Present Situation and Prospect of Comprehensive Planting and Culture in Paddy Fields in Northeast China

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Abstract The rice planting area in Northeast China has reached 5.6 million ha, but the utilization rate of comprehensive culture area in paddy field is only 2%. It is mainly dominated by fish culture in paddy field and crab culture in paddy field, which has broad development prospects. In recent years, the comprehensive planting and culture area of paddy fields in Liaoning Province has developed rapidly with a total of 80 000 ha. In accordance with the local environmental conditions, Heilongjiang and Jilin regions have introduced a new model and technology of comprehensive planting and culture in paddy fields, and developed a comprehensive planting and breeding model of paddy fields with characteristics. At present, the comprehensive planting and culture in paddy fields in Northeast China is still in the stage of rapid development, which needs to be further developed towards specialization, scale, industrialization, high quality and brand.

Key words Northeast region, Comprehensive planting and culture in paddy field, Model

1 Introduction

Northeast China is an important grain base, and the unique geographical environment provides advantages for the comprehensive planting and culture and development of paddy fields. The comprehensive planting and culture in paddy fields in Northeast China began in the late 1950s, but it is developed slowly due to the influence of many factors. Until the 1870s, the comprehensive planting and culture in paddy fields in Liaoning Province began to form a scale gradually, and the breeding technology continued to improve[2]. The comprehensive benefit of comprehensive planting and culture in traditional paddy fields in Jilin Province and Heilongjiang Province is not high, the culture mode and species are single, and the culture scale gradually decreases[3-4]. In recent years, with the increasing demand for high-end agricultural products and the support of governments at all levels, Heilongjiang Province and Jilin Province have introduced new technologies and new models of comprehensive planting and culture in paddy fields, and integrated cultivation of paddy fields has entered a new stage of development. In order to speed up the development of comprehensive planting and culture in paddy fields, governments at all levels have formulated and issued a series of preferential policies. Therefore, under the new development situation, it is necessary to grasp the general situation of comprehensive planting and culture in paddy fields in Northeast China, and put forward development suggestions, so as to provide reference for promoting the development of comprehensive paddy field planting and culture industry in this area.

2 Present situation of comprehensive planting and culture in paddy fields in Northeast China

Northeast China is rich in land resources and dense river network, and the Northeast Plain is the largest plain in China, which provides superior conditions for agricultural production. The area of paddy fields in Northeast China is 5.6 million ha, including 4 million ha in Heilongjiang Province[5], 930 000 ha in Jilin Province and 670 000 ha in Liaoning Province. However, the comprehensive planting and cultivation area of paddy field is only 130 000 ha, which accounts for a small proportion of rice planting area, and has great potential for development.

The paddy field culture area in Northeast China is mainly concentrated in Liaoning Province. According to statistics, the paddy field culture area of Liaoning Province was 82 000 ha in 2000, and the culture area in Panjin was 57 000 ha, accounting for 70.2% of the province's paddy field culture area, and Panjin is already the largest river crab culture base in northern China. In Panjin, the area of crab culture in paddy field is 53 000 ha, and the area of loach in paddy field is 4 000 ha. In addition, Yingkou, Jinzhou, Dandong and other areas also have a certain scale of paddy field farming. The main species of paddy field culture in Liaoning Province are *E. sinensis*, Taiwan Loach, *L. vannamei* and so on.

The comprehensive planting and cultivation area of paddy field in Heilongjiang Province is 13 000 ha. The main species of farming are *R. nigromaculata* and *E. sinensis*. The way of raising crabs in paddy fields is decentralized, and the scale of raising crabs is small. There is almost no fish farming in paddy fields in

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Zhaodong, Zhaozhou, Zhaoyuan and other key aquaculture areas in Heilongjiang Province.

