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Biofortification for China: Political Responses to Food Fortification and GM Technology, Interest Groups, and Possible Strategies

Carl E. Pray
Rutgers University

Jikun Huang
Chinese Academy of Sciences

Despite making enormous strides in reducing poverty, hunger, and malnutrition, China still has large numbers of people who do not consume sufficient micronutrients such as iron, zinc and Vitamin A. To meet this need, government agencies in China are supporting programs in industrial fortification and vitamin supplements. In recent years the government has also supported research on biofortification of major grain crops using both conventional plant breeding and transgenic techniques. The article assesses the potential political barriers to the acceptance of biofortified crops and concludes that biofortification using non-transgenic techniques would probably not face much opposition, while biofortification with transgenic techniques might have a more difficult time. The article then assesses which groups in China are likely to support or oppose biofortification and then proposes some strategies that the government and international agencies might use if they decide to support biofortification.

Key words: food fortification, biofortification, China, biotechnology.

Introduction

Despite making enormous strides in reducing poverty, hunger, and malnutrition, China still has large numbers of people who do not consume sufficient micronutrients such as iron, zinc and Vitamin A. In response to this problem, the Chinese government, in some cases with the assistance of the international community, has developed a number of programs to reduce micronutrient deficiencies.

China has had mandatory food fortification programs since 1994. One of the first fortification programs was the salt iodization program started in the 1990s, which is credited with a dramatic decrease in goiter in the last 10 years (Micronutrient Initiative [MI], 2004). The second was the distribution of Vitamin A supplements (MI, 2004). Two newer food-fortification programs have been initiated since 2002. The first, which began in January 2003, supports fortification of flour with Vitamins A and B in the Western Chinese provinces. The second program—fortification of soy sauce with iron—started in January 2003 and is active in five provinces and two cities working with 14 producers.

Since the late 1990s, Chinese plant scientists have begun trying to develop rice, wheat, and maize that contain elevated levels of iron, zinc, and Vitamin A. China has one of the largest plant-breeding programs in the world and in 1992 was the first country to introduce a transgenic crop (tobacco) for commercial production. Some of the biofortified crops are being developed using conventional plant breeding while others, such as Golden Rice, are being developed through genetic engineering.

The objective of this article is to review China's experience with food fortification, transgenic crops, and biofortification to identify political constraints to the development and adoption of biofortification and sources of their political support. In addition to analyzing the political landscape for biofortification technologies, this article suggests components of a strategy that could be used to encourage the spread of biofortification.

Political Responses to GMOs, Biofortified Crops, Fortified Foods, or Mandatory Fortification

Cases of political opposition to non-GM biofortification or industrial fortification in China have been rare or non-existent. Popkin (1998) mentions some difficulties in enforcing the mandatory fortification of salt with iodine. The fortification processing is decentralized. As a result, it is expensive to monitor. The costs of fortification are high relative to the price of the product, which pushes up prices and gives both producers and consumers incentives to ignore the rules. We did not find examples of political resistance to fortified food or papers that described controversy within the Chinese government about food fortification.

In contrast to industrial fortification, there has been some resistance to GM crops. China was the first country to introduce a transgenic crop for commercial production. Virus-resistant tobacco was first planted by farmers in 1992. Tomatoes with a long shelf life and resistance to virus, sweet peppers with virus resistance, and color-altered GM petunias were also grown in small amounts starting in the mid-1990s. In 1997 the first Chinese Biosafety Committee was established. It approved insect-resistant cotton and the tomatoes, sweet peppers, chili peppers and petunias that were already in the field. Since 1997 only two new genes or new crops were approved for commercial production—virus-resistant papaya and insect-resistant poplar tree varieties, which were approved in 2006.

The early approvals of GM crops were driven by scientists who were also the *de facto* regulators. These scientists knew that these technologies had been extensively tested in the United States and that many of them had been approved in the US biosafety regulatory system. The GM crops faced little opposition unless they could cause export problems or if multinationals threatened to take a large market share. We can distinguish three types of negative responses to the introduction of GMOs. The first type is a ***commercial response*** based on the risk of commercial losses to Chinese companies and is settled between the government and commercial interests before reaching the level of public controversy. The second type of response is a ***bureaucratic response*** consisting of power struggles over which part of government will control the technology and the bureaucratic resources needed to regulate the technology. In China, these struggles usually are resolved within the various parts of the Chinese and regional governments without recourse to public debate. The third type of response is a ***political response*** because it is fought out in public and involves government agencies, NGOs, and commercial interest groups.

