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Review

Establishing a biotech-modern-agriculture for China

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China, with a large population and small amount of arable land, is a populous as well as a large agricultural country. In order to ensure food security, agricultural sustainable development and prosperity of agriculture economy, modern agriculture based on biotechnology combined with modern equipment must be developed. Only in that way can we achieve intensive management and establish a resource efficiently-utilized and environment-friendly society. According to the developing history, experience of biotechnology and modern agriculture both at home and abroad, we suggest that establishing a biotech-modern agriculture country should become a national development goal of China.

Key words: Biotechnology, modern agriculture, agricultural modernization, national development goal.

INTRODUCTION

In the 21st century, six crises are proposed to be the main challenges for the agriculture in China: food security, water and soil resources, energy, environmental pollution, rapid population growth and health, and climate change crisis. The 21st century is the century of biotechnology, the counter measures and key to solve these problems is the development of biotechnology (Zhang, 2006; Zhang and Duan, 2010; Zhang et al, 2010). To overcome food security crisis, biotechnology industry including farming, cultivation, microbial engineering and food processing industry are supposed to be developed (Zhang, 2006; Zhang and Duan, 2010; Zhang et al, 2010, Wu, 2010a, b). While to overcome water and soil resources crisis, technology and industry of efficient utilization of biological resources such as biological water saving should be developed (Zhang, 2006, 2008; Zhang and Duan, 2010; Wu, 2010a, b). Also, to overcome energy crisis, development of bioenergy agriculture and biochemical engineering should be encouraged, especially in the field of biofuel production from non-food crops (Zhang and Xu, 2007). Furthermore, to overcome environmental pollution crisis, we should vigorously develop organic agriculture, ecological agriculture, green agriculture, low carbon agriculture, sustainable agriculture and biological agriculture. Also, in order to reduce pollution sources and eliminate previous environmental pollution, the government should give strong support to the development of biological pesticide, biological fertilizer, biological plastics, biological treatment and biological engineering industry (Shao et al., 2010; Ruan et al., 2010). In addition, to overcome rapid population growth and health crisis, green agriculture and ecological agriculture are the key points. Also, biomedicine and plant protection technology, by which we can reduce the hazards of various kinds of drugs and pesticides, must be on the developing list. More healthy foods, nutrition foods and functional foods are supposed to be produced (Zhang and Wang, 2010; Zhang, 2011). While to overcome climate changing crisis, seed project, biological cloning, transgenic technology and molecular marker- assisted breeding are greatly helpful (Ruan et al., 2010; Wang et al., 2010; Zhang et al, 2011). Development of urban agriculture (sightseeing agriculture), facility agriculture, factory farming as well as

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modern precise agriculture must be accelerated and only in that way the dependence of agriculture on climate can be reduced. Our goal is to achieve what we called "the independent agriculture".

THE DEVELOPMENT OF MODERN AGRICULTURE

The construction and development of modern agriculture should be a process closely related to biotechnology combined with equipment technology. Biotechnology is considered as the foundation and core of modern agriculture, while equipment technology as the wings. With the development of productivity, they underwent the following two interactive development processes: Development of biotechnology: natural agriculture→inorganic agriculture→organic agriculture→ecological agriculture→green agriculture→resource efficiently utilized agriculture→circular agriculture→low-carbon agriculture→biotech agriculture→sustainable agriculture. For the development of equipment: human powered (animal powered) agriculture→mechanized agriculture→electrified agriculture (information agriculture)→urban agriculture (sightseeing agriculture)→facility agriculture→factory agriculture→modern precise agriculture. The combination of the aforementioned technologies forms modern agriculture. The future trend would be sustainable agriculture in order to achieve harmonious development between human and nature, and ultimately the coexistence of human and the earth. From the perspective of modern agricultural developing history home and abroad, we will find that modern agriculture went through a developing period from agricultural modernization (agricultural mechanization, electrification, chemization and irrigation as main feature) to modern agriculture (agricultural informatization, biologicalization, and management modernization as main feature).

