Innovation of China's Circular Agricultural Development in the Perspective of Low Carbon Economy

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Abstract On the basis of the concept and characteristics of circular economy, this paper analyzes the restraining factors of China's circular agricultural development as follows: issues concerning agriculture, countryside and farmers are outstanding; the problems of agricultural resources and agricultural ecological environment are serious; the quality of agricultural products cannot meet the demand of domestic and international market for food. Based on the internal requirements of low carbon economic development, this paper advances four innovative models concerning China's circular agricultural development as follows: the model of combining planting and breeding of agriculture, the developmental model of leisure and sightseeing, ecological integration model, and the developmental model of reusing agricultural byproducts. Every region should choose or create different circular agricultural model in different domains, in order to better use agricultural resources, reduce the consumption of agricultural energy inputs, reduce the emission of agricultural greenhouse gas, develop low carbon agriculture, and make great contribution for meeting the international challenges and promoting China's agricultural development.

Key words New village, Development, Circular agriculture, Low carbon economy, China

Agriculture is the basis of national economy. In the face of the increasingly aggravated environment of agriculture and rural areas, developing circular agriculture is the inevitable road and practical choice of constructing new countryside, which can promote China's sustainable development of agriculture, save use of resources and energy in the process of agricultural production, and promote clean production process, ecological industrial chain, recycling of wastes, green consumption of products, retrenchment of construction resources, and purification of the environment. Therefore, researching circular agriculture is of great significance of theory and practice in promoting China's agricultural development. On the basis of the concept and characteristics of circular economy, this paper analyzes the restraining factors of China's circular agricultural development, and advances four innovative models concerning China's circular agricultural development based on the internal requirements of low-carbon economic development.

1 Low-carbon agriculture and circular agriculture

1.1 Low-carbon agriculture "Low-carbon agriculture" is a kind of agricultural economic model, on the basis of low power consumption, low pollution, and low emission. Low-carbon agriculture is an important direction of transforming agricultural developmental modes. Sustainable development of agriculture must realize the transformation from high carbon economy to a low carbon economy. Through innovating upon agricultural science and technology, and breaking through and changing production modes, we are to make agriculture realize high-yield, high-quality, high-efficiency, safe, and ecological integrated benefits. Therefore, based on the actual situation of agricultural production, we should implement the strategy of scientific development, confront global climate change, actively seek technological countermeasures, establish the model of low-carbon agriculture, and promote the development of ecological economy. Circular agriculture is the carrier of low-carbon agricultural economy.

1.2 Circular agriculture Circular agriculture is to use the thought of sustainable development and the method of circular economic theory; on the basis of protecting agricultural ecological environment and fully taking advantage of high technology, to adjust and optimize internal structure of agricultural ecosystem and the industrial structure; to promote multi-level recycling of material and energy of agricultural system; to strictly control over the external hazardous matter and agricultural wastes; to reduce environmental pollution to the extreme, so that the economic activities of agricultural production are incorporated into the agro-ecosystem cycle, and the sustainable development of agriculture and virtuous circle of ecology are achieved[1].

The basic characteristics of circular agriculture can be simply summarized as the following 4 aspects: economization, sanitation, recycling and harmlessness[2]. The circular agriculture requires that we are to organize agricultural production in accordance with feedback-type process of "resources-agricultural products-agricultural waste-renewable resources"; to improve the utilization rate of agricultural resources, and realize the maximization of use of resources; to keep the production process clean, improve agricultural production technology, implement clean agricultural production, moderately use environment-friendly agricultural chemicals, and realize minimization of agricultural environmental pollution and clean agricultural production; to recycle the agricultural waste, optimize the internal structure of agricultural system, extend agricultural ecological industrial chain, and form the joint development of industrial

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network through recycling of wastes, coupling of factors and so on; to realize harmlessness of production and living, and protect and improve the environment of agricultural production and rural living by transforming the traditional mode of agricultural production and rural lifestyle.

