of East China, but the level of economic development was inversely proportional to the degree of acceptance of GM food. The survey results imply that commercialization of GM food would not arouse extensive opposition from consumers (Huang et al., 2006b).

In 2009, Jikun Huang and his team conducted a survey of consumers in Nanjing City. Results showed that consumers' degree of concern and awareness of GM food increased largely compared to 2002 and 2003, but their degree of acceptance of GM food declined to a large extent. For instance, their degree of acceptance of GM rice was 66% in 2002-2003, but the degree declined to below 30% in 2009. Huang and his team also organized a market survey. Results showed that in the supermarket, 99% of soybean oil was made from GM soybean, and most products were labeled with GM signs that were too small to read. In addition, non-GM maize oil, sunflower oil, and peanut oil were marked with non-GM signs that were eye-catching, which seemed to exemplify food processors' and retailers' attitude toward GM food (they believe that non-GM food is better). However, based on observation of consumers' purchase behavior in seven large supermarkets. Huang and his team discovered opposite results. Fifty consumers made a choice in a short time when they purchased edible oil, and most consumers showed much interest in the edible oil's quality and price but little interest in "whether it is GM food or not". Only 15% of consumers noticed the GM sign. These findings reveal that consumers' attitude to GM is inconsistent with their purchasing behavior.

Biotech Communication Initiatives

To complement the fast development of R&D in GM and biotechnology industry, China successively conducted promotional activities with respect to knowledge dissemination and GM food acceptance. Some Chinese academic communities play a significant role with the China Association for Science and Technology (CAST) serving as the lead institution. CAST, the largest NGO of scientific and technological workers in the country, links the scientific community with the Communist Party of China and the Chinese government. It joins the nation's political parties and other social groups in the state affairs of political consultation, policy-making and democratic supervision. Member societies in biology and agriculture such as the Chinese Society of Biotechnology (CSBT), Chinese Society of Agricultural Biotechnology, Chinese Association of Agricultural Science Societies, Chinese Society for Microbiology, Chinese Society of Biochemistry and Molecular Biology, and Genetics Society of China have Public Education Working Committees and embark on science communication. They foster academic exchange and promote innovation, take the lead in popularizing scientific knowledge, disseminate advanced technologies, and improve the public's understanding of science.

Chinese Society of Biotechnology

For instance, since 2007, CSBT joins hands with more than 10 societies to sponsor and organize the China Bio-industry Convention with support from the National Development and Reform Commission. The annual convention is hosted by cities which are sponsored by local governments that are also state-level bioindustry. It aims to promote biological industry policies, introduce a technical communication platform, and promote the commercialization of GM products. In particular, CSBT organizes the Bio-media Forum to discuss with media practitioners on how they can popularize scientific reports, communicate with scientists and the public, and fulfill their social responsibilities.

Activities to popularize GM target children, media and consumers.

Public opinion poll to determine attitude towards GM food are done at an exhibition.

In 2009, the Chinese Academy of Agricultural Sciences (CAAS) and CSBT jointly sponsored the "GM Enters the Public" scientific popularization program and exhibition at the China Science and Technology Museum (CSTM) in cooperation with the Ministry of Agriculture, Ministry of Science and Technology, and the China Association for Science and Technology. Experts in the GM sector, students in the elementary and middle schools, citizens, and media participated in the activity. Resource persons from the academic and scientific sectors discussed transgenic technologies and GM food using multimedia modalities, science demonstrations, and experts' academic reports.