There are many different modern agriculture modes as a result of different natural economic and social conditions. American economist Vernon Ruttan proved the following law with empirical data: countries with more than 30 hm^2 land per capita are basically mechanical technology-oriented; countries with 3~30 hm^2 land per capita basically take the road of staggered biotechnology-mechanical way; Countries with less than 3 hm^2 land per capita mainly are biotechnology-oriented (Jin et al., 2009). As in China, land per capita is less than 0.1hm^2, hence there is need for biotechnology-oriented modern agriculture in order to improve resource utilization efficiency. China, as a populous as well as a large agricultural country, must be developed into a modern country with modern agriculture. The United States (US) as an example of the modern agriculture mode in developed countries, has its agriculture based on biotechnology, which is fast developing. As a typical representative, planting of genetically modified crops (GM crops) with excellent properties including herbicide resistance, disease and insect resistance and nutrition function improvement is developing at an amazing rate. At the same time, new methods of simplified cultivation such as conservation tillage, water saving irrigation (sprinkler irrigation, drip irrigation etc.), and large-scale mechanization management are adopted and then combined with information agriculture and precise agriculture (Zhang et al., 2010). These factors together constitute an economical and efficient high-tech modern agriculture mode. Therefore, the developed American modern agriculture mode is not simply a "mechanized modern agriculture mode" which is generally believed, but a modern agriculture mode which is based on advanced biotechnology. However, this biotechnology is integrated with mechanical technology and information technology.

Furthermore, the US has become the largest biotech crops (including GM crops) planting country in the world. In 2008, the planting area of GM crops in the US reached 62.5 million hectares, accounting for 50% of the global total. The American seed multinationals monopolize agriculture and biological economy in many countries. For instance, the seed business of two American agriculture-related companies, Monsanto and DuPont, respectively accounted for 23 and 15% of the international market (Han, 2010). In the 2009 World's Best 40 Company List, Monsanto was ranked eighth for its contribution in the agricultural field. The priority "threshold" for the selected companies is that sales in 2008 reached at least ten billion US dollars and at least a quarter of its revenue came from overseas markets. Monsanto is the world's largest seed company, ranked number one in the field of vegetables and fruits, number two in utilization of field crops and number three in agricultural chemistry. It is also the world's largest transgenic seed company, owning 90% of the global GM crops. We can see from relevant information that the US government, including the US Department of Agriculture and other important departments, has close contact with the commercial and economic activities of both Monsanto and DuPont. This is not just purely commercial behavior of companies, but national or even worldwide resource war, economic war and food war. The former US Secretary of State Henry Kissinger, claimed in 1970 that "If you control oil, you control all of the countries, if you control food, you control all human". This tells the intentions and strategies of American leaders and the US government to control the world, illustrating the extreme importance of controlling food. Therefore we need to rely on agricultural biotechnology and advanced varieties. Chinese soybean industry is defeated by American transgenic soybean in a very short term. An even more shocking fact is that "Xianyu 335", a corn variety from American Pioneer company, has become the third-largest corn variety planted in China in just three year, and has

also became the first major cultivar in Northeast China. However, it is now difficult to buy for its high price. These two typical examples can fully explain the problem from which a lesson can be learnt. According to the reports of China Daily, on September 17th 2010, the agricultural trade office established by the US Department of Agriculture in the Northeastern center city Shenyang held its opening ceremony; it is the fifth office they set up in China after Beijing, Shanghai, Guangzhou and Chengdu. Until then, the strategic layout of US agricultural products has entered the core of China's granary. Northeast China is the main producing area of soybean, corn and japonica rice, also one of the largest granaries. The establishment will no doubt strengthen their attempts to occupy Chinese agricultural market. Vice Minister of the US Department of Agriculture Jim Miller who was on his special trip for this ceremony did not hide their ambition to northeast China. He said: "Setting up the fifth trade office in Chinese mainland shows that US Department of Agriculture expanded to the center of Northeast China. As one world trade center of China, Shenyang will provide ample opportunity for US agricultural exports". The US has started to gain a dominant position in the grain and seed market by virtue of its absolute technical advantages. Once its transgenic agricultural products were promoted of mass worldwide, grain seeds cultivated in other countries are likely to be quickly knocked out from the market, which would lay a solid foundation for the US to control the world's food supply from the source (Wu et al., 2010).

It should be noted that a seed can change the world; on the contrary, a seed can defeat an industry, or even threaten a country's food security. An agricultural (seed) company can also play games with the world's agricultural economy and food security. Therefore, the development of agricultural biotechnology should not be underestimated; the development of biotech modern agriculture is unstoppable. In the current circumstances of economic crisis and food security challenges, we suggest that establishing a biotech modern agriculture country should become a national development goal of China. This is of great practical and historical significance for the national food and economic security.

