Guest editorial

Impacts of and attitudes toward GM technology in China: challenges, policy and research implications

Introduction

The global food security will be facing great challenges in the near future. The latest baseline projections by the International Food Policy Research Institute (2017) show that the global food production should increase by at least 60 percent in 2050, as compared to 2010, in order to meet the growing demand for food, feed, fiber, and fuel. In addition, after considering further issues related to this matter, agri-food researchers and policy makers along with their stakeholders could be well advised on how to examine every resource available in their toolkit. These may include prospective climate change, growing competition for water and land use, resource governance and environmental protection, poverty reduction, and the need to improve maternal and childhood health and nutrition outcomes.

Genetically modified (GM) technology is one of major tools that can significantly boost agricultural productivity (National Academies of Sciences, Engineering, and Medicine (NASEM), 2016). In most countries that have adopted GM crops, there has been a rapid growth in their planted area due to the advantages of GM technology. The global areas of GM crops increased from 1.7 million hectares in 1996 to 185 million hectares in 2016 (ISAAA, 2017).

While GM technology has been commercialized for over two decades, the pros and cons of this technology are still hotly debated. These debates range from environmental to health and socioeconomic impacts (NASEM, 2016). The debates affected the public attitudes toward GM technology, which further affected the decision making by the national leaders in many developed and developing countries. Therefore, despite its rapid growth in the planted areas, only 26 countries had planted GM crops by 2016 (ISAAA, 2017).

Even for China, one of the first countries that have commercialized GM technology, the GM crop area expansion has stagnated since the middle 2000s when the government started to respond to the public's concerns about safety of this novel technology. Despite huge and increasing investment in research and development (R&D) of GM technologies by the government (Hu *et al.*, 2012; Huang *et al.*, 2012), China has not approved any major field GM crop for production after the commercialization of the insect-resistant GM cotton in 1997 (Huang *et al.*, 2017). Understanding the attitudes of major stakeholders related to GM technology, the impacts of commercialization on major GM crops, and the regulations and policy governing the use of GM technology are critical for this technology's development and commercialization in China in the future.

This special issue on GM technology provides new evidence on the economic benefits and/or costs of GM technology for the major stakeholders, their attitudes toward this technology, and policy implications of regulating and commercializing GM technologies in China.

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The impacts of GM technology on the major stakeholders

Three papers in this special issue address the impacts and promises of GM technology. The first paper by Huang *et al.* (2017) examines the impacts of the insect-resistant GM maize on China's macro-economy and each of the major stakeholders who can influence the national policies. This is a very timely study because China is about to decide whether GM maize should be commercialized in the coming years. The other two papers also address the issue of the impacts of GM technology as one of their objectives, by analyzing the value of

GM Canola in Canada and its implications for China (Brewin and Malla, 2017) and the potential promises of GM technology in meeting the increasing demand for agricultural products in world, and China in particular, in the future (Dang *et al.*, 2017).

On the basis of the data from the production trials of the insect-resistant GM maize and the economic impacts of commercialization of the GM crops, Huang *et al.* (2017) use a modified Global Trade Analysis Project (GTAP) model and show that China can gain USD8.6 billion and improve its feed and livestock production. The most significant beneficiary is the consumer who gains from the fall in prices of meat and other food items. The livestock industry (and feed) also gains significantly from GM technology because of the lower maize price (and the higher GM seed price). Farmers who produce other crops benefit from land saving due to GM maize commercialization. Only the chemical sector shows a decrease in output, because the pesticide use falls with the GM maize commercialization. Their paper is the first study that assesses the economic impacts of commercializing GM maize in China (Xie *et al.*, 2017). The findings have significant implications on whether China should commercialize its GM crops and who should support this technology, which has been further discussed in their paper.

Brewin and Malla (2017) further support earlier studies on the value of GM crops. For example, they show that farmers in Canada can gain more than CND1 billion per year from GM canola. While the paper by Dang *et al.* (2017) does not examine the impacts of GM technology specifically, it presents some key challenges facing the agriculture and agri-food sector and the potential role GM biotech can play in addressing them. These papers suggest that GM technology can play a great role in China's agriculture and food security as well as in the improving farmers' income.