The paddy field culture area of Jilin Province is 13 000 ha, and the paddy field culture area is scattered, covering all areas of the province except Yanbian area. According to statistics, in 2000, the total output of fishes and crabs harvested in paddy fields was 2 million kg, there was an increase of 7% in rice income, and a decrease of 1% to 15% in the use of pesticides and chemical fertilizers. The main species of paddy field culture in Jilin Province are *E. sinensis*, Taiwan Loach, *P. clarkii* and so on.

The development of comprehensive planting and culture in paddy fields among provinces and cities in Northeast China is also not balanced. The culture technology and benefit of Liaoning Province are good, and the yield of young crabs in most paddy fields for comprehensive planting and culture is 450 – 750 kg/ha. In the first ten days of May, 1 200 – 15 000 baby crabs per ha weighing 5 – 6 g were cultured and caught from the pond in September. The income will be increased by 12 000 – 18 000 yuan/ha. The comprehensive planting and culture level and benefit of paddy fields in Heilongjiang Province and Jilin Province are low, and most ponds produce 225 – 300 kg/ha young crabs. In the first ten days of June, the number of baby crabs with a body weight of 8 – 10 g was relatively small (4 500 – 7 500/ha), and they were caught from the pond in the first ten days of September. The income will be increased by 3 000 – 6 000 yuan/ha.

3 Comprehensive planting and culture model of paddy field and its cost and benefit

The comprehensive planting and culture model of paddy field in Northeast China is mainly represented by "Panshan model". Limited to seasonal factors, the rice for planting is single-cropping rice, and the yield is high. The main economic models of comprehensive planting and culture in paddy fields are crab culture in paddy fields and fish culture in paddy fields. In the main comprehensive planting and culture areas of paddy fields, the results of the investigation on the culture model, costs and benefits are as follows:

3.1 Symbiotic model of raising crabs in paddy fields in Panjin area of Liaoning Province The yield of rice in paddy field was 11 250 kg/ha, the output value was 36 000 yuan, and the profit was 9 000 yuan; the yield of river crab was 750 kg/ha, the output value was 37 500 yuan, and the profit was 9 000 yuan. The comprehensive benefit of the model of raising crabs in paddy fields totaled to 18 000 yuan. Compared with the traditional planting mode, the yield of rice remained unchanged, the price was about 0.10 yuan/kg higher than that of local rice, and the comprehensive benefit increased by 19 125 yuan/ha.

3.2 Symbiotic model of raising loach in paddy fields in Panjin area of Liaoning Province The yield of rice in paddy fields was 11 250 kg/ha, the output value was 34 200 yuan, and the profit was 8 100 yuan; the yield of loach was 2 475 kg, the output value was 69 000 yuan, and the profit was 15 570 yuan. The comprehensive benefit of the model of raising loach in paddy fields was 23 685 yuan/ha. Compared with the traditional planting mode, the rice yield remained unchanged, and the comprehensive benefit increased by 16 695 yuan/ha.

3.3 Symbiotic model of raising crabs in paddy fields in Heilongjiang Province The yield of rice in paddy fields was 9 000 kg/ha, the output value was 28 800 yuan and the profit was 13 800 yuan; the output value of river crab was 225 kg, the output value was 10 350 yuan and the profit was 4 800 yuan. The comprehensive benefit of the model of raising crabs in paddy fields totaled to 18 600 yuan. Compared with the traditional planting mode, the rice yield remained unchanged, and the comprehensive benefit increased by 5 700 yuan/ha.

3.4 Symbiotic model of raising frogs in paddy fields in Heilongjiang Province The traditional ecological breeding model of paddy fields needs no feeding. The average yield of *R. nigromaculata* was 120 kg/ha, the profit was 960 yuan, the income of rice increased by 5.9%, and the yield increased by 525 kg. The total comprehensive benefit was 21 525 yuan, and the comprehensive benefit increased by 2 910 yuan/ha.