GM Experts

With the support of the Chinese government, experts from public research institutions actively popularize GM concepts and issues through China's mainstream media such as *People's Daily*. Yang Xiaoguang, Member of Agriculture GM Crop Biosafety Committee and Professor of Chinese Center for Disease Control and Prevention, offers scientific answers regarding GM rice food safety, a major concern of the public. He said: "GM rice is as safe as non-GM rice, and consumers can put their minds at ease. As to nutrition evaluation, GM rice has no biological difference in main components, micronutrients, and anti-nutrient factors as compared to non-GM rice." On the issue about GM rice's effect on the environment, Professor Peng Yufa from the Institute of Plant Protection, CAAS, assures the public that "experimental and field analyses show that homegrown GM rice is safe for the ecological environment". When interviewed on the GM insect-resistant rice's safety evaluation process and its potential social benefits, Professor Wu Kongming, director of the Institute of Plant Protection, CAAS, explained: "To ensure the safe application of GM rice in the long-term, the Ministry of Agriculture requires that once GM rice is commercialized for cultivation, the applicants shall conduct long term monitoring of the ecological environment. In addition, the state's relevant scientific research plans will arrange programs to monitor fluctuation of the long term impact of GM rice on the ecological environment" (Jiang, 2009).

At present, the media and the public show much interest in Academician Yuan Longping's attitude to GM rice because he is touted as the "Father of Hybrid Rice". When interviewed in March 2010, Academician Yuan said: "Biotechnologies including GM are an inevitable trend for agricultural technology, but the public's worry on GM products is understandable." He noted that he is willing to eat GM rice and suggested that volunteers (particularly young volunteers) should be recruited to receive clinical tests so as to make sure that GM food is safe (*People's Daily*, 2010).

ChinaBIC and Partners

In addition to local institutions and experts, international non-profit organizations also contribute to GM popularization and promotion and contribute to commercialization efforts by cooperating with Chinese departments. These include the International Service for the Acquisition of Agri-biotech Applications (ISAAA) and CropLife China. ISAAA holds annual launch and conference on its annual report *Global Status of Commercialized Biotech/GM Crops*. The annual report covers a broad range of topics and is an authoritative reference for R&D institutions and authorities in making a development strategy and research plan.

Publications such as "Let's Talk About GM" reaches consumers in supermarkets.

In February 2008, ISAAA and CSBT jointly established the China Biotechnology Information Center (ChinaBIC) to further provide scientists and the public with biotechnology and GM information through knowledge sharing activities. ChinaBIC also promotes the sharing of global agricultural information through the translation of the weekly e-newsletter *Crop Biotech Update* into Mandarin which is then sent to subscribers from the public and private sectors. It, likewise, convenes experts' symposium, media workshop, and other science popularization activities.

During the 2009 Spring Festival, ChinaBIC held "Let's Talk about GM" targeted for consumers of big supermarkets like Carrefour and Walmart. Over 3,000 copies of the pamphlet *Let's Talk about GM* were distributed. The pamphlet's chief editor, Huang Dafang, is professor of the Biotechnology Research

Institute of CAAS. The publication gives an overview of GM, GM food in daily life, safety regulations, and issues and concerns. In addition, ChinaBIC conducted a survey on GM awareness and answered the public's questions on-site.

On February 25, 2010, the Crop Bio-breeding Industry Development Seminar was held in Beijing. It was jointly sponsored by CSBT and Chinese Society of Agricultural Biotechnology and supported by ChinaBIC. Dr. Clive James, Chairman and Founder of ISAAA, gave a presentation entitled *Global Status of Biotech/GM Crops: 2009*. In addition, Academician Fan Yunliu from the Biotechnology Research Institute of CAAS, who developed GM phytase corn in tandem with Academician Zhang Qifa from Huazhong Agricultural University, who developed GM insect-resistant rice, discussed the R&D efforts that led to these two products. Students and scholars from the Chinese Academy of Sciences, CAAS, and Beijing-based universities and colleges, and media representatives also attended the seminar.