However, the foreign countries have achieved many useful results on the development of circular agriculture[3]. For example, German scientists conduct directional seed selection on beet, potato, rapeseed, corn, and so on, to extract ethanol, methane, and so on, and successfully develop green energy, which makes it become the paragon of "green-energy" agriculture; the USA applies the technology of GPS system to the field of agricultural production, guides the production and management process of agricultural crops, such as fertilization, irrigation, deinsectization and so on, and develops the model of "precision agriculture"; the UK endeavors to use land resources economically as far as possible, emphasize the use of perennials, encourage the use of self-conditioning system, adopt the technologies of planting various varieties of crops and green shield to maintain land and monitor the local environment when farming, frame green development planning, avoid the use of artificial fertilizers and pesticides, and plant diverse vegetation and prompt the carnivore to enter the ecosystem to prevent pests, which is the representative of "permanent agriculture". Therefore, the development of China's circular agriculture can choose to absorb their successful experience, refer to the foreign advanced method of agricultural operation and management and agricultural production technology, and form a complete set of development model and technology system suitable for the actual situation of China on the basis of the existing theories and techniques of ecological agriculture in China.

2 The restraining factors of China's circular agricultural development

2.1 Issues concerning agriculture, countryside and farmers are outstanding In recent years, as the modernization of China has advanced to a new stage and level, issues concerning agriculture, countryside and farmers have become the most prominent contradiction. The main manifestations are as follows: the agricultural development mode is extensive, and the pressure of guaranteeing national food security and balance of supply and demand of agricultural products mounts; the rural economic system is not perfect, and the task of coordinating interests of workers and peasants, interests of urban areas and rural areas is arduous; it is difficult for the farmers to increase income, and the prospect of narrowing the income gap between rural residents and urban residents is worrying; the productive forces in rural areas are backward, the level of agricultural modernization is low, educational level of farmers is low, and urban-rural gap is widening further. Currently, issues concerning agriculture, countryside and farmers, the obstacle to acceleration of the development of new village construction, are yet to be solved.

2.2 The problems of agricultural resources and agricultural ecological environment are serious China's land area is 9.6 million square kilometers, but at the end of 2010, the total area of farmland in China was less than 0.121 73 billion hm^2, and the area of farmland per capita is below 0.1 hm^2, less than 1/2 of the world average and 1/4 that of the developed countries, only 1/6 of that of the USA, 1/9 of that of Argentina, and 1/14 of that of Canada. In addition, in recent years, the quantity and quality of arable land show a conspicuous downward trend, and the land resources that we can use in China are not so abundant. As the agricultural society evolves into industrial society, the agricultural production mode also changes from traditional agriculture to modern agriculture. In the process of change, on the one hand, we enjoy the results of modern industry, and continually and considerably use agricultural machinery, chemical fertilizer, and pesticides, so that the agricultural productivity is promoted significantly, and the output of agricultural products is increased substantially; on the other hand, the ceaseless deterioration of agricultural ecological environment affects the future development of the agricultural economy. First, the use of agricultural chemical fertilizer increases year by year, which causes increasingly serious pollution to the ecological environment. In recent years, the use of chemical fertilizer per hectare of arable land in China increases incessantly. The long-term use of a large number of chemical fertilizers will easily change the physical properties of the soil, and cause soil compaction, leading to declining soil fertility. Second, the improper use of pesticides contaminates part of grain, vegetables, fruits and other agricultural products. Third, a large number of crop straws are burnt, causing air pollution. Fourth, the direct discharge of untreated excrement of fowl and livestock expedites the process of contamination of rivers. Therefore, in the process of building new socialist village in China, we should vigorously develop circular agriculture, so that the agriculture realizes sustainable and healthy development.

2.3 The quality of agricultural products cannot meet the demand of domestic and international market for food China is facing the contradiction between incessantly increasing demand for the market and export of safe and high-quality agricultural products, and a large number of scattered and unorganized small-scale family production. With the incessantly increasing inputs of chemicals in the process of agricultural production, such as pesticides, fertilizer, plastic film and so on, domestic and foreign consumers increasingly worry about security problems of agricultural products, and have increasing demand for safe and high-quality agricultural products. Zhang Shanling, *et al.* (2004) advance that the consumers' awareness and acceptance on "safe agricultural products" have become the biggest obstacle to developing the domestic market of safe food for the time being[4]. Improving the quality of agricultural products is the key to confronting some problems after joining WTO and strengthening market competitiveness for the agriculture. Meanwhile, this is the necessary choice to adapt to changes of supply and demand of domestic agricultural products. Currently, the international market has more stringent requirements on the quality of agricultural products. The western developed countries pay unprecedented attention to safety, en-

