Experience of agricultural engineering development in China

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Abstract: This article illustrates the positive role of agricultural engineering development on agricultural modernization in China. Agricultural engineering helps urbanize China, lays the foundation for the integrated operation of agriculture and agricultural modernization, and contributes significantly to the food security and sustainable development of national economy. The higher education system on agricultural engineering has been established, serving agriculture, food sector, ecology and the environment. Thousands of technicians and managerial professionals have been trained. It is noted in the article that government promotion and policy support are the drive for agricultural engineering in China, researchers and technicians and innovation are the key, and industrial development and farmers' demands are the very foundation. Agricultural engineering has effectively facilitated agricultural modernization and has been highly functional in many ways, such as promoting the industrialized operation of agriculture, leading farmers' cooperatives, extending better technologies, applying research results, educating and training farmers, making an efficient use of resources, increasing productivity, upgrading production approaches, making agricultural products more competitive on the market, generating rural local job opportunities and enriching farmers, protecting the environment and improving ecological conservation.

Key words: agricultural engineering; agricultural engineering science and technology; industrialized operation of agricultural engineering; developmental experience

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1 Introduction

At the beginning of the 21st century, the Chinese government placed top priority on the issue of agriculture, rural area, and farmers, calling for coordinated economic and social development of both urban and rural China, building up the well-off society in an all round way, and constructing a new countryside and modernizing agriculture[1]. These provide unusual opportunities and challenges for agricultural engineering.

With less than 7% of the world farmland, China successfully feeds more than 22% of the world population, and is now moving towards a well-off society. During this process, agricultural engineering technology plays a critical and irreplaceable role. In China, agricultural engineering provides sufficient modern, applicable equipment and technologies; agricultural mechanization and electrification modify agricultural production; modern water conservation facilities and projects secure agricultural stable and high yield; over ten years' fast development of protected agriculture provides a fundamental solution to urban vegetable supply; the use of more rural bio-gas and energy efficient ovens helps improve farmers' living standards and protects the environment; agro-processing functions as an effective means to add value to farm produce, increase farmers' income and generate job opportunities in rural areas; and agricultural information engineering technology is rapidly applied to agricultural animal farming and automation control of farming equipment, and as a most dynamic science application, serves the agricultural market[2,3]. The application and development of agricultural engineering in China improved agricultural workers' capacity, industrial operation of agriculture and the quantity, quality and value of farm produce. As a consequence,

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farmers get richer and live a better life, and it greatly helps to provide jobs for more than 200 million working age rural people, advance urbanization, lay a solid foundation for integration of agricultural operation, modernize agriculture, and contribute to food security and sustainable development in China[4]. The agricultural engineering higher education system is established within certain colleges in China, and thousands of people have received training and education on this subject.

2 Government Initiative and Policy Support: Vital to Agricultural Engineering in China

In 1980′s, to facilitate rural reform and agricultural development, the Central Government of China issued five annual No. 1 Documents successively from 1982 to 1986, optimizing the household contract responsibility system as a basic rural economic policy, stipulating at least 15-year lease of land by farmers, and removing farm produce unified purchasing system that had been effective for 30 years under planned economy[5]. These policy measures gave farmers plenty of incentives for agriculture and production increased dramatically.

In the new century, China′s agriculture is under dual restraint of resource availability and market pressure. Farmers′ income increases slowly, the rural/urban gap widens, and the traditional farming model becomes more of a restriction. To address these concerns, the central government issued other four annual No. 2 Decrees successively from 2004 to 2007, proposing policy measures to stimulate income growth for farmers, removing agricultural tax that had been collected for more than two millennia in China. Other proposals to improve agricultural comprehensive productivity included consolidating agricultural infrastructure, speeding up scientific research process, addressing other major and urgent issues for higher productivity, subsidizing grain production and purchase of quality seeds and machinery, and calling for building a new socialistic countryside[6]. On January 29, 2007, the central government circulated opinions on modernizing agriculture and steadily advancing new socialistic countryside development. It is noted that modernized agriculture is the top priority for the new socialistic countryside, and agriculture should be provided with modern resources, upgraded with modern science, restructured with modern industrial systems, advanced with modern operation, guided with modern perspectives, and handled by modern farmers. Water conservation, machinery application and information technology should be improved for higher yield, resource utilization efficiency and productivity, as well as competitiveness of agriculture. These policy measures further clarify future directions for China′s agriculture, namely resource-efficient, environment-friendly, and locally tailored modern agriculture. Industrial integration, intensive farming, scale operation and standardization are key recipes[7]. The goal and role of agricultural engineering are thus defined as two of the four pillars (policy, science & technology, equipment, and human resources) to guide agricultural modernization[8].