An example of commercial response is the demise of GM tobacco in the mid-1990s. First approved in 1992, GM tobacco varieties were grown on 1.8 million ha by 1997 (James, 1997). The China National Tobacco Corporation (CNTC) and perhaps also Peking University, which inserted the transgenes into tobacco varieties, profited from this technology. By reducing farmers' costs of production, CNTC could pay them a lower price for tobacco leaves and increase its profits. However, some of these profits and a substantial amount of foreign currency would be lost if CNTC lost important international tobacco customers. Some American tobacco companies using Chinese tobacco for Japanese markets expressed concern about possible negative reaction of Japanese consumers to cigarettes containing transgenic tobacco. As a result, the Chinese government pulled this GM technology off the market in the late 1990s (Jia & Peng, 2002).

Chinese scientists and bureaucrats have debated internally whether China should have mandatory refugia (plots of non-Bt cotton to prevent the rapid development of bollworms that are resistant to Bt) for Bt cotton since the mid-1990s. Their debate was resolved initially through a bureaucratic response. Several meetings of scientists and policy makers were held to discuss this topic and the decision was made that the extensive planted areas of crops such as corn and vegetables that are also hosts for bollworm made mandatory refugia unnecessary. The difficulty of enforcing refugia on millions of small farmers also may have played an important role in this bureaucratic decision.

The first public attack on Chinese GM crops alleged that refugia for Bt cotton are necessary but were not possible under Chinese conditions and that Bt cotton was damaging biodiversity as measured by the number of insect predators of cotton pests. This attack was launched in 2001 by Greenpeace and Professor Xue Dayuan of the Nanjing Institute of Environmental Studies (NIES), one of three research institutes under the State Environmental Protection Authority (SEPA). Xue's report, published on Greenpeace's website and by NIES, implied that Bt cotton should be regulated more effectively or taken off the market (Xue, 2002); Xue's argument ignored the large economic and health benefits that small farmers receive from this technology.

The Chinese Ministry of Agriculture's (MOA) public response sought to discredit Xue's report (Keeley, 2003). And while the MOA itself made no *official* public response, Xue's conclusions, based in part on unpublished research by Dr. Wu Kongming, were contradicted by a series of papers that Wu published in 2002 indicating that he found no significant pest resistance to Bt cotton in the field or an increase in insect predators in Bt cotton fields (Wu, Gao, & Gao, 2002a; Wu, Guo, Nan, Greenplate, & Deaton, 2002b).

This debate on refugia continues through occasional internal discussions between scientists and regulators, but the Chinese government has chosen not to cut back on the use of Bt cotton, and it has not required that farmers grow non-Bt cotton as refugia. However, it has not ignored the potential importance of refugia, which is supported by research by Dr. Wu and other scientists. When Bt corn was proposed for commercialization by Monsanto in the late 1990s, one of the main reasons given for not approving it was that corn is an alternative host for bollworms and provides a "natural" refuge for susceptible bollworms.

Monsanto's dominance over the international biotechnology industry has evoked a commercial and bureaucratic response by Chinese scientists, officials, and seed companies. The government's concern is that seeds are too important to Chinese food security to be dominated by foreign companies. In addition, some scientists and officials have a financial stake in local seed companies that benefit from protection against competition.

In the early 1990s the US-based companies Monsanto and Delta and Pineland (DPL) started testing a number of GM cotton varieties in collaboration with the national Cotton Research Institute of the Chinese Academy of Agricultural Sciences (CAAS) at Anyang, Henan Province. Monsanto and DPL developed the joint venture company, JiDai, with the Hebei provincial and county seed companies to produce and market the GM cotton variety 33B. At the same time, the Biotechnology Research Institute (BRI), another part of CAAS, had developed their own Bt cotton varieties, and was developing partnerships with other provincial seed companies to market their varieties.

