Development Situations and Countermeasures of Low Carbon Ecological Circular Agriculture: A Case Study of Nantong City

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Abstract Developing the low carbon ecological circular agriculture is an effective approach to realizing low carbon development of agriculture. Through investigation on existing measures and performance of development of low carbon type ecological circular agriculture in Nantong City, we analyzed the potential and problems of Nantong City in developing low carbon type ecological circular agriculture. Finally, with reference to domestic and foreign research achievements and practical experience, we put forward countermeasures for developing low carbon type ecological circular agriculture in Nantong City from building technical system and government guidance.

Key words Low carbon, Ecological circular agriculture, Nantong City, Countermeasures

1 Introduction

The low carbon agriculture is an agricultural operating mode that uses scientific development idea to realize the objective of low consumption, less input, low emission of pollutants and high yield and benefit. Also, it ensures ecological safety and takes various measures to minimize negative impact brought by environment. Developing low carbon agriculture needs resource conservation, pollution reduction, high efficient production and supporting management technologies and supporting industrial policies[1].

Implementation and development of low carbon agriculture involve coordination of many fields, especially the coordination between production and ecology. There is difference and connection between low carbon agriculture and ecological circular agriculture. Their essence and background of coming into being are different. The former is oriented towards climatic changes, while the latter focuses on ecological and environmental safety and stresses circular utilization of materials. To develop low agriculture, we can learn theories and practice of ecological circular agriculture. In the course of low agriculture development, it should take account of how to avoid the damage of agriculture to environment from technologies, systems and management, ensure quality of agricultural ecological environment, emphasize circular use of resources, raise the resource utilization efficiency, and finally realize the energy conservation, consumption reduction, carbon sequestration and emission reduction. Thus, developing the low carbon ecological circular agriculture is an effective approach to realizing low carbon development of agriculture[2].

2 Current development situations of low carbon agriculture in Nantong City

2.1 Popularizing fertilizer application through soil formula testing and developing alternative fertilizer According to calculation, the fertilizer application through soil formula testing can lift the nitrogen fertilizer utilization ratio to 30% -40% from 20% -30%, accordingly reducing emission of N_2O for 10%. In Nantong City, the fertilizer application through soil formula testing for major crops has covered nearly 90%, and the popularization area is up to 409 300 hm^2. Compared with conventional fertilizer application, it saves cost and increases revenue of 226 million yuan.

Developing non-fossil fertilizer, such as organic fertilizer and green fertilizer, not only can nurture soil, fix carbon and nitrogen, but also reduce discharge of greenhouse gas, and increase agricultural carbon-sinking function. In 2009, the application of organic fertilizer in Nantong City exceeded 6 700 hm^2, the green fertilizer reached 30 000 hm^2 (about 500 000 tons), farm manure 846 700 hm^2 (about 13 400 000 tons), and the average organic fertilizer application of each hectare reached 0.14 ton. Straw returning to fields is the most effective measure of increasing content of organic matter in soil. In 2009, 466 700 hm^2 straws (2 400 000 tons, accounting for 45% of straw resources) were returned to fields in the whole Nantong City[3].

2.2 Promoting marsh gas project In recent years, Nantong City implemented the marsh gas project in all counties and districts). The project, taking marsh gas as the link, estab-

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lished "pig – marsh gas – vegetable and fruit" agricultural circular economic model, improved township and village ecological environment and farmers' living conditions. At the same time, breeding plants actively conducted comprehensive use of marsh gas, realized zero discharge of pollutants, clean and harmless production, promoted rural circular economic development and ecological agricultural construction[4].

2.3 Promoting comprehensive utilization of straws For promoting comprehensive utilization of straws, Nantong City mainly implements five projects. (i) Implementing the project of building model towns and villages of returning straws to fields. (ii) Developing straw marsh gas project, to actively popularize straw marsh gas technology and take full advantage of straw resources and develop gasification and marsh gas project. (iii) Expanding the project of returning straws to fields after passing through cattle's stomach. (iv) Expanding clean energy project. (v) Implementing straw storage and transportation project.