3.5 Symbiotic model of raising crabs in paddy fields in Jilin Province The yield of rice in paddy fields was 9 000 kg/ha. The output of river crab was 225 kg/ha, the output value was 3 975 yuan, and the profit was 3 015 yuan. The income of rice increased by 7.15%, the yield increased by 795 kg, the comprehensive benefit totaled 29 400 yuan, and the comprehensive benefit increased by 6 120 yuan/ha.

4 Problems

There are still some outstanding problems in the development of comprehensive planting and breeding industry of paddy fields in Northeast China, such as lack of professional knowledge of employees, lack of government funds and relevant guiding policies, poor infrastructure and backward technical level of comprehensive planting and culture in paddy fields, and unstable production due to climate and rainfall. The external commercial fish affects the sales and prices of locally cultured species.

4.1 Comprehensive planting and breeding project in paddy fields The traditional comprehensive planting and culture project in paddy fields can no longer be applied to the modern paddy field comprehensive planting and culture model, and the paddy field needs to be reformed. At present, the road between paddy fields is narrow, which is not conducive to aquaculture management and the transportation of aquatic products; the lack of power system in paddy fields for comprehensive planting and culture also restricts the modernization and information-oriented development of comprehensive planting and culture in paddy fields.

4.2 Temporary culture problem In most parts of Northeast China, fishes and crabs are in a period of rapid growth in autumn and September, while paddy fields have to be dried, and fishes and crabs will be put in temporary culture ponds for intensive fattening. Fishes and crabs were cultured in Heilongjiang and Jilin in

early June, and young crabs were temporarily reared in April. During the temporary culture period, the mortality rate is higher if it is not managed properly.

4.3 Germplasm degradation The degradation of aquatic species quality leads to the miniaturization of fish, shrimp and crab, slow growth rate and weak stress resistance. Panjin City, Liaoning Province is the breeding base of river crabs in Northeast China, but the supply of high-quality offspring is still insufficient. It is generally difficult for comprehensive planting and breeding personnel in paddy fields to select and breed fine varieties, and it is necessary for relevant units to provide a sufficient quantity of high-quality aquatic species.

4.4 Lack of supporting agricultural machinery The comprehensive planting and culture facilities of paddy fields need to be further improved to meet the requirements of the development of modern agriculture. For example, in the process of the transformation of the comprehensive planting and culture project of the paddy field, the ditch needs to be excavated around the paddy field, and the technology of large ridge and double rows is adopted in rice planting, but there is no supporting agricultural machinery[2,6].

4.5 Artificial feeding The degree of acceptance of compound feed by breeders is low. The nutritional needs of fishes and crabs are different in different growing periods, and the natural bait in the water can not meet the needs of growth, so it is necessary to offer artificial compound feed in time. In the comprehensive planting and culture of paddy field, the cost of compound feed is high, so it is imperative to develop cheap and suitable feed.

4.6 Small scale of aquaculture The comprehensive planting and culture in paddy fields in Heilongjiang and Jilin areas is mainly in the form of dispersion, which does not form a continuous scale, and it is dominated by the extensive farming mode, with high production and management costs and low benefits. The number of professional cooperative organizations and leading enterprises is small, and the driving role is relatively weak, which limits the rapid development of comprehensive planting and culture in local paddy fields.

4.7 Restriction on the number of years of land transfer The comprehensive planting and breeding project of paddy field is an one-time project, and it will be used for many years, and needs a long period of land transfer. The management of land transfer is not standardized, and sometimes farmers terminate the contract at will, which causes economic losses to the operators[7].

4.8 Poor marketing awareness The paddy field aquatic products of farmers are produced and sold by themselves, so it is difficult to sell them. For example, the local sales of river crabs cultured in Heilongjiang and Jilin provinces are limited, most of them are sold to Liaoning Province, and the sales price is kept down. We should make use of the quality advantage of the local green pollution-free commercial fish to establish the brand, strengthen the market publicity and ensure the market competitive advantage.

4.9 Weak service system There are few technical personnel of comprehensive planting and culture in paddy fields, and the promotion and training work lags behind. Farmers do not master enough planting and breeding technology in paddy fields, which can not meet the needs of production. Training and guidance for local fishermen need to be strengthened.