BIOTECHNOLOGY AS NATIONAL DEVELOPMENT GOAL AND COMPETITION STRATEGY IN MANY COUNTRIES

As early as 1987, The US government convened a group of biotechnology researchers and national strategy researchers to study and published a book "Agricultural biotechnology is a national competition strategy" (Ray, 2003). In 2003, American scientist Ray V. Herren published his new book "Introduction to Biotechnology: An Agricultural Revolution", which was very popular in the international community and was reprinted by many publishing companies. The US government issued a series of development strategies and blue book reports such as "Biotechnology in the 21st Century". In order to ensure its leading position in biotechnology industry, high-level coordination mechanism and industrial organization systems are established in the US. Each year, more than 38 billion dollars are invested in biotechnology research and development (R & D), five bio-valleys and more than 1400 biotechnology companies have been developed. To encourage the development of biomass energy in agriculture, the plan is that biomass fuels will replace 10% of the fuel oil consumption by 2020, and 50% by 2050 (Research Report of China, 2010). A special National Agricultural Biotechnology Council (NABC) was established in the US. Researching and consulting organizations of the US congress have paid long-term attention to biotechnology and its applications in agriculture. In 2010, two reports were issued, one is about the background and progress of agricultural biotechnology (Tadlock and Geoffrey, 2010), and the other is about the dispute of biotechnology between US and the European Union (EU) (Charles and Hanrahan, 2010). Although the attitude of the EU towards GM crops is prudent, its member states are required to actively develop biomass energy and energy agriculture in order to alleviate the supply-demand contradiction and improve the environmental condition. According to the requirements of the EU, biomass fuels will account for 20% in the traditional fuel market by 2020 (Research Report of China, 2010). Turning from traditional agriculture to biological energy agriculture is an important direction during the agriculture transformation in developed countries.

In 2005, "High Flyers Think Tank" of Australian Academy of Science published its proceedings "Biotechnology and the future of Australian agriculture"(High Flyers Think Tank, 2005). The goal of the report "development of biotechnology" issued by British government is to ensure its world's second position in biotechnology field. In Japan, a new strategy called "Biological Industry as Foundation" was proposed and identified as a national goal. A new organization "Biotechnology Strategy Council" headed by the Prime Minister has also been set up. India is also seeking to become a great power of biotechnology, and has set up its special "Department of Biotechnology". In addition, Singaporean government has drawn up a plan named "Entering the Top Ranks of Biotechnology in Five Years". Singapore is expecting to become a bio-island (Research Report of China, 2010). After entering the 21st century, South Korea has vigorously developed its biotechnology, which is regarded as a new engine of economic development. Its annual production value of biology industry has now entered the reached the advanced level in the world. It is predicted world top 15. In the field of fermentation technology, stem cell technology, somatic cloned cattle, AIDS DNA vaccine and herbicide-resistant crops, they all have currently

that in 2010, the total output value of biological industry in South Korea will reach 3.1 billion dollars, accounting for 1.9% of the international market. These figures will respectively reach 7.5 billion and 2.0% in 2015, 11.6 billion and 2.2% in 2020 (Yin and Li, 2010).

The international agricultural organizations also attach great importance to agricultural biotechnology development and utilization. In an article published in “Science”, Ismail Serageldin, an expert of Consultative Group on International Agricultural Research, World Bank, pointed out that biotechnology will play an important role in food security in the 21stcentury (Ismail, 1999). In 2000, Food and Agriculture Organization (FAO) held an international conference on biotechnology in Japan and published their declaration on biotechnology, they also constructed a specialized biotechnology website. Similarly, International Council of Science (ICSU) published “Biotechnology and Sustainable Agriculture Report” as well (Persley et al., 2002). Since 1991, International Service for the Acquisition of Agri-biotech Applications (ISAAA) began to pay close attention to the potential of biotechnology applications in agricultural production and latest advances in agricultural biotechnology. They irregularly publish “Biotec crop update” and “Biofuels Supplement”. In their latest publications “14 Years of Biotech Agriculture” and “Global Biotech Crops Report 2009”, where they specially mention that Chinese government has recently approved the cultivation of transgenic rice and corn.

ESTABLISHING A BIOTECH MODERN AGRICULTURE: A NATIONAL DEVELOPMENT GOAL OF CHINA

ISAAA point out that agricultural biotechnology, the second wave of global biotechnology development, is now entering a vigorous developing period with the arrival of this century (the first wave was biotechnology in medicine industry). Hence developing agricultural biotechnology in China is worth our deep consideration and scientific decision-making. Science and technology is the first productivity, so biotechnology must be the first productivity in agriculture. Great importance has been attached to biotechnology in China. A series of books “Report of the Biotechnology Industry Development in China” co-published by National Development and the Reform Committee together with Chinese Society of Biotechnology is now publishing the seventh book (National Development and the Reform Committee, 2009). Comrade Deng Xiaoping once pointed out: “The future of agriculture will eventually depend on bio-engineering technology and other sophisticated technologies.” Premier Wen Jiabao also mentioned in a government conference: “In order to solve the food problem, we must rely on scientific methods, including biotechnology and transgenic technology.” In 2006, four deputies to National People's Congress (NPC) put forward a suggestion about making a national strategy on biotechnology. Biotechnology was therefore proposed as a focal point of technology in “Long-term Scientific and Technological Development Planning Outline (2006 to 2020)” of China.