Besides ISAAA, CropLife China is also active in advancing knowledge on GM by holding media workshops in different provinces and cities. In 2008 and 2009, it held workshops with the themes such as "Social, Economic and Environmental Benefits of Biotechnologies", "Biotech Ensures Food Security", "Traditional Breeding and Biotechnology Jointly Ensure Grain Security", and "Hybrid Rice Development and GM Rice's Economic Benefits" in cities such as Beijing, Shanghai, Chengdu, Changchun, Wuhan, Changsha, Guangzhou, and Xi'an. CropLife China organized these workshops in collaboration with a large number of universities, colleges, and research institutes. These activities received extensive attention from the media and the public.

It is worth noting that there will always be voices against GM food. Some extremist environmental protection organizations frequently convene anti-GM activities. As a result, the media issues some negative reports against the technology. The strong opposition against the commercialization of biotech rice, particularly because rice is a staple food, remains to be a frequent anti-GM event.

Enhancing Popularization of GM Technology

In the past, the government and researchers were unaware of the importance of popularizing GM concepts and issues. As a result, the public had little knowledge on transgenic technology and relevant state policies. Influenced by negative reports on GM, the public had many doubts on transgenic technology, which subsequently exerted negative impact on the GM commercialization process.

In 2001, China approved the celebration of Science and Technology (S&T) Week to be held every third week of May. This is a large-scale public S&T activity where local cities can organize programs according to their specific needs. During the last two years, more top scientists started to transform from "Only Devotion to Farmland and Paddy Field Tests" to "Active Participation in Scientific Popularization". They became aware of the need for greater participation in providing accurate information that will allow informed choices.

However, there is no decree specific to GM popularization. The MoA and the Ministry of Science and Technology (MoST), CAST, and main media like China Television, and *People's Daily* need to be involved. During the GM commercialization process, the government should ensure the public's "right to know" and duly provide the public with accurate information. Relevant departments like the MoA and MoST have no professional public education team for GM promotion. Although the government has set up many projects for GM research and development, there is no specific budget for public communication of these activities. There is inadequate comprehensive planning of GM promotion, and consequently, lack of an institutionalized efficient mechanism or professional and large scale scientific popularization team to link government, research institutions, and the public. Hence, the government should intensify fund support for promotion and public education activities.

The role of mass media channels is important. Consumers' awareness about GM food mainly comes from media but many local reports are negative or anti-biotechnology. Some technology groups and scientists discuss GM food with the public through mass media, but there is still much to be desired in terms of impact. Positive promotion of GM food will undoubtedly contribute to a higher degree of consumer acceptance. Consumer resistance to GM food like Bt rice can pose immense obstacles and challenges for the entire GM industry. How consumers feel about the technology and GM food will influence how policy makers will proceed with future biotech policies and approval of applications.

Summary

China is one of the key leaders in crop biotechnology. It is commercializing several biotech crops with Bt cotton extensively being planted. A supportive government and a strict biosafety management system are important in the development of biotechnology and has made possible the realization of crop varieties from R&D efforts of the public sector. The country does not have a strong anti-biotech sentiment although environmental protection organizations organize anti-GM events. It sees the importance of institutionalizing science communication inititatives to inform the public about GM concepts and products. This entails a comprehensive communication plan, a professional team to link institutions and sectors, and a clear budhet for public communication. A favorable perception of GM technology through deliberate science communication efforts hopes to contribute to decision making among policy makers that favor the technology and to greater consumer acceptance.

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Appendix 1. Highlights of GM Crops in China