vironmental protection and consumer rights, far beyond the Chinese people's understanding of the practice. In 2002, Japan increased the test items of imported rice from the original 42 to 114, and the U. S. Food and Drug Administration announced a ban on the import of food of animal origin which contains 11 types of drugs, including chloramphenicol and so on. In China, more and more places begin to implement pollution-free food program, and gradually implement market access system. Nowadays people have more and more urgent need for safe and high-quality food, and the price gap is widening, but the quality is unqualified, thus the international market and the domestic market both cannot be developed effectively, so that we get fewer agricultural benefits. In summary, the key to improving the quality of agricultural products in China is to change the traditional agricultural model, organize production in accordance with international standards, and improve the level of industrialization of agriculture and clean production. Only by doing these can we realize the goal of internationalization of China's agriculture and long-term occupation of the domestic market as quickly as possible.

3 Innovative model of circular agriculture

Circular agriculture, a new type of agriculture which focuses on ecological benefits, social benefits and economic benefits, is the inevitable choice for sustainable agricultural development, which can be conducive to solving a large number of problems emerging in the process of rural development and agricultural development in China at present. China has unique agro-ecological environment and characteristic agricultural resources, therefore, on the premise of emphasizing and implementing 3R principle, according to the actual situation, we should innovate upon the development model of circular agriculture with Chinese characteristics and the regional individuation, which can be seen in Fig. 1.

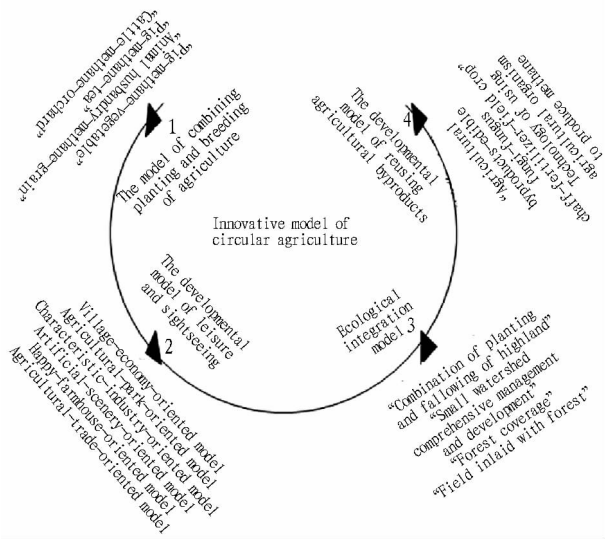

Fig. 1 Innovative model of circular agriculture

3.1 The model of combining planting and breeding of agriculture By using food chain technology, the model, taking methane as a link, integrates farming, breeding industry and processing industry. By increasing breeding of fowl and livestock, and anaerobic ferment of marsh gas pool, it is to organically connect the traditional simple planting, high-efficiency breeding and recycling of wastes, and to realize multi-level energy use within the agricultural system and virtuous cycle of materials, so as to attain the goal of high yield, high quality, high efficiency, and low consumption. There are several "three-combination" models, such as "pig-methane-vegetable", "animal husbandry-methane-grain", "pig-methane-tea", "cattle-methane-orchard" and so on. Many regions of China have tried these models in terms of promoting farmers' income increase, saving energy and protecting rural ecological environment and so on.

3.2 The developmental model of leisure and sightseeing The leisure and sightseeing agriculture, as an emerging industry, relying on farming activities as the basis, characterized by agricultural production and management, makes use of profuse agricultural landscape resources and rural natural environment; fully taps the agricultural functions of production, ecology, living and so on; on the basis of local production of agriculture and animal husbandry industry, planting of forests, fruits and flowers, agricultural management activities, rural cultural life, folk custom and so on, promotes the organic combination between agriculture and tourism, technology, culture and other industries; attracts tourists to come for the purpose of watching, tasting, shopping, exercising, experiencing, leisure, vacation, playing and so on. It has become the category of interacted new modern agriculture. It is a "green sunrise industry", based on rural resources and agricultural management, integrating the primary industry, the second industry and the tertiary industry. In terms of farming technique and production technology, it focuses on the combination of modern high technology and the traditional intensive cultivation, according to the green, standard and canonical production process; in terms of mode, it focuses on the three-dimensional structure with rational layout, rich content, and beautiful environment, according to the characteristics of different species. The leisure and sightseeing agriculture expands the agricultural functions, further extending from the agricultural functions of food nutrition, industrial raw materials, promoting farmers' income increase, increasing jobs for farmers and so on, to the functions of low carbon, ecological protection, sightseeing and tourism, and cultural heritage. With the development of low-carbon technologies, the developmental model of leisure and sightseeing will have greater room for development.