2.4 Developing ecological and healthy animal husbandry In recent years, Nantong City has explored, summarized and popularized many models for effective combination of animal husbandry and planting, and stepped the way of low carbon animal husbandry economic way. The whole city launched marsh gas control project for large scale breeding plant. It converted organic waste of breeding plant into marsh gas for living fuel or power generation with marsh gas technologies. Marsh gas manure was used to produce harmless agricultural products and develop circular agriculture. In 2009, it built 68 marsh gas projects for poultry breeding plants. In 2010, the number reached 80[4].

2.5 Reducing use of pesticide Pesticide is an indispensible input for prevention and control of crop diseases and insect pests. Nantong City has been energetically promoting comprehensive prevention and control technologies for crop diseases and insect pests through combining various measures such as agricultural, biological, physical and chemical methods. The implementation of high efficient and low toxic and less residual pesticides and biological pesticides effectively reduces use of pesticides.

3 Existing problems of low carbon agricultural development in Nantong City

3.1 Serious reduction and loss of cultivated land fertility According to relevant data of environmental protection authorities, due to industrial expansion, loss of high quality cultivated land is serious in Nantong City, and also the environmental deterioration is also challenging[5].

Every year, Nantong City uses more than 1 000 tons of pesticides, however 10% to 20% pesticides are still attached to crops, and most parts are lost in soil, water and air. Chemical fertilizers still take up a large portion in fertilizer application in rural areas of Nantong City. The annual consumption of chemical fertilizer is up to 276 300 tons, with 591.15 kg/ha on average, far higher than the 225 kg/ha limit specified by the developed countries for preventing chemical fertilizers polluting water, also higher than the average chemical fertilizer consumption of 330 kg/ha in the whole China. According to estimation of Veldkamp and Keller, about 0.5% of nitrogen fertilizer is lost in the form of N_2O, thus Nantong City annually discharges about 13 815 tons of N_2O. As a result, low utilization efficiency and high loss ratio of fertilizer in agricultural production not only lead to pollution of soil, but also lead to organic pollution and eutrophication, even underground water pollution and air pollution.

3.2 Weak awareness of agricultural producers for low carbon production At present, most farmers in Nantong City are less educated. Those young farmers who have received certain education would like to go to cities and those who stay at home are women, old or children. This situation directly influences development of low carbon agriculture, makes the agricultural production stagnate at the level of low technology, low benefit, and low cycle traditional agriculture. Therefore, the low carbon development will be an impact and challenge for rural residents, especially those farmers, in ideas, living and production methods, as well as agricultural technological system and management system. What's worse, imperfect grass – roots agricultural technology extension system presents difficulties in extension of low carbon agriculture among farmers.

3.3 Weak scientific and technological support and imperfect technical system The low carbon agriculture of Nantong City is still at the early stage: theoretical research just starts, it lacks practical experience, and large scale development only takes up a small portion in agriculture. Quite a large portion still uses traditional process and backward facilities, so the resource utilization efficiency is low and ecological disruption is serious. The existing low carbon technologies in agricultural production are often used separately, rather than applied comprehensively. This is mainly because of lack of systematic coordination in the technological research and development. For example, in the course of popularizing fertilizer application through testing soil formula, it only considers basic nutrients of soil, without giving consideration to variety feature, panting method and cropping system. This will merely bring into play single function of a certain technology, without receiving comprehensive function of many technologies, leading to achieving half the result with twice the effort.

3.4 Insufficient policy support and relatively backward fund input Currently, policies and regulations of low carbon economy are formulated for heavy duty industries including power, petroleum and machine manufacturing. Few touch upon agricultural fields, and the policies about developing low carbon agriculture are much less. In Nantong City, there is no express provision of low carbon agricultural development at policy level. Developing low carbon agriculture needs more fund input. The lagging of fund input is mainly reflected in technological research and development, demonstration and popularization, and system innovation. In addition, personnel training, achievement conversion, popularization and application also need policy and financial support.