Government initiative and policy support are highly functional. For instance, in the middle 1980′s, to address the vegetable shortage, the Chinese government implemented the Vegetable Basket program. With government input and farmers′ participation, greenhouses boomed—the acreage increased to 2.5 million hactares, ranking world No. 1 in 2006— and protected agriculture developed rapidly. Current production expands from vegetables to horticulture, fruits, saplings, edible fungi, and herbal medicines. Protected farming solves the long time difficulty—the annual fluctuation of vegetable supply, thus production can satisfy demands despite the seasonal changes. Traditional operation is developing into a scale and intensive model, and animal-farming capacity increases. Poultry farming and production for swine, cattle, sheep and goats take greater shares and become the dominant supply. The per capita availability of meats and eggs in China is among the top level in the world.

The Seed Project, implemented in mid-1990′s to ensure good quality seed production, application and higher productivity for agriculture, effectively promoted agro-processing equipment development. By now, all major crop seeds are dried, cleaned, and coated by machines and stored in special houses. Professional production and industrial operation promote quality seed application and bring consider-

able social and economic benefits.

The cross-region machine harvest of wheat program, initiated last century by the Chinese government, realized a historical breakthrough in machinery application in agriculture, from single unit to machine sets, from production to the whole process, and for the first time the whole process machinery was applied to the major crop-wheat[9]. Machine operation is thus promoted for major crops, particularly after the promulgation of the P. R. China Agricultural Machinery Promotion Law in 2004. Government supportive policy measures are escalated to legal provisions, further defining the role of agricultural machinery application in agriculture, and rural economic development. To facilitate the Law, the central government leased specified supportive policy to subsidize the purchase of agricultural machines. In 2004, the central government allocated 70 million yuan of subsidy and local government input was 600 million yuan. In 2005, the central government input was 300 million yuan, and local input was 1 billion yuan. In 2006, these numbers increased to 1. 2 billion yuan and 1. 8 billion yuan, respectively. In 2007, the central government input will be 1. 2 billion yuan and more in the coming years[10].

To improve rural working and living conditions, protect eco-environments and increase farmers' income, the Chinese government initiated the Eco-homeland and Enriching Farmer program in 2001, which was to build on rural bio-gas application, tap resource potential with eco-farming and renewable energy technology, and promote efficient planting and animal farming to enrich farmers. When needed, solar energy, wind power, efficient ovens, and micro-hydro power renewable energy facilities were constructed, to make a full use of land, solar energy, and biomass. With sound circulation of energy and mass, ecological benefits and economic benefits can be realized at the same time so that clean energy is used for households, yard production is optimized, and agriculture is environment-friendly. Between 2001 and 2005, the central government invested 3. 4 billion yuan for rural biogas application and beneficiary households increased by 11. 12 million. 93. 85 million yuan was invested for the construction of 98 major biogas projects[10]. Statistics show that by the end of 2005, national biogas digestors totaled 18. 07 million (household), animal farm biogas projects totaled 3556 (location), municipal sewage biogas purification digestors totaled 140 thousand (location), fuel-efficient oven users 189 million (household), solar energy ovens 6. 856 billion, solar energy power generators 86200, micro-hydro power generators 81200, small wind power systems 105600, and stalk gasification for biogas supply 539[10]. More investment will be made in 2007.

The quality grain industry program and the fertile farmland program, both initiated in 2004, and current agricultural modernization and new countryside development will give a full range boost to agricultural engineering in China.

