China aggressively pursuing horticulture and plant biotechnology

Jikun Huang
Scott Rozelle

As the world debates the costs and benefits of plant biotechnology, swinging between optimism generated by a long list of breakthroughs and pessimism caused by a consumer backlash in some places, a new source of plant biotechnology discoveries is emerging in a most unlikely place: China. And the discoveries being made are more than cosmetic transformations. China's research community has made a major investment into understanding the structure and function of the rice genome, the use of agrobacterium to transform the rice plant, and new methods of transforming other crops, including a wide array of horticultural plants.

China has one of the largest and most successful agricultural research systems in the developing world (Stone 1988). Historically, much of China's research was focused on grain, and the government invested in research and development (R&D) as part of its pursuit of food self-sufficiency. Horticulture played only a small role in China's development strategy.

Economic growth, the rise of markets and the opening up of China's economy have resulted in a sharp shift in government policy and producer decision-making. As markets emerged in the 1990s, farmers reduced their area sown to traditional grain and fiber crops and began to cultivate vast tracts of produce. Fruit and vegetable area has nearly doubled in China, expanding by more than 20 million acres during the 1990s, adding the equivalent of a "new California" every 3 years for the past 12 years.

The Chinese research system has responded to the new demands. In the mid-1990s, top research administrators began allocating more funds to nontraditional crops. Researchers, including those in a nascent private-sector seed company, were given more freedom to work on broader array of crops and provided with incentives to shift to horticultural crops.

Research in modern plant biotechnology began in the mid-1980s. Chinese scientists now apply advanced biotechnology tools to plant science, regularly working on the synthesis, isolation and cloning of new genes, and the genetic transformations of plants. Our survey of China's plant biotechnology laboratories identified more than 50 plant species and more than 120 functional genes that scientists are using in genetic engineering, making China a global leader. China's scientists have generated an array of technological breakthroughs in transgenic plants and animals (Huang et al. 2002), and are currently working on a large number of horticultural crops such as tomatoes, melons and peppers (table 1).

Chinese scientists now apply advanced biotechnology tools to plant science, regularly working on the synthesis, isolation and cloning of new genes, and the genetic transformations of plants.

The technologies that have been approved for commercial release also demonstrate China's ability to move ahead with its biotechnology program. Among the varieties approved and licensed for commercialization before 2000 were shelf-life-altered tomatoes, color-altered petunias and pest-resistant peppers. Although approvals for genetically modified (GM) food crops have slowed recently, China was allocating about 9% of its research budget to plant biotechnology in 1999. In the late 1990s, China accounted for more than half of the developing world's expenditures on plant biotechnology. Recently, officials announced a plan to drastically raise research budgets.

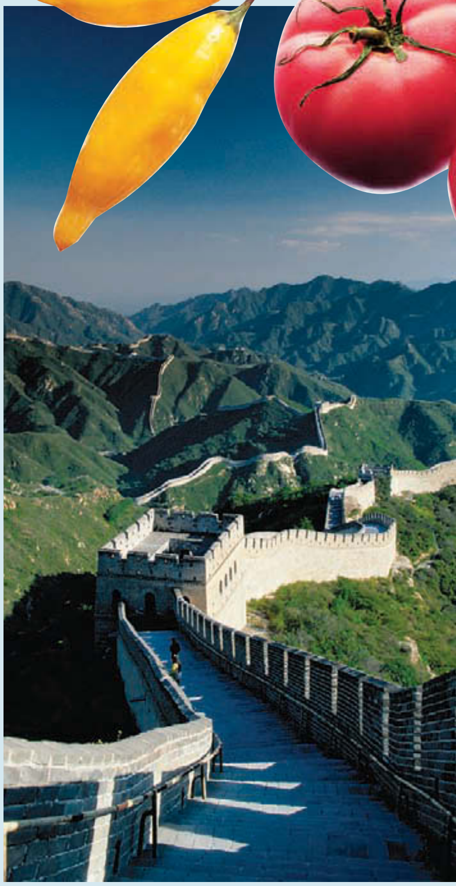
Many issues face China's research administrators. China's government recently put into place a regulation and biosafety system, but it is new, underfunded and has not proven its ability to enforce regulation. Chinese leaders are struggling with issues of consumer safety and acceptance, both within their own country and in countries that import its farm commodities. Almost nothing is known about how

TABLE 1. Field trials, environmental releases and commercialization of genetically modified horticultural plants in China through 2000