4 Countermeasures for developing the low carbon agriculture in Nantong City

On the basis of actual situations and relevant problems of low carbon agricultural development in Nantong City, we believe that it should particularly value reasonable and scientific and elimination of petroleum in the course of existing agricultural production system. This needs to establish a technical system oriented towards construction of ecological circular agriculture. With the aid of government actions, it is expected to actively implement policy guidance, technical promotion and service support. Further, the government should take proper measures to promote rural limited fund, talent, technology and land to flow to low carbon ecological circular agriculture, promote rapid and healthy development of low carbon agriculture in rural areas, increase farmers' income and raise the agricultural yield, and realize harmonious and sustainable development of agriculture.

4.1 Establishing technical system

4.1.1 Establishing the technical mode centered on recycling use of wastes.

(i) Comprehensive recycling use of straws. Taking straws as fertilizers, such as returning straws to fields, composting technology; using straws as feed, such as straw storage, ammoniation, pressed feed block; using straw as energy, such as thermal gasification technology, biomass gasification technology, pressed feed block replacing fire coal, carbonizing straws to produce ethanol; using straws as base material, such as using straws as base material of edible fungus to realize multiple level recycling use[6].

(ii) Comprehensive disposal of livestock manure. Domestic marsh gas technology, such as ecological chain of "pig – marsh gas – fruit", "pig – marsh gas – vegetable" and "pig – marsh gas – grain"; intensive livestock breeding plant large and medium marsh gas engineering technology, such as building centralized marsh gas supply works using livestock manure as raw material, to supply nearby households with marsh gas; using livestock manure to make organic fertilizer, such as converting to organic fertilizer with the aid of earthworm or conducting harmless treatment with the help of microbial agent, to realize commercial production of organic fertilizer, and harmless and recycling use of livestock manure[6].

(iii) Comprehensive use of rural domestic rubbish. This is mainly to establish rural domestic rubbish collection, transportation and disposal system with village as base, town as link and city (or county) as center, *i.e.* the mode of "village collection, treatment in near place, transfer in town, and centralized disposal". Treatment in near place is mainly directed against domestic rubbish that can be recycled, to reduce cost for terminal treatment. For instance, papers, plastics, and waste metals can be collected and recycled by local waste collection depots, and organic rubbish such as perishable melon peel and vegetable leaves can be composted for farming[7].

(iv) Recycling of agricultural and rural sewage. Rural domestic sewage is firstly intercepted with proper technology. The intercepted water can be discharged to farmland. After using in farmland, the water can be discharged to rivers. Large and medium sized livestock breeding plants can use livestock manure sewage recycling technology.

4.1.2 Energy conservation and emission reduction centered agricultural production technology.

(i) Farmland water saving technology. It is required to focus on the reform of cropping system, optimize planting layout, provide field water-saving facilities, integrate innovative water-saving mode, to form a water-saving pattern integrated with water storage, collection, conservation and utilization.

(ii) Farmland fertilizer saving technology. The key is to popularize fertilizer application through testing soil formula, mainly for superior crops, such as wheat, maize, cotton, vegetable, garlic, hot pepper and peanut, *etc.*

(iii) Farmland pesticide saving technology. It should focus on popularizing biological prevention and control, ecological control, physical prevention and control, scientific use of pesticide, precise application of pesticide, and high efficient prevention and control technology of plant diseases and insect pests.

(iv) Farmland saving technology. Main technological modes include high efficient three-dimensional inter-planting with cotton as major crop; taking full advantage of land under tree shade to develop forest undergrowth industry; actively developing courtyard economy and three-dimensional cultivation.

(v) Agricultural energy saving technology. It is recommended to popularize clean energy technology and energy saving and consumption reduction technology; speed up upgrade of mechanical equipment for rural living; actively popularize coal saving cooking utensils and reduce energy consumption of agricultural equipment; actively manufacture low carbon agricultural machinery, popularize joint harvesting and protective farming, and multiple operating machinery.

4.1.3 Technical model centered on developing new agricultural industry.

(i) Circular technology with agriculture extending to industry then returning to agriculture. Specifically, this chain is a closed chain of "agricultural byproducts – industrial raw materials – industrial byproducts – agricultural products – agricultural production". Through such closed chain, it is expected to realize the organic combination of agricultural production and industrial production.