3　Technical Experts and Technical Innovation: Key Factors in Research and Development for Agricultural Engineering

As a subsidiary discipline of engineering science, agricultural engineering has formed a primary shape with the multiple tier education system in pace from high school, college, Bachelor's Degree study, Master's Degree study, to PhD degree study. In China, the agricultural engineering Bachelor's Degree program is set up in over 70 higher education institutions, the PhD degree program is conferred as first level discipline in four universities, as secondary discipline in 17 sites of 11 universities, the Master's Degree program is conferred as secondary discipline in 62 sites of 38 universities and research institutes, and five secondary disciplines in four universities are approved as national key laboratories[4,9]. This development is generally among the leading position in developing countries. In recent ten years, academic exchange and cooperation are very active both within China and internationally with certain impact. Currently, there are 73 kinds of literature and journals on agricultural engineering, including 14 core journals. A survey shows that 9149 papers on agricultural engineering were published in 2005 in China[9].

In China, generally speaking, the research fields of agricultural engineering can be summarized into the following aspects[11]:

1) Agricultural mechanization engineering;
2) Agricultural soil and water engineering;
3) Agro-biological environmental engineering;
4) Agricultural energy engineering;
5) Agricultural electrification and automation;
6) Agricultural products processing engineering;
7) Land use engineering;
8) Agricultural system engineering.

In China, the development of agricultural engineering and wide application of advanced science and technology of agricultural engineering have made great contributions to agricultural efficiency promotion, farmer's income increase, the development of agriculture and rural economy, and the transformation from traditional agriculture to modern agriculture. Especially in the past ten years, the Chinese government greatly increased its investment on scientific research in the field of agricultural engineering. After the "Industrialized High-efficient Agricultural Demonstration Project" became a special project for national key industrialized projects in the "Ninth Five-year Plan" and in the "Tenth Five-year Plan", "Technological System of Modern Water-saving Agriculture and the Research and Development of New Products" was listed among major projects for the National 863 Plan, and "Research and Development of the Technology and Equipment for Further Processing of Agricultural Products" became a special project for the science and technology research plan. Besides, the national science and technology research plan also provided support for some other projects, including "Research and Demonstration of Key Technology for Industrialized Agriculture", "Research and Development of Key Technology for Agricultural Mechanization" and "Research and Development of Key Technology and Equipment for Modern Agriculture." In the "Eleventh Five-year Plan", the national science and technology research plan will provide support for the following projects: "Agricultural and Forestry Bio-energy Project", "Research and Demonstration of Technology for Modern Agriculture and Mechanized Farming" and "Research and Development of Multi-functional Agricultural Equipment and Facilities"; and the National 863 Plan will provide support for the following projects: "Technology and Equipment for Precision Agriculture", "Technology and Products for Modern Water-saving Agriculture" and "Digital Agriculture[9]."

Entering the 21st century, the rapid development of biological and information technology is leading to a revolution for agricultural science and technology. Promoted by the revolution for agricultural science and technology and economic globalization, agricultural engineering technology in China has broken through the traditional mode. It has become an interdisciplinary and integrated discipline, and the strategic thought of sustainable development is exerting a greater influence on its development. Its fields of study are widening and the content of research is becoming more penetrating and precise. These are the major trend and characteristics for the development of agricultural engineering technology. These factors are promoting the continuous and further development of agricultural engineering technology, and are leading to the fundamental transformation of traditional ideas and modes of agricultural production[11].

4 Industrial Development and Farmers' Feeds: the Driving Force for the Development of Agricultural Engineering

China is a country with poor water and soil resources. China's per capita cultivated land area is 0.094 hm^2, which is only 40% of the average level for the world; and the cultivated land area per household is 0.487 hm^2, which is only 1/400 of that in the United States. China is much short of water resources. Its per capita water resource is only 28% of the average level for the world. Every year, China's agriculture is short of about 30 billion m^3 water. The area of soil erosion is as much as 3.56 million km^2, accounting for 37% of the total area of China. Every year, about 5 billion tons of soil is lost because of soil erosion, accounting for 1/5 of the world[10]. Income gap between the residents of urban and rural areas keeps widening. In 2006 the ratio was as high as 3.28 ∶ 1, and it has become more and more difficult to increase the farmers' income. Agricultural labor productivity is quite low and only equals to about 1/8 of that of the Second Industry, or about 1/4 of that of the Third Industry in China. Agricultural labor productiv-