In 1997 at the Chinese Biosafety Committee's first meeting, the BRI Bt cotton varieties were approved for use in nine provinces, but JiDai's 33B was turned down with a request for more information. At the second 1997 Biosafety Committee meeting, JiDai's 33B was approved, but only for the Hebei Province. By 2003, JiDai varieties still had not been approved for cultivation in Henan Province despite ecological and agronomic conditions virtually identical to Hebei and Shandong and the fact that "illegal" cultivation of 33B was being conducted successfully there. Keeley (2003) concludes that BRI was able to influence the Biosafety Committee not to approve JiDai varieties for Henan in order to limit competition.

GM rice production in China has created far more political controversy than production of GM cotton, tobacco, or vegetables. Government scientists developed transgenic rice with a gene from African rice that provides resistance to bacterial blight. It was approved for trials in open fields in 1997 and one variety entered pre-production trials in 2001. Significant progress has also been made with rice varieties able to control rice stem borers and leaf rollers with Bt and cowpea trypsin inhibitor (CpTI) genes. These varieties started field trials in the late 1990s and have been in pre-production trials since 2001. None of these transgenic rice varieties have been approved anywhere else in the world. So, there is little scientific evidence on their safety elsewhere. In addition the scientists who created these varieties had not done much research on the food safety or environmental impact before 2000. In that year, the government commissioned a number of studies by the Ministry of Health on the food safety of transgenic rice and studies by MOA on the environmental impact of these rice varieties. Both Ministries found that there were no problems, but the reports were never published.

The political campaign against GM rice research started with a Greenpeace-financed survey in 2003 on consumer attitudes towards biotechnology conducted by a university faculty member in Guangzhou, China (Greenpeace, 2004). It reported that Chinese consumers were very negative about biotechnology and GM food. The survey was posted on the Greenpeace-China website and generated press coverage in Hong Kong and outside China but was never published in a refereed academic journal.

The Greenpeace campaign then focused on GM rice starting in 2004. In that year the MOA was close to approving for commercial production the GM rice variety with the African rice gene resistant to bacterial leaf blight. Greenpeace launched an attack on GM rice from their website claiming that GM rice may be dangerous to people's health and the environment and that the Chinese government has not researched its food safety or environmental effects. This stimulated an immediate electronic debate involving almost 10,000 emails through several major Chinese websites before these websites closed off the discussions as they veered from the technology itself to personal attacks on scientists involved.

In fact, the Chinese government has studied the impact of the Bt genes and rice pollen flow (Jia & Peng, 2002). However, these studies have not been publicized or published in academic journals. The government departments that regulate and fund scientific studies on these topics rarely challenge Greenpeace's assertions publicly.

In 2005, Greenpeace produced samples, allegedly from farmers' fields, of rice seed for planting and rice in consumer markets that both contained a Bt gene, according to tests by Genescan (a German lab). They said that they sampled rice from fields and markets near Wuhan. GM rice could be grown legally near Wuhan as part of extensive pre-production field trials run by the government. However, neither the rice produced in these trials nor the seed was supposed to be sold. The Greenpeace claims were published in the English language and Chinese press. Greenpeace attracted more publicity by allegedly finding Bt protein in Heinz baby food in Beijing in a Carrefour store in Wuhan, in Guangzhou and Hong Kong markets, and most recently in Chinese rice noodles sold in Europe (see http://www.greenpeace.org.hk).

The response of the Chinese government has been to investigate the allegations. Some Chinese scientists have cast doubt on the reliability of Greenpeace's testing. However, the Greenpeace-inspired publicity seems to have made government officials and scientists very cautious about GM rice.

One of the interesting parts of the Chinese story is what has not caused controversies. Early permits to produce GM tobacco, cotton, sweet peppers, tomatoes, and petunia caused no political controversy. This was primarily due to timing—before 1997 there was relatively little controversy about GM crops any place in the world, and there was little known publicly about biotechnology in China. Virus-resistant GM papaya and insect-resistant GM poplar trees were approved in 2006 for cultivation with little fanfare or public resistance. It is not clear why they have not created any controversy.

Another non-controversy has been the importation of GM commodities. Many varieties of GM maize, soybeans, and canola are cleared for importation. They are being extensively imported and soybean oil is being labeled as GM. Consumption of GM-labeled soybean oil has provoked little consumer resistance (Lin, Tuan, Dai, & Zhong, 2006).