(ii) Agricultural oil product processing and recycling technology. This is to process staple agricultural products such as farming, livestock and aquatic products, to increase the added value. In the course of processing, it is recommended to promote environment-friendly technologies, to accelerate establishment of closed circular chain of enterprise units.

(iii) Model of leisure and tourism agriculture. It is recommended to build characteristic fruit orchard, vegetable garden and flower nursery in suburban areas or scenic spots, and integrate agricultural production field, consumption place and leisure place. In remote areas and those areas with bio-diversity, it is proposed to build forest park and folk custom tourism village. Besides, it can combine the protection of wild resources, to realize combination of protection and popular sci-

ence education, and combination of protection and reasonable development.

4.1.4 Technical model centered on developing regional aquatic product industry.

(i) Shallow sea three-dimensional ecological breeding technology. It is proposed to breed different fishes at different water layer, to realize three-dimensional ecological breeding.

(ii) Facility fishery healthy breeding technology. It adopts physical filtration, biological cleaning, ozone or ultraviolet disinfection to treat breeding water, to realize external-closed, internal circular, and zero pollution environment-friendly aquaculture.

(iii) Aquaculture in saline and alkaline land. It is recommended to take full advantage of saline and semi-saline resource to carry out suitable aquaculture. In areas with resource concentration and abundant water, it is proposed to establish joint development of fishery, grain, fruit, and vegetable.

(iv) Shallow water ecological fishery technology. In shallow water areas, such as lake side and reservoir bay, it can develop water economic plants (such as water nut and lotus root) combined with fish, duck and goose aquaculture. In paddy field where condition permits, it is recommended to popularize ecological fishery in traditional lotus root pond.

4.2 Strengthening guidance of government

4.2.1 Strengthening propaganda of media to raise the low carbon awareness[8]. The development of low carbon agriculture involves transformation of agricultural production mode, rural life style and farmers' value concept, which require joint efforts of all levels of agricultural authorities, low carbon agricultural scientific and technological extension institutions, and farmers. Since the existing concept is formed in a long time of practice, it will be an arduous work to transform it. We can take actions from two aspects. Firstly, raise farmers' awareness and advocate rural low carbon life. For example, comprehensive use of straws, livestock manure, marsh gas and solar energy can satisfy energy demand for rural cooking and living, and also can greatly reduce discharge of greenhouse gas. Secondly, raise citizens' awareness and advocate low carbon living from clothing, food, and lodging to transportation, encourage low carbon consumption, guide farmers and enterprises to produce or process green agricultural products, to promote development of low carbon agriculture.

4.2.2 Intensifying policy guidance and increasing policy support[9]. It is recommended to include the development of low carbon agriculture into performance assessment system of local government and party cadres, to raise consciousness and sense of responsibility of government and party cadres at all levels. Besides, it can actively guide farmers, entrepreneurs, investors and knowledgeable people to contribute to low carbon agriculture through policy favor, financial subsidy, fund support, taxation deduction and exemption. Favorable policies include: policy pilot of green credit and environmental protection insurance; establish and perfect local preferential policy system that is favorable for utilization of renewable resources, key technical tackling, circular economic demonstration project construction, production and application of energy conservation and water saving, and use of solar energy; low carbon compensation policy for organic fertilizer application, resource conservation, rural cleaning energy and renewable energy, and agricultural waste recycling and harmless disposal.

4.2.3 Encouraging research and development and promoting conversion of scientific and technological achievements. It is required to encourage colleges and universities, scientific institutions and agricultural enterprises to carry out multiple level and channel exchange and cooperation. Besides, it should support innovation and undertaking activities of scientific and technological personnel related to low carbon agriculture and ecological and circular agriculture. In addition, it should encourage technical alliance and project cooperation between enterprises. Finally, it is recommended to support local agricultural enterprises to actively introduce and digest and assimilate domestic and foreign low carbon agricultural development technologies, so as to develop low carbon agriculture of Nantong City to a higher level.

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