Crop	Highlights
GM Tobacco	Tobacco mosaic virus- (TMV) resistant tobacco was developed by the Institute of Microbiology of the Chinese Academy of Sciences. In 1990, it was extensively planted in China. The TMV-resistant tobacco became the world's first GM plant put into production and application, and also the largest GM plant cluster. Over a period of time, the GM tobacco helped reduce insecticide application, but its planting was later halted due to controversy on its safety (Zhang, 2004).
GM Insect-resistant Cotton	Under the direct support of the National "863" Program and GM Plants Research and Industrialization Special Project, China achieved dramatic performance in GM insect-resistant cotton research. In 1991, the National "863" Program launched a significant and key technological project called Insect Resistant Cotton Gene Engineering Breeding Research. Three years later, the Biotechnology Research Institute of Chinese Academy of Agricultural Sciences successfully completed the artificial synthesis of Bt gene Cry1A and constructed a highly efficient plant expression vector. The BRI also adopted the pollen-tube-pathway method invented by Chinese scientists to introduce Cry1A into cotton varieties. Consequently, it successfully cultivated insect-resistant Bt transgenic cotton (*Cry1A*), and China became the world second largest country next to the U.S. with its own intellectual property on insect-resistant cotton. This laid the foundation for the speedy development of locally developed insect resistant cotton. BRI developed the Cry1A/CpTI double-gene transgenic cotton in 1996, which prolonged *Helicoverpa armigera*'s resistance. In 2000, BRI launched the double fusion Gene Insect Resistant Cotton Research and Production Project. Two years after, double fusion gene insect resistant cotton was successfully developed. As early as 1998, BRI started to research on GM three-line hybrid cotton molecule breeding. In 2005, the first insect-resistant three-line hybrid cotton was approved by the state and put into production, which made China the first country in the world to use the technology. By the end of 2008, 160 GM insect resistant cotton varieties were studied, as well as planted on 315 million *mu* of GM cotton nationwide. As a result, the increased output value surpassed 44 billion Yuan (US$6.6 B), and increased farmers' income by 25 billion Yuan (US$3.7 B). The application of GM insect resistant cotton not only efficiently controlled *Helicoverpa armigera*'s harm to crops like cotton, maize, and soybean but also reduced 70%-80% of insecticide application. This resulted in the reduction of insecticide poisoning accidents and protection of the ecological environment (Zhang, 2009).

Appendix 1 continued.

Crop	Highlights
GM Insect-resistant Poplar	Pests like *Apocheima cinerarius, Malacosoma neustria testacea* Motschulsky, and *Lymantria dispar* severely jeopardized the poplar's growth, and posed a serious threat to North China's reforestation program. However, GM insect-resistant poplar's breeding and cultivation greatly mitigated this problem. At present, there are several institutions engaged in GM insect-resistant poplar research and development. Insect-resistant Poplar No. 12 developed by Chinese Academy of Forestry Science (CAFS) and GM741 Poplar developed by Agricultural University of Hebei successively passed the cultivar assessment, and they obtained permission for commercial production in 2002. After that, several institutions did similar research on GM poplar. In 2007, CAFS and other agencies cultivated 100,000 GM Europe Black Poplars in Hebei and Shandong Province covering more than 4,200 *mu* in Inner Mongolia and Jilin Province or two times the volume of previous years. In addition, GM Robusta Poplar was planted in over 300 *mu* in Henan and Heilongjiang (Zhang, 2008).
GM PRSV Papaya	Papaya ringspot resistant, China's first GM fruit allowed for commercial production, was developed by the South China Agricultural University. After nearly 10 years of research it was granted the Production and Application Safety Certification in Guangdong Province by the Ministry of Agriculture in July 2006. Statistics reveal that planting area of GM papaya increased from 5,000 hectares in 2006 to 17,000 hectares in 2007, with yields of 15,000 tons in 2006 to 51,000 tons in 2007, with a value of 120 million Yuan (US$18 M) in 2006 to 408 million Yuan (US$61 M) in 2007 (Zhang, 2008).
GM Rice	Institutions including Huazhong, CAS Institute of Genetics, Zhejiang University, and BRI of CAAS have been involved in the research of GM rice. Huazhong Agricultural University's GM insect-resistant rice products Huahui1 and Bt Shanyou 63 were granted Biosafety Certificate by National GM Crop Biosafety Committee, MoA in 2009, which was of great significance to GM crop development in Asia and the entire world. Huazhong University was eventually granted the Biosafety Certificate after 11 years of safety evaluation. Several years of experimental results showed that Huahui1 and Bt Shanyou 63 have remarkable anti-rice borer performance and are high yielding. Findings show no impact on surrounding ecological environment and plants. In addition, the MoA organized several authoritative institutions as third party to test the environmental safety and food safety of Huahui 1 and Bt Shanyou 63 during 2007-2008, and test results were consistent. At present, the GM rice will undergo variety registration, and it will be put into commercial production and application after which it will be granted a Seed Production and Operation License.