Crop	Introduced trait	Field trial	Environmental release	Commercialized
Cabbage	Turnip mosaic virus resistance	Yes	No	No
Tomato	Cauliflower mosaic virus (CMV) resistance	Yes	Yes	Yes
	Tobacco mosaic virus (TMV) and CMV resistance	Yes	No	No
	Shelf-life altered	Yes	Yes	Yes
	Cold tolerance	Yes	Yes	No
Melon	CMV resistance	Yes	No	No
Sweet pepper	CMV resistance	Yes	Yes	Yes
Chili	CMV and TMV resistance	Yes	Yes	No
Papaya	Papaya ringspot virus resistance	Yes	Yes	No
Petunia	Flower-color altered	Yes	Yes	Yes
Pogostemon*	Bacteria wilt resistance	Yes	No	No

Source: Author survey.

*An Asian shrub, used to make patchouli oil for fragrances and medicinal purposes.



China has dramatically expanded its production of fruits and vegetables, while allocating significant research funds to agriculture biotechnology. *Above*, Chinese scientists have developed genetically engineered crops, including peppers, tomatoes, papaya and cabbage (conventional crops shown).

Chinese consumers would react if they knew that their food was produced with GM varieties, although recent research suggests a relatively high degree of acceptance.

China's government also must decide if it will continue to bear almost the entire burden for funding biotechnology research. There is almost no private-sector funding. In the late 1990s, total spending by foreign firms on agricultural research in China was less than $16 million (Pray et al. 1997). China has options for increasing private research but is constrained by poor intellectual property rights (IPR), underdeveloped seed markets and prohibitive regulations on private firms.

Finally, the size of China's research investment, the improved education of its scientists that are involved in plant biotechnology research and its past success at developing biotechnology tools and GM plants suggest that its plant biotechnology industry may one day become an exporter of research methods and commodities. In both industrialized and developing countries, opportunities are expanding for contract research, exporting GM varieties, and selling genes, markers and other biotechnology tools. China has advantages such as large groups of well-trained scientists, low-cost research, limited regulation and large collections of germplasm.

At the same time, it has the disadvantage of almost no commercial biotech industry, a fragmented seed industry, public researchers inexperienced in working with corporations and a weak IPR regime. The Chinese agricultural-biotechnology sector will have to compete with the private and public sectors in other countries — the private life-science giants, smaller private biotech firms in industrialized countries, and universities in the United States and other industrialized countries. Because of its lack of capital and experience in global competition, China may have trouble competing in the most lucrative markets. However, the multinational life-science companies may be willing to leave relatively minor crops, including many horticultural crops, to China.

The emergence of China as an agricultural trading nation, and its rising strength in plant biotechnology research, offers fundamental challenges to California. China has a large advantage in producing labor-intensive horticultural crops, given its low wage structure and virtually unregulated agricultural economy. Indeed, China has already begun to make inroads into fruit and vegetable markets in East Asia that were once dominated by California growers. In contrast, California's marketing infrastructure and UC-based agricultural R&D system give it an edge in producing and delivering high-quality products and competing for foreign markets. To the extent that science will improve the quality and marketability of China's fruit and vegetable producers, plant biotechnology will improve China's competitiveness.

Inside China, where consumer acceptance is less of an issue, a more productive farming sector could mean less room for California's products. However, if China relies primarily on plant biotechnology to improve product quality, it might give California an advantage in world markets. As a developing country with a poor reputation for emphasizing food safety, China may not easily garner access to world markets for commercial releases of GM fruits and vegetables. Countries such as Europe and Japan are already skeptical about GM foods and likely would be especially concerned about importing them from a nation with a relatively short and untested consumer and biosafety record.

J. Huang is Director, Center for Chinese Agricultural Policy, Institute of Geographical Sciences and Natural Resource Research, Chinese Academy of Sciences, Beijing; and S. Rozelle is Associate Professor, Department of Agricultural and Resource Economics, UC Davis, and Associate Director, UC Agricultural Issues Center.

References

Huang J, Pray C, Rozelle S, Wang G. 2002. Plant biotechnology in China. Science 295:674–7.

Pray C, Huang J, Rozelle S. 1997. Agricultural research policy in China: Testing the limits of commercialization-led reform. Contemp Econ Stud 39(2):37–71.

Stone B. 1988. Developments in agricultural technology. China Quarterly 116 (Dec).