The biotechnology R & D level of China can get the leading position among developing countries, even is world-leading in some fields. China is now one of the few countries who can independently complete gene sequencing of main crops. In China, agricultural biotechnology has the smallest gap with that of developed countries among all high technologies. Seven plants have got the commercial production license until October, 2009. The transgenic rice and corn cultivated in China can increase insect resistance of rice and nutritional value of feed corn, which can not only increase farmers’ income, create huge economic and social benefits, but also play a significant role in environmental protection (Han et al., 2010). The Chinese government has invested tens of millions of dollars in agricultural biotechnology. We have the world’s second largest research fund of biotechnology, preceded only by the US. The current agricultural biotechnology development is mainly in the field of biotech crops, particularly in China. Agricultural GDP includes the output value of animals, crops, vegetables and forestry. In developed countries, the output value of animal agriculture accounts for about 55% of the total agricultural GDP, even as high as 80 to 90% in some individual countries like Netherlands, Israel. However, this ratio is only 34% in China while that of crops is 46~47%. A higher GDP of animal agriculture than that of crops is an important symbol of modern agriculture (Long and Li, 2010). Therefore, while keeping the growth of crop agriculture, we are supposed to pay more attention to animal and microbe biotechnology at the same time.

In the early age after liberation, Chairman Mao Zedong claimed that the fundamental way of agricultural modernization is agricultural mechanization. We believe it is an advanced theory on the social and economic conditions at that time. However, judging from the current development of modern agriculture and biotechnology both at home and abroad, we believe that in China, the fundamental way of agriculture is to develop modern agriculture with combined biotechnology and modern equipment technology. It is not simply or purely mechanized agriculture nor biotech agriculture. This should be the mode of modern agriculture with Chinese characteristics. Although the Chinese government attaches great importance to biotechnology and modern agriculture, there is no overall development strategy. Faced with so many new concepts of agriculture such as organic agriculture, ecological agriculture, green agriculture, biological agriculture; mechanized agriculture, facility agriculture, modern agriculture, etc, there is a need to sort out an overall idea of agricultural development and

form a modern agricultural system in China. After a long-term exploration, we believe that establishing a biotech modern agriculture country should become a national development goal.

THE DEVELOPMENT OF BIOTECH AGRICULTURE

During the past 30 years, modern agricultural development system has changed a lot as the concepts of biotechnology, agricultural biotechnology, biotech agriculture, modern agriculture, GM crops and biotech crop changed. According to the developing process of agriculture and biotechnology both home and abroad, we suggest the developing process of biotech modern agriculture country like this: Agriculture→Biotechnology→Biotech crops→Agricultural biotechnology→ Modern agriculture→ Biotech agriculture→ Biotech modern agriculture→ Biotech modern agriculture Country. In this developing process, biotechnology started with one or two techniques simply applied in agricultural production, and then large scaled applications in crops (such as virus-free tissue culture, rapid propagation technology, GM crops, molecular design breeding), and then universal applications in agriculture as agricultural biotechnology (including agricultural food processing, bioenergy agriculture), and then finally replaced conventional agriculture.

Biotechnology is one aspect of modern agriculture, but the proportion varies in different stages of modern agriculture development. Recently, ISAAA noted that agricultural biotechnology does not mean only GM crops, but also include traditional breeding, tissue culture, micropropagation, molecular breeding, marker-assisted selection, genetic engineering, molecular diagnostic tools, etc. (International Service for the Acquisition of Agri-biotech Applications, 2010). However, the current concentrated area is still GM crop breeding, the concept and application services of which are still somewhat limited. In fact, it also includes some other categories, such as biological breeding, biological energy, biological fertilizers, biological pesticides, biological control, biological treatment, biological engineering, biological refining, biological plastics, biological economy and so on.

RESEARCH DIRECTIONS OF BIOTECH AGRICULTURE IN CHINA

In the national forum on agricultural production of major grain producing areas on September 18th, Vice Premier Hui Liangyu pointed out that in recent years, faced with great challenges of natural disasters, the international financial crisis and the severe impact of abnormal fluctuations in international agricultural markets, food and agricultural development are put in a prominent position by the Party Central Committee and the State Council. In current and the coming period, the difficulties and challenges of agricultural development will keep growing, increasing pressure of keeping quantitative and structural balance of agricultural products supply will become more and more prominent. Hence, to improve food and agricultural producing capacity as the core, to speed up the progress of agricultural science and technology, to improve yields and optimize the product structure as the main direction, we must vigorously promote institutional innovation, accelerate the transformation of agricultural development, strive to build long-term mechanisms to promote steady agricultural development and increase income of farmers. Only then the basis of national food security can be strengthened (Hui, 2010).