At present, in light of the investigation and analysis on development model, tourism content, activity programs and so on, concerning the leisure and sightseeing agriculture in China, the leisure and sightseeing agriculture can be broadly divided into village-economy-oriented model, agricultural-park-oriented model, characteristic-industry-oriented model, artificial-scenery-oriented model, happy-farmhouse-oriented model and agricultural-trade-oriented model. The leisure and sightseeing agriculture magnifies agricultural production function towards ecologi-

cal function, living function and so on, which is the extension and permeation of the primary towards the tertiary industry, conducive to the extension of agriculture towards economy, science and technology, education, environmental protection, tourism, cultural heritage and other fields, better meeting the development requirements of low-carbon economy.

3.3 Ecological integration model Traditional agriculture is a kind of one-way linear structural model of "resources-products-pollutant discharge", with the prominent characteristics "two highs one low" (high consumption of resources, high emission of pollutant, low efficient use of material and energy). In the traditional strategy of agricultural development, the farmers intensively use the natural ecological resources unplanned and uncontrolled. In the mean time, they adopt the technology and workmanship with low use rate, to conduct production and processing, resulting in a large number of "pollutants of no value for use". They discharge a large number of pollutants into the natural environment, and pursue the quantitative growth of economic output at the cost of nature with reverse growth. Through the circular mechanism of "resources-products-reuse", the ecological agriculture is to achieve coordination of economic development and ecological balance. The specific form of ecological integration model includes "combination of planting and fallowing of highland", "small watershed comprehensive management and development", "forest coverage", "field inlaid with forest" and so on. It can clearly be seen that developing circular agriculture, on the basis of elevation and integration of ecological agriculture, is conducive to China's agricultural development. Due to the complex topography of the regions in China and great difference of distribution of agricultural resources, each region can choose to promote the form that is suitable for the regional development, in accordance with the actual situation.

3.4 The developmental model of reusing agricultural byproducts Through processing and disposal, the model is to transform the byproducts in the process of agricultural production into usable resources, so as to make the agricultural byproducts become resources, reduce the pollution and damage of the byproducts on the environment and ecology, and ensure the sustainable development of agriculture[5]. It can be divided into the following two forms.

3.4.1 Use excrement of fowl, straw and other byproducts to promote production technology of edible fungus. It takes the byproducts, such as excrement of fowl, straw and so on, as the material for the production of mushroom. It extends the agricultural ecological industry chain, and realizes the multi-level use and virtuous cycle of "agricultural byproducts-edible fungi-fungus chaff-fertilizer-field crop", which can not only create considerable economic benefits, and provide high-quality edible fungus products, but also improve physical and chemical properties of soil, so as to achieve good economic benefits, social benefits and ecological benefits.

3.4.2 Use the technology of producing methane by agricultural organism. Through processing and disposal, it is to use the straw of agricultural crops generated in the process of agricultural production, so as to make the straw become compost, feed, raw material, and resources, and smooth away the pollution and damage of straw on the environment and ecology, thus it is an important measure of constructing recycling-based agriculture and low-carbon agriculture, and realizing sustainable development.

4 Conclusion

We should vigorously promote the development of circular agriculture, and realize sustainable use of the limited agricultural natural resources, with less resource consumption and less environmental pollution, which is the need of China's new village construction, and the need of realizing high-efficiency sustainable use of agricultural resources and virtuous cycle of agricultural ecological environment, and gradually strengthening the agricultural sustainability. In terms of the development of circular agriculture, China has taken actions with enthusiasm and achieved good results. In the future, China should choose or create different circular agricultural model in different domains, in order to better use agricultural resources, reduce the consumption of agricultural energy inputs, reduce the emission of agricultural greenhouse gas, develop low carbon agriculture, and make great contribution for meeting the international challenges and promoting China's agricultural development.

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