ity in China only equals to 1/108 of that in Canada, or 1/120 of that in the Untied States. It is very difficult for the surplus labor forces in rural areas to seek employment. Now there are 150 million surplus labor forces in rural areas, and every year there add 6 million labor force in rural areas of China[10]. Now traditional mode of agricultural production cannot solve the above-mentioned problems and can no longer meet the requirement of agricultural development. The modernization of China urgently requires the majority of farmers to stop doing traditional farm work, and farmers also would like to get their income increased and to enjoy modern way of life like urban residents. Therefore, all of these factors require agricultural growth modes and organization forms of farmers to be transformed. That is to say, China must take the road of agricultural industrialization and enhance the organizational level of farmers, which brings forward objective requirements and urgent needs for the development of agricultural engineering in China.

Let us see a typical example. In recent years, organizations and individuals that provide agricultural machinery services have been developing rapidly in China. New types of organizational forms, such as agricultural machinery cooperation and agricultural machinery limited company, continue to appear. Intermediary agencies, associations and brokers also develop rapidly. By 2005, the total number of various kinds of agricultural machinery cooperative organizations(including individuals to provide agricultural machinery services) had reached 33.863 million, and the total income from agricultural machinery services had reached 260.6 billion yuan[10]. The development of agricultural machinery service organizations has further enhanced the organizational level of agricultural machinery service and the prosperity of the agricultural machinery market. Service items have developed from single kind of service to integrated and full service, and the content of agricultural machinery service has extended from mid-harvest to pre-harvest and post-harvest, and from planting industry to animal husbandry and post-harvest disposal and processing of agricultural products. The economic benefits keep growing and the market order also improves. By and large, a socialized service system for agricultural machinery has already formed. Trans-regional operation of agricultural machinery has given full play to the fundamental role of the market in resource allocation, avoided repeated purchase of similar equipment, enhanced the organizational level and efficiency of agricultural machinery, facilitated the process of commercialization and industrialization of agricultural machinery service, provided a mode suitable for China to promote agricultural mechanization, and also created a good condition for the complete and rapid development of socialized agricultural machinery service and agricultural mechanization in the future.

The use of agricultural machinery has effectively enhanced output rate per unit area of land. For example, in North China, because of mechanized agricultural production, wheat and corn production has changed from three crops in two years to two crops in one year, and the multiple cropping index has also been increased. Sub-soiling techniques have made the outputs of corn, wheat, soybean and cotton increased by 19%, 12%, 9% and 55%, respectively. Returning of crop straws under the application of farm mechanization has made the output increased by 5%~29%[10].

The use of agricultural machinery has greatly reduced the labor cost for the production of agricultural products. For example, in the south of China, a rice harvester is able to do the work of more than 200 laborers, which may save the cost by 1050 RMB/hm^2. Compared with manual harvest, mechanization of wheat harvest can reduce the cost by 450~ 500 RMB/hm^2[10]. The use of agricultural machinery has also reduced the input of agricultural production material, therefore reducing production cost. For example, advanced seeding-machines are able to do the work of seeding and fertilization at precise depths and numbers, which may save seeds by 30%~ 50% compared with ordinary seeding-machines.

The use of agricultural machinery may effectively save water, fertilizer, seeds, pesticides and energy, realize integrated utilization of resources, and promote sustainable development of agriculture and the development of recycles economy in rural areas. For example, in the north of China, compared with traditional surface irrigation, spray irrigation may save 1/3~ 1/2

of water. Compared with traditional manual fertilization, mechanized fertilization helps to increase the utilization rate of fertilizer from about 30% to (60%~80%)[10]. Modern spraying machinery carries out variable spraying operation according to detected targets, which may save 30%~40% of the cost and reduce pollution to the air and environment. Using agricultural machinery to carry out straw mulch cannot only retain water in the soil, but also effectively avoid environmental pollution caused by straw burning. Compared with traditional cultivation technology, mechanized conservation tillage is able to reduce surface runoff by about 60%, soil loss by 80% and strong wind and sand dust by 60%, effectively control sandstorms, and protect the ecological environment[10].

Facility agriculture has become an important industry with the highest benefits in agricultural production. For example, in China, the production value of facility gardening is more than 10 times that of open-field gardening and more than 25 times that of field crops. Facility gardening has become one of important ways for the adjustment of agricultural structure and farmer's income increase. Using relevant facilities to produce vegetables, 20% area of vegetable field is able to provide 40% of vegetable yield and 60% of production value of vegetables[10].