During the initial years, 1999 to 2003, importation of GM soybean was debated, but the debate has waned. Opposition was mainly from governments of major soybean-producing regions (e.g., Northeast China, particularly the Heilongjiang province, where soybean accounts for about 50% of total crop area) wanting protection from competition. The processing industry and traders supported GM soybean imports because they wanted inexpensive inputs and it is virtually impossible for China to be self-sufficient in oilseeds. In addition, the US government pressured the Chinese government to allow imports of soybeans. There was also some concern from environmental institutions such as SEPA, who were concerned that some of the GM soybeans might be planted and influence biodiversity in the center of the origin of soybeans.

Beneficiaries of Industrial Food Fortification and Biofortification

To assess how important it is to work toward commercialization of GM or biofortified crops and to identify who would support or oppose these technologies with the government would be useful to have an assessment of their possible impact. Such a study was beyond the scope of this article, but there is some evidence available on current and potential impact.

MI's website (2006) describes the impact of micronutrient deficiencies in China that could be prevented or reduced through food fortification: more than 20,000 child deaths each year from increased susceptibility to infection; approximately 12% of China's children are growing up with lowered immunity, leading to frequent ill health and poor growth; deaths of up to 1,000 young Chinese women every year in pregnancy and childbirth; approximately 100,000 Chinese infants a year at increased risk of death immediately before or after birth; and approximately 35,000 to 40,000 severe birth defects annually, including infantile paralysis.

Food supplements and fortification are starting to have some impact—presumably primarily in urban areas. The MI (2006) reports that the Vitamin A supplementation programs in China were estimated in 1998 to be saving the lives of approximately 70,000 children a year and preventing a similar number of cases of permanent blindness. More than 90% of China's newborns are currently being protected to some degree against mental impairment by adding iodine to household salt.

The total goiter rate has been lowered from more than 50% to about 5% in the last decade. However, this still leaves poor areas in the countryside—particularly hilly and mountainous areas which are not well integrated into the market economy—with major Vitamin A, Vitamin B, iron, and zinc deficiencies to be mitigated by biofortified foods.

Organizations that Could Support the Development and/or Introduction of Biofortified Crops

Potential Allies for GM Fortification

The major institutional and financial supporter of GM research and technology development in China has been the Ministry of Science and Technology (MOST). MOST has invested heavily in biotechnology through three major research programs—the 863 program for applied research, the 973 program for basic research, and the Transgenic Engineering Crops Breeding Special Funds for GMO commercialization.

Other supporters of GM technology are scientists working on developing transgenic plants. The leaders include the President of the China Agricultural University, Beijing; leaders of the Chinese Academy of Sciences; CAAS and biotech scientists at Central China

Agricultural University, Wuhan; and the Hunan Hybrid Rice Research Center. However, few of the most influential Chinese scientists have GM biofortification research programs.

Scientists involved in GM biofortification projects also are obvious supporters. There are three official institutional collaborators with the international Golden Rice project, such as the Yunnan Academy of Agricultural Sciences. In addition, one of the pioneers of biotechnology research at CAAS has been involved with biofortification as the leader of the Chinese HarvestPlus program since 2005.

Farmers could be major economic and health beneficiaries of GM food crops like disease- and insect-resistant rice. In addition, poor farmers are likely to be the main beneficiaries of biofortified crops because they are the ones who do not get access to supplements and commodities with industrial fortification. However, farmers in China are not mobilized into political organizations that can push for new technology which suggests that the farm community is unlikely to provide strong political support for biofortification.

There are a number of government-owned and local private seed companies that made money selling the new Bt cotton seeds that could be supporters of GM crops. If the yield and other traits of the biofortified varieties are the same as the local varieties, they would probably have to make money by selling biofortified varieties to the government for distribution in poor areas where nutrition is a concern. If the trait can be put into a hybrid rice, corn, or wheat cultivars that yield more than the local varieties, then commercial companies might push these varieties on their own Multinational companies.