4.10 Insufficient policy support The early scale of comprehensive planting and culture in paddy fields is generally small, the investment is huge, and the financing is difficult. The government should formulate preferential policies to promote the development of comprehensive planting and culture in paddy fields, increase policy and financial support, and solve the problems of hydropower and roads in comprehensive planting and culture in paddy fields.

5 Development prospects

Comprehensive planting and culture in paddy fields is an important way to promote agricultural quality and efficiency improvement, transformation and upgrading, which can realize "rice + aquatic products = food security + ecological security + farmers' income increase + enterprise efficiency increase"[8-10]. Northeast China has a friendly ecological environment and has favorable conditions for the development of comprehensive planting and culture in paddy fields. The paddy fields in Northeast China are mostly distributed in low and flat areas with fertile soil and rich water sources. The fishes, shrimps and crabs in paddy fields for comprehensive planting and culture are of good quality and good taste, which are welcomed by the majority of consumers and the price is high. There is no pesticide application, no yield reduction in the rice under comprehensive planting and culture in paddy fields, it has good quality, and the price of rice is higher than that of traditionally cultured rice.

As for the traditional comprehensive planting and culture in paddy fields, the culture level is low, there is a lack of scientific management and technical support, and drugs are blindly used in disease prevention and control, causing economic losses to farmers. Therefore, the comprehensive planting and culture model of paddy fields needs to carry out sustainable development, coordinate the relationship between comprehensive planting and culture in paddy fields and environment, and speed up the scientific research on the key points of comprehensive planting and culture model of paddy fields, such as energy flow and breeding facilities, further improve the technology of culture and management, and form an industrialization model of "breeding-culture-processing-marketing".

The rice planting area in Northeast China is located in the plain area with dense river network, so there is great potential and broad space for the development of comprehensive planting and culture in paddy fields. The rice produced is of good quality, especially Wuchang Daohuaxiang rice, Ningan Xiangshui rice and Panjin rice, which is famous all over the country. Through the combination with the comprehensive planting and culture in paddy fields, it is more conducive to building eco-organic rice, river crab and high-quality fish brands, and greatly improving the potential benefits of rice.

(To page 65)

papers as the first author. In addition, the students' experimental skills have also been significantly improved. They have won 4 first prizes, 5 second prizes, and 2 third prizes in national level discipline competitions, and won 2 second prizes and 1 third prize in the Guangdong Challenge Cup.

6 Conclusions

Implementing the bilingual teaching of bacteriology can effectively follow the development frontier of international pathogenic biology, and make the teaching content in line with international standards. It is conducive to stimulating students' curiosity, fully cultivating students' English thinking, enhancing their enthusiasm for learning foreign languages, and improving their professional English literature search level and English paper writing level, so as to lay a solid foundation for their smooth transition in the future and to adapt to the study and research work of the undergraduate stage and even to the scientific research position. Also, it can effectively improve the students' experimental operation level, and finally enable them to be competent to do experiments in relevant foreign laboratories. In addition, it is conducive to improving the foreign language level and professional quality of bilingual teachers.

The bilingual teaching mode of Aquatic Animal Bacteriology constructed in this study provides a new idea for the reform of bilingual teaching in biology courses. However, there are still shortcomings. It is hoped that in the future, we can continue to improve the teaching quality of Aquatic Animal Bacteriology through cooperation with other universities and enterprises.

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(From page 53)

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(From page 56)

The country has listed the comprehensive planting and culture in paddy fields as one of the key points of the agricultural sustainable development plan from 2015 to 2030. The attention and support policies of governments at all levels provide new opportunities for the comprehensive planting and culture in paddy fields in Northeast China. Governments at all levels take this as an opportunity to increase investment in policies, funds and technology to provide support for the comprehensive planting and culture development of paddy fields in Northeast China.

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