Based on the findings of Huang *et al.* (2017), published in this special issue, and the previous studies on the impacts of GM technology on different stakeholders of Bt cotton and Bt rice (Huang *et al.*, 2004; Hu *et al.*, 2009), it can be stated that in addition to the producers, the major beneficiaries are consumers, stakeholders in the mid- and down-stream of the commodities (e.g. processing and livestock), as well as seed industry and technology inventors (e.g. scientists). So, the next set of questions examined in this special issue is as follows: what are the attitudes of these stakeholders toward GM technology? Are they willing to buy GM food? Are their perceptions of and attitudes toward GM technology/food consistent with their economic benefits/costs from GM technology as well as their actual consumption behaviors?

The attitudes of major stakeholders toward GM technology and food

To provide some of answers to the questions raised above, we include four papers in this special issue. The first paper by Huang *et al.* (2017) assesses the scientists' attitudes on whether China needs to develop its national agricultural GM technology and the willingness to buy GM food. The second paper by Deng *et al.* (2017) assesses attitudes toward R&D investment in GM technology and GM foods, and lobbying activities among several agribusiness firms. The last two papers examine the consumers' attitudes toward and their willingness to pay for GM foods (Zheng *et al.*, 2017; Deng *et al.*, 2017).

The first two papers are of importance because both scientists and the industrial managers may potentially lobby the policy makers on whether to invest in the R&D in GM technology and whether to commercialize the GM crops. On the scientists' attitudes, Huang *et al.* (2017) show that about three-quarters of scientists agree that China needs to develop its agricultural GM technology. But the number differs largely among scientists with different disciplines: it ranges from 59 percent in science and 65 percent in social science to 86 percent in agricultural science. The results also show that different attitudes toward GM technology are correlated with not only their professional disciplines but also personal characteristics, type of research engaged, and knowledge on biology. However, the agricultural-related industries are generally not in favor of using this technology in China (Deng *et al.*, 2017). The industries in descending order of opposing the uses of this technology are chemical, feed, seed, and food industries. Also, about one-third of the surveyed firms were invested in biotechnology R&D and nearly 15 percent of managers lobbied the government to change GM technology policies. The expected gains or losses from the technology are found to be the main factor affecting their attitudes (Deng *et al.*, 2017).

On the attitudes toward GM foods, both studies show low rates of acceptation. While most scientists support GM technology development, less than 30 percent of scientists are willing to buy (WTB) GM food, even oil produced from GM soybeans (Huang *et al.*, 2017). Low WTB for GM soybean oil is observed for nearly all scientists, except those who work more in agricultural fields. Deng *et al.* (2017) show that only 22.5 percent of the surveyed firm managers have positive views on GM foods, ranging from 8 percent for those from chemical firms to 36 percent for those from seed companies. They also found that the managers' attitudes toward GM foods significantly affect the firms' decisions to invest in biotechnology R&D and lobbying activities (Deng *et al.*, 2017).

Two studies examining Chinese urban consumers' attitudes show low rates of acceptance for GM foods. Zheng *et al.* (2017) investigate the consumers' knowledge and acceptance of GM foods in 2013 and compare their results with an earlier study using the similar survey method, conducted in 2002 (Huang *et al.*, 2006). They find that while the levels of consumers' awareness on GM foods, biotech knowledge, and subjective knowledge have all improved significantly in the past ten years, consumers' acceptance of GM foods has declined significantly over the same period (Zheng *et al.*, 2017). By 2013, on average, only 28 percent of the surveyed urban consumers accepted GM foods. The other study gives special attention to a newly developed GM food product – Fad-3 GM lamb – and finds that when the respondents were asked about the safety of GM lamb with regard to consumption, about 17 percent say "it is safe", 52 percent say "don't know", and the rest consider it unsafe (Chen *et al.*, 2017). Further analysis shows that on average each respondent is willing to pay a 21 percent discount for this GM food relative to the price of conventional lamb (Chen *et al.*, 2017).

Across the above studies, several interesting points can be made. First, on the attitudes towards GM foods, there is not much difference in the average acceptance rates among scientists, agricultural firms' managers, and urban consumers. For example, the acceptance rate among urban consumers for GM soybean is 27 percent. This is almost the same as that among scientists (29 percent). Second, as suggested by Zheng *et al.* (2017), if consumers with "neutral" attitudes could be shifted to favor GM foods, the percentage of consumers who would accept GM food would reach about 60 percent. Third, the low levels of willingness to buy GM soybean oil are not consistent with the facts that the soybean oils are nearly all produced from GM soybeans and GM soybean is the most common edible oil in China. These points raise questions on the relevance of making national GM development policy decisions based on the research results using the method of the willingness to buy GM food.