International biotechnology companies would be obvious collaborators in pushing GM technology in general. They are very interested in having China approve GM rice (or wheat), which they believe would help open both Chinese and world markets to transgenic crops. In China, the multinationals Pioneer, Monsanto, and perhaps others have breeding programs on conventional maize hybrids, sunflower hybrids, and sorghum hybrids. Only one multinational—Syngenta—has any explicit interest in a GM biofortified crop—Golden Rice. Other companies, such as Monsanto and DuPont, have research on GM and conventional maize with improved qualities, such as high protein for cattle feed. In addition, US food and feed companies that operate in China, such as Cargill, are interested in improved quality maize mainly for animal feed. Elsewhere in the world, these multinationals are working to biofortify crops that can produce improved quality cooking oil, omega-3, and other traits for humans.

The US Embassy, particularly the agricultural attaché's office, is another obvious ally. They have been very active in encouraging China to import GM crops.

Potential Allies for Non-GM Biofortification

For biofortified crops produced through conventional plant breeding, genomics, and marker-aided selection, several groups in addition to supporters of GM biofortified crops are potential allies: government and private sector plant breeders who use these techniques, commercial seed companies, the food fortification industry, and supermarket firms.

Many conventional plant breeders in government institutions have felt that MOST and MOA were putting too much money into developing transgenic crops. Many of these breeders would welcome programs that financed the use of conventional techniques, genomics, and marker-aided selection to improve the nutritional qualities of their crops.

The private seed industry would also be interested in incorporating nutritional traits if these were linked to improved agronomic traits in hybrid crops such as rice, maize, sunflower, and sorghum. These companies also could be interested in producing nutritionally improved varieties if the government guaranteed a market for these crops, even if they contain no improved agronomic traits. Finally, if consumers, the food industry, or supermarkets were willing to pay a sufficiently high premium for enhanced nutrition, they would be happy to supply it.

Government organizations responsible for the health of Chinese citizens are another potential ally of biofortification. Many of them are already involved in food fortification and some have signed on to the Global Alliance for Improved Nutrition (GAIN) programs, which emphasize food fortification. GAIN has helped create a Chinese National Fortification Alliance (NFA), which includes agencies such as the Ministry of Health, Ministry of Finance, State Bureau of Grains, the China Center for Disease Control (CCDC), and the China Center for Public Nutrition and Development. It does not appear to include the Ministry of Agriculture.

Other potential allies are the Chinese and international food and supermarket industries. Forty Chinese companies and 35 international companies agreed in October 2005 to the "Beijing Declaration on Food Fortification." The Declaration is part of a worldwide program in which food industry leaders pledge to "Seek and pursue opportunities to produce and distribute affordable fortified foods around the world, and in the developing world particularly" (GAIN/BAFF, 2005, p. 4).

Like the government agencies described above, the food industry will cooperate with biofortification groups if they see that it is in their interest to do so. If they can get more government contracts, a competitive advantage in marketing their products, or lower costs of production, they will be interested and cooperative.

Several trends in the Chinese food industry indicate that Chinese consumers would welcome biofortified foods. There is a "healthy food" component of the Chinese food industry. Such companies have established a market niche of fortified foods. In addition, a broader range of consumers are becoming aware of the importance of food fortification through government programs to reduce micronutrient deficiency.

Local Organizations or Institutions Most Likely to Resist the Development or Introduction of New GMOs and/or Biofortified Crops

The organization most actively opposing GM crops in China is Greenpeace International, which established its Greenpeace-China affiliate office in Hong Kong in 1997 and more recently has established offices in Guangzhou and Beijing. Its website lists "food safety" as a priority. For Greenpeace-China, food safety appears to consist almost entirely of stopping GM crops (Greenpeace, n.d.). They are clearly opposed to Golden Rice because it is GM. Their arguments against Golden Rice—there are other sources of Vitamin A that are more "natural," etc.—could also be leveled at biofortified crops, but so far they do not seem to be concerned about non-GM biofortified crops.

Greenpeace is the only major international anti-biotech NGO working in China. Its presence in China is due in large part to its collaboration with the Chinese environmental agency, SEPA. Top officials in China clearly are more skeptical about GM crops than they were five years ago. This undoubtedly is due partly to Greenpeace—particularly its campaign against GM rice; but other material on the web and the general skepticism of Europe, Korea, and Japan about GM crops has made an impression on these officials and the public. Chinese employees of foreign biotech companies interviewed in China expressed the opinion that Greenpeace had been effective in changing Chinese attitudes about GM crops.

