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Technological system for sustainable development of Chinese agriculture

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Abstract—Along with the rapid development of economy, Chinese agriculture with a long history is facing the challenge from environment. So, the technological system for sustainable development of agriculture with Chinese characteristics, which are based on the eco-economic principle, should be established through using the approach of system engineering, carrying on the cream of Chinese traditional agricultural techniques and adopting modern agricultural techniques. The sustainable development should be realized on the basis of sound cycles of economy and ecology and coordinated development between environmental protection and economic growth or exploitation and regeneration of natural resources.

Keywords: sustainable development; technological system; ecoeconomy; sound circulation.

1 Introduction

With the ancient agriculture civilization, China has supported 22% of the world's population on 7% of the world's land. This fact was paid much attentions by the world. But, along with the rapid development of economy in the recent year and the increasement of population, heavy pressure was put on agriculture and the problems such as agro-environment pollution, eco-environment deterioration and natural resources degradation gradually came into being. In this respect, the sustainable development of agriculture and the economic construction in the rural area was facing great challenge. So we have to summarize all experience of Chinese agriculture construction during the past decades and the development of foreign agriculture to probe a new sustainable strategy which is suitable to China's condition and can promote the development of agriculture and protect the eco-environment.

In the early 1980s, as a kind of practice of sustainable development of agriculture, ecological agriculture was raised and spread out in China rapidly. Both Chinese ecological agriculture and other kinds of sustainable agriculture practices appeared in China

recently were developed in three levels. Firstly, programming according to the strategy of harmonizing the exploitation and protection of regional natural resources. Then, designing development model which is suitable to the ecoeconomic condition of that area. Finally, shifting these strategies and models into action by a series of projects and techniques. So, it is very important to establish technological system for sustainable development of Chinese agriculture.

This paper discuss about the technological system for sustainable development of Chinese agriculture according to the experience of ecological agriculture construction.

2 The characteristics and components of the technological system for sustainable development of Chinese agriculture

2.1 The characteristics of the technological system for sustainable development of Chinese agriculture

The goal of sustainable development of agriculture should be realized through the cycling of ecology and economy. It centers around the following three aspects:

(1) The ecological environment should be managed and stereo-planting should be developed through biological and engineering measures which were assembled according to ecological principle and system engineering to strengthen the farmland productivity, and, at the same time, optimize the construction of farming, forestry and animal husbandry.

(2) The chain of "planting feeding-processing", in which the value of resources and agroproducts could be greatly raised, should be established according to the regional resources, the ecoeconomic principle and the rule of market economy to promote the adjustment of industrial construction and the shift of labors.

(3) The techniques of efficient use of regenerative resources should be developed to improve the efficiency of the use of natural resources, realize the benignant circulation of materials and strengthen the sustainability of the use of regenerative resources and the environment stocks according to the ecological food-chain principle.

With the realization of the three benignant circulations, the harmony of economy and ecology, the rational exploitation and everlasting use of the natural resources should come into being. So, the technological system should be with the characteristics of systematization, comprehensive benefits and engineering.

2.2 The components of the technological system for sustainable development of Chinese agriculture

The sustainable agriculture techniques are inseparable from both the traditional agriculture techniques and modern agriculture techniques according to our research and practice and the most important thing is to assess and select them with the standard of

sustainable development of agriculture. Any single technique has the characteristic of dual nature which is decided by the quantity and the environmental condition. Because of the complexity of the agro-ecoeconomic system, all the single techniques should be assembled to fit the multi-goal request of sustainable development of agriculture with the method of system engineering. In general, the sustainable techniques are as follows:

(1) The cream of Chinese traditional agriculture should be developed and the productivity of them should be improved by integrating them with modern agriculture techniques.

(2) Modern agriculture techniques should be adopted and the attention should be paid to their suitability, harmony and comprehensive benefits (economic, ecologic and social) as well as advanced degree.

(3) Resources regeneration, efficient utilization and no-waste production techniques should be used to promote the benignant circulation of substance in the agroecosystem.

3 The major techniques in the practice of sustainable development of Chinese agriculture

3.1 Technique of multi-step utilization of substance

In the construction of complex system concentrated around the combination of cropping and animal raising, the industry of animal husbandry is developed according to the principle of ecological niche. And the interface techniques such as returning straw to fields, anaerobic digestion, straw ammoniation and high efficient rotted manure gradually come into being. In this way, the straw, excrement and other side agroproducts become nutrition of plants and other animals and the efficiency of biological energy can be improved. The setting up of mulberry ditch-pond systems, which suits for the lowlying land and has had a history of 3000 years, has spread out furtherly. In waterlogging area of North China, for developing cropping and animal raising, this system has also adopted.