In the actual world, some consumers may buy GM food, even if they say "I am not willing to buy GM food". Of course, consumers might not be aware of what they bought. Buying the GM foods due to their lower price can be the other important reason, which is also evidenced from the study by Chen *et al.* (2017). Finally, while there is room for popularizing GM science and technology among consumers (Zheng *et al.*, 2017) and even within the scientist community (Huang *et al.*, 2017), it is a challenge for two reasons: the recent government efforts in popularizing GM science and technology have been accompanied with a continued fall in consumers' support for GM technology; and even though the scientists have much more knowledge on biotech than the public, their acceptance for GM food is not different from that of the consumers.

Prospects of promises and investments in and challenges of managing GM technology

In this special issue, several papers have directly and indirectly addressed the prospects of GM technology in the future. Despite low level of acceptance for GM foods, majority of scientists continue to support the development of the technology (Huang *et al.*, 2017). This might be because the economic gains from GM maize are substantial (Huang *et al.*, 2017). GM technology can improve China's food security (e.g. 45 percent of consumers say "GM lamb can alleviate the problem of food shortage"; nearly 37 percent say "not sure"; and only 18 percent disagree about its role in food security) (Chen *et al.*, 2017). The potential roles of GM technology in meeting the food, feed, fiber, and fuel needs are promising (Dang *et al.*, 2017). The gains can be expanded with more private sector investments, as in Canada's case discussed by Brewin and Malla (2017).

Canada's successful biotech crop, canola, shows the roles of intellectual property rights, institutions, and policies in the development of biotech. Brewin and Malla (2017) suggest considering the characteristics of the integrated (up, mid-, and down-stream) innovation process of biotech. It is not surprising that private sector investments in Canada are much higher than public sector investments. Institutional innovations have been a powerful trigger to improve the internal rate of return on R&D and productivity, which has important policy implications for China.

China's biotech in general, and GM in particular, has been mainly developed by the public sector (Huang *et al.*, 2005, 2017). But the Chinese Government has established many policies to encourage innovation in agribusiness firms. In this regard, the paper by Jin *et al.* (2017) in this special issue examines the relationship between government policies and innovation in agribusiness firms or commercial agricultural R&D output and public R&D investment in biotech. They find that only raising R&D expenditure in public research does not increase commercial innovation, but moving budget or resources to the development patentable biotech does improve commercial and research productivity. Their results suggest that policies to increase research in agribusiness firms will facilitate technology innovation. These may include strengthening the legal framework and institutional resources in public research institutes for the protection and enforcement of intellectual properties (Jin *et al.*, 2017). This is consistent with the GM canola case study in Canada by Brewin and Malla (2017).

Besides financing agricultural R&D, regulating and managing GM technologies are the other critical issues that need to be focused on to have a successful GM program in any country. The research done by Dang *et al.* (2017) finds that each nation has evolved its own system of governance on agri-biotech or GM R&D, application, industrialization, and commercialization, as well as the trade matters. These systems take into account the different challenges facing the society, the recognized potential of different biotech interventions, and citizens' collective perceptions regarding both the potential and the risks that biotech innovations embody. Systems that are less evidence based appear to be more discretionary and therefore are less predictable in their outcomes. This increases risks for prospective exporting and importing firms, driving up system costs and effectively serving as a barrier to entry and to trade. It also dampens and distorts entrepreneurial and innovation incentives. The sometimes disjointed, sometimes strategic use of biotech regulations have fragmented markets and created fiefdoms, which undermine the potential of novel technologies to address the challenges facing the society.

Summary notes

This special issue selects the papers that draw on both empirical research works and literature from a number of disciplines related to agricultural economics and GM technologies. We believe it will contribute to the current debates on the pros and cons of

GM technology in China and the rest of the world. There is a stark contrast between the low acceptance rate for GM soybean among nearly all stakeholders and more than 80 million tons of GM soybeans consumed annually since 2015 in China. This suggests that the public and private researchers and policy makers may need to think more about the actual preference of individuals, be it consumers or scientists or industries, rather than the subjective perception of GM technology. Of course, to have a successful and sustainable development and maximize the promises offered by GM technology, getting more support from the public is important. Institutional innovations in biotech R&D and appropriate regulatory policies governing GM technology are also essential.

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