SEPA is the Chinese government Ministry most opposed to GM crops. Its opposition reflects both genuine concern about the problems that GM crops might cause the environment and bureaucratic self-interest. SEPA is the center of most international—particularly European—donor activity on the environment. It is the Chinese government agency that both negotiated and is supposed to implement the Convention on Biodiversity. In addition, SEPA would like to have a much larger role in the regulation of biotechnology. At present, the Ministry of Agriculture runs the biosafety regulatory system for *agricultural* biotechnology, and the State Forest Bureau (SFB) runs the biosafety regulatory system for *forest* biotechnology. Thus, the staff, budget, and other bureaucratic resources of the regulatory role are in MOA and SFB instead of SEPA.

MOA is the Chinese Ministry which is the currently the major constraint on GM rice commercialization. Most government officials in Beijing Ministries with whom we have spoken, other than MOST, express personal concern over the potential risks of approving GM foods. On the other hand, many non-GM agricultural scientists oppose production and consumption of GM foods because they not only believe they receive less funding for their research because of GM research, but also think their technology is as good as GM technology, with less food safety risks.

Officials' concerns about the negative health effects may be due to their interpretation of the media. The internet and the regulated official media are major sources of information for officials. The internet has extensive anti-biotech information that is not available through official channels. Official newspapers are more neutral in reporting about GMOs, but China's official media neutrality about news on GM foods could be interpreted by officials as "maybe not good" or "maybe there are some problems."

Based on personal discussions with officials, we conclude that MOA leaders have not approved the commercialization of insect- or disease-resistant GM rice for several reasons:

1. Rice is the major food crop, not some minor crop. MOA leaders do not want to risk a mistaken decision because it could cost them their careers.
2. There are concerns about food safety of GM rice.
3. There are concerns about whether consumers will accept GM rice and also about rice exports.
4. Currently, there are no major disease or stem borer problems for rice.

5. China has a surplus of rice and so grain security is not an issue right now.

If disease or stem borers would emerge as a major problem and China had to increase its imports of rice, our assessment is that MOA would approve these GM varieties for commercialization despite Greenpeace and SEPA objections. MOA and MOST leaders both continue to support biotech research, but MOA supports it as insurance for the future in case there is a return to grain shortages and imports.

There are a variety of industries who might oppose GM or biofortified crops because they fear that they would lose money by the introduction of GM biofortified crops. These would include exporters of non-GM crops who would have to segregate their crops and test them to assure consumers of their non-GM status. It could include food companies that supply vitamin supplements and the materials needed for industrial fortification, and the companies that actually do the fortification which might lose some markets to biofortified crops. Some seed companies who do not feel that they could compete with GM or with biofortified varieties might also be concerned.

Many European governments and UN organizations have been very "precautionary" in their advice to the Chinese government and some have been actively opposed to Chinese approval of GM technology.

The Technical Options Most Likely to Find Local Acceptance

It seems clear that, at the moment, GM biofortified varieties of major food grains would have a tough time making it through the biosafety regulatory process and then through the political process to obtain permission to be grown commercially. The Biosafety Committee will require several years of food safety and environmental field trials even if the Golden Rice genes, for example, come with an extensive portfolio of food safety research results from the United States and Europe. The gene and the varieties containing it will come under extensive attack from Greenpeace, which will make both the regulators and political leaders very cautious about approving it for cultivation.

In contrast, non-GM biofortification does not have the same problems of going through the biosafety regulations and facing political concerns of the government. In theory, biofortified crops would be regulated by the food fortification and crop variety laws. All new crop varieties have to be tested by the Ministry of Agriculture or provincial agricultural bureaus for improved agronomic traits such as yield and resistance to major pests and diseases. Health foods and industrially fortified foods are reviewed under legal regulations administered by the Ministry of Health (MOH). Biofortified foods from varieties made through conventional plant breeding could be introduced by MOA without needing MOH approval. MOH approval will probably be required if a government subsidy would be needed to motivate farmers to grow the variety because the variety has yields that are equal to or less than traditional cultivars. MOH approval might also be required if the Ministry of Food takes on the role of purchasing and distributing biofortified grain to the poor.