3.2 Stereo-planting and stereo-raising techniques for the goal of improving comprehensive productivity and the stability of the agroecosystem

In recent years, there are some new creation in the case in intensive labor and technology cultivation by designing reasonable farming system to make full use of rich labors, growing season, lands and some other resources.

Generally, stereo-planting and stereo-raising have three types: they are the multiple layer agricultural community, the complex agricultural community and the zone compounds of agricultural community. In plain zones, the first type, the multiple layer agriculture community may be found easily, such as the model of interplanting cotton with melon in Henan Province, the techniques of this model are to plant water melon

seeds before cotton transplanting or seeding and to cover earth films, and then to plant a line water melon seeds in wide row. In this way, water melon can mature when the height of cotton plants are about 50—60 cm, yields of cotton can not decrease or can increase a little bit, while yields of water melon can be obtain 1500—2000 kg, the income of using the model increase 1.5 times higher than that of using single planting cotton. The second type is agriculture complex community. Such as the model of that "rice-fish-duckweed" which has been popularizing in south of China. In term of the condition that three populations (rice, fish and duckweed) all need water, it should be conducted elaborately for the optimizing species combination through culturing duckweed above water surface and culturing fish in water as well as planting rice in basis soil, each of three species all has itself living spaces that constituting time-space construction to bring integrated effect into play. The zonate combination of agricultural community can be found easily in mountain area. Usually, it has been conducted to develop comprehensively for agriculture, forestry, grass, livestocks and aquatic products, while it has been put in different positions for different vertical zones according to local water and heat condition. The multiple matured plantation is one of contents of the optimized construction in cropping system. Besides these, stereo-planting and stereo raising techniques also include culture and rural processing.

3.3 The technique of "courtyards farming"

The techniques of courtyard farming management have been spread in more than 20 provinces for the following reasons: raising peasant's incomes, and reducing products costs; resolving the problems of surplus labors efficiently, and increasing labor productivity greatly; improving the living environment by the rational using of limited land resources and realizing non-waste production. For instance, in 1986, the households adopting courtyard farming management was 30% of the total households in Jilin Province. In 1990, the number of household with 3000 RMB Yuan of courtyard income reached to 27500 and the cover area was up to 8600 ha which covered 21.56% and 17.64% of the whole county respectively in Nanxian County, Hunan Province. And, in Hebei Province, the courtyard income occupied 27% of the total income of farmer.

The main techniques of the courtyard farming are as follows: (1) making full use of limited space, to develop so called three-dimension planting and animal raising, such as grape production on the trellis and the chicken and rabbits rearing as well as flower planting under the trellis, at the same time the fish keeping in the ponds; (2) combining courtyard rearing with byproducts processing and the contracted farmland planting, to effectively promote the sound recycle of the courtyard ecosystem and upgrade the utilization efficiency of the agricultural wastes; (3) with the biogas plant as the "transformer", such as using solid residues and liquid sludge of biogas plant to feed pigs as well as fish, and other residue as manure for farmland.

3.4 Water-saved farming (dryland farming) technology

Dryland farming technology is characterized mainly by deep ploughing during the summer and autumn and paying attention to water and soil moisture conservation. To absorb more rainfall water and decrease soil moisture evaporation loss, it is necessary to combine the earlier and deeper ploughing with turning back the straw and stalks to soils, leaving the stubble stand for covering of the soil surface, planting crops along with the contour lines, and improve the ploughing implements. In addition there are a series of measures useful to soil moisture conservation, such as: application of more fertilizers to soil; rotation of crops, especially arrangement of the forage and green manure crops in the rotation plan; building of horizontal terraces, tableland, ditch-dam-land, flood-silted land and sandstorm deposited land, turning the "three (water, soil and nutrition) losses land" into "three conserved land"; selecting crop varieties which need less water; introduction of the plastic film covering technology; as well as change of farming patterns. In this aspect furrow sowing technology play a very important role in resistance to drought and freeze for winter wheat crop. A recent innovation of "high-yield furrow" in Shanxi Province has been tested itself as a highly effective way of dryland farming in hilly or mountain areas. This technology is quite different from conventional ones such as terracing which is too expensive in labor cost, and contour farming which is merely favor for erosion control. By building a special furrow that consists of furrow bed made up by fertile topsoil concentration and earth dike made up by subsoil, in addition to plastic film covering the furrow bed, peasants can reap two benefits of both making full use of fertility and maintain and absorb more water. Besides, the furrow building operation can be conducted by tractors. The record yield has been received by 4.5 tons per ha under the very limited precipitation (less than 400 mm; Zhang, 1992).