Appendix 1 continued.

Crop	Highlights
GM Maize	Institutions engaged in GM maize R&D mainly include BRI of CAAS and China Agricultural University. GM phytase maize of BRI-CAAS was granted Biosafety Certificate by the National GM Crop Biosafety Committee, MoA in 2009. Phytase maize will allow pigs to digest more phosphorus, resulting in faster growth/more efficient meat production, and likewise prevent soil and groundwater from phosphate pollution brought by animal waste.

Appendix 2. GM Enterprises in China

Biocentury Transgene (China) Co., Ltd	The agricultural biotechnology company is mainly controlled by Shenzhen Oriental Pearl (Group) Co., Ltd., Beijing Origin Seed Technology Inc., and BRI-CAAS. It is mainly engaged in cloning and transformation of functional plant gene as well as selection and cultivation, production, processing, sales, and technical services of new varieties of plants like cotton, cole, and fruits. Biocentury also owns exclusive implementation license right of core technical patent of insect resistant cotton, China's only GM agricultural crop in large-scale commercialization. More than 70 scientific institutions and enterprises are authorized by Biocentury to make use of the insect-resistant cotton patented technology, which shattered multinational's monopoly of the technology in China and brought in enormous social benefits. Biocentury's development in the insect-resistant cotton commercialization sector aroused extensive attention from the world, and it has established cooperative relationship with such countries as India, Philippines, Vietnam, Pakistan, and Burma. By virtue of successful performances in international market, Biocentury was touted as the agricultural biotechnology pioneer that marched into the international market in the wake of China's entry into the World Trade Organization.

Appendix 2 continued.

Beijing Origin Seed Technology Inc.	This agricultural biotechnology joint stock company integrates high-tech means (like modern biotechnology and genetic breeding) and engages in selection and cultivation, production, processing, sales, and technical service of new agricultural crops. With headquarter in Zhongguancun Life Science Park, it is China's first agricultural biotechnology company that was listed in NASDAQ of America in 2005. Besides building up its own core R & D team and system, it has become a bridge between the scientific research institutions and the market. So far, the company has established long-term partnership with more than 10 scientific research institutions (such as Chinese Academy of Sciences, CAAS, China Agricultural University, Peking University, Jilin Academy of Agricultural Sciences, and Henan Agricultural University) in scientific research and product development. By joining hands with CAAS and capitalizing on its own resources, the company has developed high-activity stable inheritance trans-phytase gene maize hybrid varieties. It will become the world's first seed company in terms of phytase maize promotion.
China National Seed Group Co., Ltd.	The seed company was founded by the MoA in 1978. It has evolved into a large-scale seed group that integrates scientific research, production, processing, marketing and technical service, and features a complete industry chain. So far, it has been jointly recognized by nine ministries and committees as "Leading Enterprise in Agricultural Commercialization", and was honored with the title "No.1 Among China's Top 50 Seed Enterprises" for two consecutive times. The company is mainly engaged in scientific R & D, production and processing, sales, and service of seeds of agricultural crops like maize, rice, vegetables, and sunflower. It continues to maintain its domestic lead in seed operation scale. In 2008, the company participated in the state-level regional experiment with its more than 10 new rice portfolios and several new maize portfolios. This is in addition to taking part in provincial-level regional experiment with its nearly 100 rice varieties, dozens of maize varieties, and several cotton varieties. On average, the company introduced nearly 100 new oil seed and vegetable varieties from home and abroad.