The great potentiality of post-harvest processing of agricultural products has provided more jobs for farmers besides farm work, created new channels for the employment of farmers in relevant second and third industries, and promoted the transfer of surplus labor forces in rural areas. In China, the ratio between the production value for the processing of agricultural products and that of agriculture increased from 0.8∶1 in 2001 to 1.2∶1 in 2005. With 0.1% increase of that ratio, it will lead to 2.3 million new jobs and an increase of 193 RMB to the farmers' per capita income[10].

Every year in China, more than 700 million tons of crop straws, 200 million tons of forest wastes, 600 million tons of livestock and poultry feces and a large amount of organic wastes are produced[10]. There are also more than 100 million hectares of marginal land. These resources have not been fully used, and many of them have become environmental pollution sources. For bio-energy industry, these agricultural and forest wastes and marginal land are valuable energy resources and material wealth. The total amount of bio-energy which can be used by China every year is about 500 million ton-coal-equivalent (tce), among which there are about 350 million tons of crop straws (amounting to about 150 million tce) which can be used as energy resource. Theoretically speaking, livestock and poultry feces and industrial waste water can be used to produce about 80 billion m^3 of marsh gas (amounting to about 57 million tce), and the energy resource of fuel-wood forest, forest wastes and wastes from wood processing is equal to about 200 million tce. It is expected that by 2020, the potentiality for China to use marginal land to plant energy crops and to produce liquid fuels can reach more than 50 million tons, among which there are more than 28 million tons of fuel ethanol and 24 million tons of biological diesel[10]. Therefore, the utilization of agricultural bio-energy is becoming a new way to reflect multi-functional agriculture and to increase farmers' income. It creates a new mode for the economic development in rural areas. In this way, agricultural resources are used efficiently and wastes are turned into valuable resources. This will not only provide new jobs for the labor forces in rural areas, but also increase the income of farmers in China. The development of agricultural bio-energy industry is of great realistic significance for the extension of the contents of agriculture and for the guarantee of national energy security. The utilization of bio-energy resources is able to provide clean energy for rural areas, to improve the environment of rural areas and to make contribution to the building of the new countryside.

5 Conclusions

To sum up, it can be concluded that the development of agricultural engineering has effectively promoted the construction of modern agriculture in China, which is obviously reflected in the following aspects[5-9]:

- Promoting the development of agricultural industrialization;
- Promoting the development of cooperative organizations of farmers;

• Promoting the popularization and application of advanced agricultural technology, and integration and collaboration by using agricultural scientific and technological achievements;

• Enhancing farmers´ capacity;

• Promoting the efficiency of resource utilization;

• Enhancing labor productivity;

• Promoting the transformation of modes of agricultural production;

• Enhancing competitiveness of agricultural products;

• Promoting on-the-spot transference of surplus labor force in rural areas and the increase of farmers´ income;

• Promoting environmental protection and ecological construction.

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中国农业工程的发展经验

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摘　要: 阐述了农业工程发展在推进中国农业现代化中所起的积极作用。农业工程科技有助于推进中国的城市化发展进程, 为农业和农业现代化的一体化发展奠定了基础, 为保障中国的粮食安全和国民经济的可持续发展做出了重要贡献。建立了完备的农业工程高等教育体系, 服务于农业、食品、生态和环境领域。系统培养了数以千计的农业工程技术人才和管理人才。文章指出, 政府的倡导和政策支持是中国农业工程发展的驱动力, 科研人才和工程技术人才及其创新是关键, 产业发展和农民的需求是发展的基础。农业工程有效的推动了农业现代化发展, 并在很多方面发挥了积极作用, 如促进农业产业化发展, 引导农民合作组织, 推广应用先进实用技术, 促进研究成果的转化利用, 教育培训农民, 高效利用资源, 提高生产效率, 提升生产方式, 增强农产品的市场竞争力, 创造农村劳动力就业机会和增加农民收入, 保护环境, 维护生态平衡, 等等。

关键词: 农业工程; 农业工程科学技术; 农业工程的产业化实践; 发展经验