3.5 Integrated pest management (IPM) and other bio-diversity techniques

The IPM techniques are with the characteristic of protecting the biodiversity and improving the environment. China's IPM technologies consist mainly of following items: wide application of good crop varieties resistant to plant diseases and pests; protection of the natural enemies of pests; application of pesticides of high effective with less residue and more safety to natural enemies, as well as improvement of the application method; application of the liquid sludge from the biogas plants for plant protection; scientific designing of intercropping, mix cropping and rotation, etc. High quality, high output and safety of crops are ensured by these means. Since 1979, IPM has been extended to more than 10 provinces and cities, especially applied to the crops of rice, wheat, cotton, oranges, and vegetables. The application area covered 15.4% of the total farmland area in the suitable regions. Since early 1980s a "pollution-free vegetable" farming technology has been experimented. So the pesticide residue in the vegetables has been guaranteed to meet the demand regulated by the Maximum Permitted Residues

Standards set up by the country. According to the statistics, there have been 171 cities, big and medium, having established the production bases of "pollution-free vegetable". The total area of the bases add up to 12.7% of the basic vegetable planting land.

3.6 Integrated plant nutrition management (IPNM)

China's IPMN technology principally comprise both of "applying chemical fertilizers according to prescription" and rationally developing and application of organic manures. The farmer consists of both procedures of "prescription" and "application". The essence of the "prescription" is to correctly chose the variety and amount of the applied fertilizers according to real situations of the soils and the planned crops prior to the planting; to rationally arrange the ratio of the basic manure and the topdressing; to chose the reasonable date and method of fertilizer application. So the most effectiveness of the fertilizer application in the production could be achieved. The resources of organic manures are also developed in the integration with the "applying fertilizers according to prescription" by means of collection manure through pig rearing, planting legumes and green manure crops, composing, as well as turning back the straw and stalks to soils. The prescription fertilizing technology has been applied on the farmland of more than 26 million ha which accounts for 20% for the entire sown area of this country. It functions well, especially good for the enhancement of the land fertility, prevention of pollution caused by abuse of fertilizers, protection of the eco-environment, reduction of the production costs, increase of output and income, as well as prevention of the plant diseases and pests.

3.7 Soil erosion control technology taking small watershed harnessing as the principal mean

The integrated control of water and soil loss in the small watershed is to plan the small watershed as an unit to be harnessed. The systems engineering is used in the overall planning. On this basis, a correct structure ratios arranged for soil and water conservation and their order of implementation are also arranged properly, in organically combination of the vegetation covering measures with the engineering measures as well as the conservation farming measures. The engineering measures include the comprehensive harnessing of mountains, waters, farmland, forest and roads, and the construction of dams reservoirs and waterways. The biotic measures include the emphasis on the construction of forest and grassland, in combination of arbor with arboreta and grass. Agriculture, forestry, animal husbandry, and sideline production are developed simultaneously. A completed soil and water conservation system is thus formed from the hill tops to the bottom of the ditches, from the upper reaches to the lowers. By this way the soil and water erosion is controlled and the diversified commodity economy is developed locally. To take Wenxi County, Shanxi Province as an example, it is located in the edge area of the loess plateau and has harnessed its half gully area and the soil and water ero-

sion rate is reduced by 67%, the total accumulated water amount in soil is relatively enhanced by more than 100 mm, the annual income of the most contracted household is 4-fold higher than the county average.

3.8 Sewage water irrigation and its purification technology

The sewage irrigated farmland accounts for more than 1.4% of the total. It is more and more important especially for the Northern area, where the water resource is badly inadequate.

The research and extension of sewage utilization and purification technologies have been viewed as a very important linkage for the full use of nitrogen and phosphorous in the wastewater and prevention the damage to crops and soils of its containing pollutants.

Land treatment of waste water includes using the oxidation ponds as the waste water treating facilities and then applied to farmland where the crops and their planting patterns have to be specially chosen. The "duck" lake in Hubei Province has been used as an oxidation pond to treat the waste water. Through the treatment not only the water quality is obviously improved to meet the demand for land irrigation, but also the purified water can be used to rear the aquatic lives. So the economic benefit has been achieved. In some regions where the soils contain too many pollutants, the pollution-tolerant crops, especially the non-edible crops are often chosen to grow. So the pollutants could be avoided accessing into the food chain.

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