In 2009, with the recommendation and promotion of Lu Yongxiang, president of Chinese Academy of Sciences (CAS), “Integration and Development Center of Green Agricultural Technology, CAS” was set up. Based on the abundant strength of CAS in life sciences and biotechnology, this center will become an important transformation, integration and application platform of green agricultural biotechnology, its function includes technology incubation, technology integration, industrial demonstration and achievement transformation. Faced with the great challenges of national security, food security, ecological security, environmental security, this center will offer technological support to green agriculture and sustainable social development in China. Based on the comparative research on modern agriculture mode and biotechnology developing strategy abroad, and considering national condition of China, we can then put forward the Chinese theory system, technology system, policy system and developing strategy of modern agriculture.

Moreover, goals of modern agriculture should include the following eight aspects: grain security, food quality security, biological security; environmental security; ecological security; energy security, economic security and social security. All of the aforementioned have to be based on biotech modern agriculture. We believe that to establish a biotech modern agriculture country, the priority development areas should include the following ones:

(1) Anti-adversity farming (grain and economic crops)
(2) Anti-adversity breeding industry (animal husbandry and fishery industry)
(3) Microbial engineering (brewing and pharmacy industry)
(4) Functional food engineering (refining process and artificial synthesis)
(5) Frontier technology of biology (genomics, proteomics, metabolomics, gene networks, bioinformatics, biomedicine)
(6) Biotechnology (biological cloning, transgenic technology, molecular breeding, enzyme engineering,

fermentation engineering, cell engineering)
(7) Biological industry (biological fertilizer, biological pesticide, biological control, biological plastics, biological energy, biological pharmacy, biochemical engineering, bio-refining)
(8) Land security and efficient utilization
(9) Water security and efficient utilization
(10) Environmental security and efficient utilization
(11) Ecological security and conservation
(12) Research on climate changes and agricultural disaster resistance
(13) Agricultural economy and subsidy policy

CONCLUSION

Life sciences and biotechnology is one of the main areas which will fundamentally shape the human development in the 21st century. It will change the traditional development mode, build green and renewable industry system, and significantly improve human health. China has a solid foundation and market space in this area, which is a great advantage for the development of biology industry. According to "the State Council decision on accelerating the development of new strategic industries" released on Chinese government website on October 18th, 2010, China plans to take about 10 years to foster new pillar industries of national economy, including biotechnology. FengFei, Minister of Industrial Economics Research Department of Development Research Center in China, analyzed that compared to other industries, biology industry is of more far-reaching strategic significance. Biotechnology can relieve the resource and environment pressure, improve human health, and moreover, improve the capacity of sustainable development. In fact, the importance of biology industry has long been noticed by senior leaders. As early as 2004, Ding Shisun, vice chairman of NPC Standing Committee, sent a letter to the government and recommended biotechnology industry as a national strategy. WenJiabao replied to this letter and indicated that development of biotechnology industry should be an emphasis of national economic, social development and scientific progress, and should also be included in the medium and long term planning.

In 2007, China firstly issued "the Eleventh Five-Year Plan for Biology Industry", while in 2009, General Office of the State Council issued "Notice on the Issuance of a Number of Policies for Promoting the Development of Biotechnology Industry". Also in the same year, China held the world's first international biology economy conference in Tianjin. National biology industry bases are continuously established everywhere. Besides, as China Bio-industry Convention held every year fueling the development of biology, biology economy is now vigorously developing in China. Moreover, in the recently issued "Recommendations of the Twelfth Five-Year Plan for National Economy and Social Development", the government pointed out that the construction of modern agriculture should be accelerated. China's agriculture is increasingly restricted by natural resources. Improving agricultural output only by means of increasing investment of natural resources is becoming more and more difficult. The fundamental solution depends on agricultural modernization with Chinese characteristics, which means speeding up agricultural mode transformation, promoting development of agricultural science and technology, improving agricultural production capacity, anti-risk ability and market competitiveness.

In such a development background and historical conditions, there is no doubt that biology industry is entering a period of rapid development. In China, the development of biotechnology has close links with the agricultural modernization, which determines that biotechnology will become an area of strategic importance. Thus, it is easily acceptable that establishing a biotech modern agriculture country should become a national development goal of China.

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