The failure of biofortified varieties to achieve improved agronomic traits, better taste, and better cooking quality would imperil approval from the national and/or provincial variety testing system. Even if biofortified varieties with little agronomic improvement are approved, it will be very difficult to promote farmer acceptance of them. Therefore, biofortified varieties that are higher yielding with good quality and are non-GM are the most promising technical option.

Strategies for Promoting GM and Conventional Biofortification in China

The absence of controversy about industrial fortification and the government's support of fortification and the distribution of vitamin supplements show that there is political support for the concept of fortification. This suggests that the government and people of China are also likely to support and accept biofortification, particularly if it is non-GM and if there is clear evidence that malnourished rural people will benefit.

The political controversies around GM crops show that policy makers generally make their decisions on the basis of what they perceive to be beneficial for large numbers of farmers and consumers as well as the power of certain special interest groups. The political controversies and non-controversies around GM tobacco, cotton, and imported GM commodities described above show that when there is a clear economic benefit for Chinese farmers, Chinese seed companies, and Chinese processing companies, new technologies can be quickly passed through the regulatory system and will continue to be supported by the government even if there is some criticism from organizations like Greenpeace. If there are major potential export losses, the technology can be withdrawn. However, if the main beneficiary of the technology would be *foreign* biotech or seed companies, the government is willing to slow the spread of the technology to farmers. The approval of imported GM oilseeds and feedgrains also shows that the government takes a practical approach to these issues. In this case, it solved urban consumers demand for inexpensive cooking oil by approving imports of GM soybeans and canola while trying to reduce consumer concerns by introducing GM labeling. Consumers are buying the labeled GM cooking oil with little measurable concern about food safety effects.

In the controversy over GM rice, concerns about food safety and environmental impacts and the role Greenpeace and SEPA have played a large role in decision-making. Even in this case, however, it still seems likely that a combination of real need for more rice production, more attractive rice varieties, more scientific evidence of the food safety of GM rice, and more active promotion of this technology by the government could lead to the approval and acceptance of GM rice.

If MOA decides to promote non-GM biofortification, it has several options. First, the MOA would need to develop some well-documented success stories which show that biofortification can really work to reduce micronutrient deficiencies. If the MOA agencies need support to do this, outside funders could provide support through HarvestPlus or directly to Chinese social scientists at universities or government institutes. This would then become the foundation of an effort led by MOA, or perhaps MOST, to build a coalition of ministries that would have biofortification as the rural part of an overall strategy for reducing micronutrient deficiencies. Second, international foundations that fund organizations like Micronutrient Initiative-China, GAIN China, HarvestPlus China, and the Golden Rice research could encourage their Chinese grantees to work toward an integrated program of industrial fortification, supplements, and biofortification to reduce micronutrient deficiencies. Third, these grantees could then encourage organizations like UNICEF and the World Bank to finance programs and encourage Chinese government agencies who currently work on fortification and supplements to include biofortification as one of their tools for reducing malnutrition.

If the government decides to promote GM biofortification, its options include a program to develop appropriate technology. They need to finance research to develop GM products that are attractive to farmers—high yields, high-quality grain, and resistance to biotic and abiotic stress—and with traits that are attractive to the consumers and the Chinese elite, particularly the top bureaucrats in MOA, MOH, and SEPA, and consumers more generally. These bureaucrats want some of the same things that appeal to consumers in the United States and Europe, such as Omega 3, healthy vegetable oil, and healthy vegetables. The development of this technology could be encouraged by a well-publicized prize or competitive research and development program to give government research institutions the incentives to develop and commercialize transgenic crops—especially those with improved nutrient content. Publicity for these prizes or the research funding may be needed to show Chinese scientists that there still is national and international support for GM biofortified crops. The program would be open to public research organizations and private corporations. Public-private collaborative research programs would be encouraged, including collaborative proposals that incorporated leading multinational companies and Chinese public research institutes.

A second program in addition ot developing attractive GM technology would also be needed if GM biofortified crops are to succeed. The government would have to develop a more visible and transparent biosafety regulatory system for GM crops. This would include more research on GM rice food safety in particular, with publication of the results in refereed academic journals and publicity concerning the results; public education to convey that GM crops are tested for food safety and environmental impact; and education/risk communication about benefits of GM crops. Research in China has shown that few people know that a biosafety regulatory system exists, but as they learn of the system, they have more confidence in the safety of these crops (Zhang, 2004).

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