Research Status and Development Trend of Green Manure in Rice Fields in China

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Keywords: Green manure; Rice fields; Research progress; Development trends

Abstract: Under the background of "zero growth" of chemical fertilizers in China, green manure has great potential for development as a biological fertilizer. In this paper, the research history of green manure in rice fields in China, the types of green manure in rice fields, the effect of green manure in rice fields on soil improvement, the effect of green manure in rice fields on rice yield and quality and the development trend of green manure were reviewed.

From the 1950s to the present, many scholars have made a great deal of research on the planting of green manure in rice fields, sorted out and bred a number of new varieties of green manure with good high yield performance, and published a number of valuable documents, proving the application of green manure in effectively promoting the nutrient supply of crops, ensuring stable and high yield of crops, comprehensively improving the biological characteristics of soil physical chemistry and reducing greenhouse gases. In the past a long period of time, chemical fertilizers have made great contributions to the improvement of crop yield, but in recent years the effect is not obvious, and even there is a reduction in production. In addition, the social demand for environmental protection and quality and safety of agricultural products is constantly increasing, so it is imperative to restore and develop green fertilizers. Green manure is widely used in rice fields. Under the green manure-rice circulation system, nutrients in the paddy soil are changed, and rice can absorb more nitrogen and obtain higher yield. After planting green manure, the amount of chemical fertilizer can be reduced accordingly, meeting the requirements of high quality and low cost. The following is a summary of several issues concerning the development of green manure in rice fields.

1. Research History of Green Manure in Paddy Fields in China

In 1955, Huagui Chen systematically summarized the green manure farming system in rice fields and put forward several constructive suggestions, which are of great guiding significance to the later research.In 1965, Gengling Liu put forward a set of measures to prevent rice from "sitting in autumn" by "winter in autumn, applying phosphorus in autumn, treating the symptoms of phosphate fertilizer, treating the root causes of green manure, changing single season to double season, and late rice exceeding early rice". In the 20 years after 80 years, China's chemical fertilizer industry rose rapidly and green manure production fell into a low ebb, but scientific research achieved good results. Entering the 21st century, large quantities of chemical products have led to serious pollution problems. Jike Yang issued a call for planting green manure. Subsequently, with the strong support of the state, the green manure industry has made great progress.

2. Types of Green Manure in Paddy Fields

In 1957, Rongshen Gu proposed a variety of green manure suitable for all regions. At present,

  DOI: 10.25236/isafb.2019.033

there are more than 3,000 kinds of known green manure. People have to distinguish green manure in different ways according to different natural environments and farming systems, different planting time and methods of green manure, and different plant species. At present, the most commonly used classification method is to divide paddy field green manure into leguminous green manure and non-leguminous green manure according to plant disciplines.Commonly used leguminous green manure mainly includes milk vetch, hairy vetch, ViciavillosaRothvar, broad bean, alfalfa, arrowhead, etc. For example, milk vetch has strong nitrogen fixation ability and is widely used. Non-leguminous green manure refers to other green manure except leguminous green manure, most of which are later discovered varieties, mainly cruciferous, gramineous, compositae, etc., and common ones include cruciferous radish, rape, gramineous ryegrass, etc.

Leguminous green manure is mostly planted in the south, mainly in the main rice areas in the middle and lower reaches of the Yangtze River. In addition, green manure has been planted in rice fields in Shaanxi, Guangdong, Hunan, Jiangsu, Zhejiang, Yunnan, Guizhou, Sichuan, Fujian and other places for decades. As for non-leguminous green manure. Gramineous green manure mainly composed of ryegrass is commonly found in higher latitudes such as northwest and northeast of China.

3. Effect of Green Manure on Paddy Soil

High-yielding paddy soil is characterized by good structure, rich nutrients, proper water-holding capacity and vigorous activity of beneficial microorganisms. In actual planting, green manure can change the physical and chemical properties of the soil surface layer through its root system, absorb and stabilize various nutrients in the soil, improve the water retention performance of the soil, and to a certain extent, can also increase the content of microorganisms in the soil and increase the content of soil enzymes.

3.1 Green Manure and Soil Structure in Paddy Fields.

The root length, biomass and distribution depth of green manure will affect the soil structure to some extent, and regulate the organic carbon in the soil through the activities of root tissue. The paddy field rotation system has obvious ecological effects, and has the advantages of improving soil physical and chemical properties, adjusting soil fertility, improving system productivity, etc. When improving soil, green manure can activate insoluble substances in soil and transform them into a state easy for plants to absorb. Chunxia Yang believes that green manure can effectively increase soil porosity, reduce soil bulk density, increase soil organic matter, promote the formation of soil aggregates and improve soil structure. In the experiments of Qin Zhang et al., continuous planting of green manure can improve the mechanical stability and water-stable aggregate content of soils with different grain sizesIn the paddy field where green manure has been continuously planted for many years, the surface soil is loose, which is conducive to the elongation of rice root system.

3.2 Green Manure and Soil Nutrients in Paddy Fields.

Green manure has a good fertilization effect in paddy fields. In practical application, green manure can raise soil temperature, significantly increase the content of available potassium and organophosphorus in soil, and at the same time can promote the accumulation of organic carbonin soil, leaving only a small amount of materials and not adversely affecting the next crop Milk vetch has the best effect. Green manure of Gramineae can effectively increase the content of soil organic matter when turning over fields. Green manure crop can activate mineral elements in the soil through its own material circulation and continuously plant green manure all year round, which can effectively improve the soil and turn the desert into an oasis. Research by Bing Zhao et al. found that under acidic conditions, radish in fertile fields still has the ability to activate insoluble phosphorus and has a good activation effect on iron in soil. When ryegrass was returned to the field, Wenting Yang and others found that properly increasing soil water content in the later stage could accelerate ryegrass decomposition and nitrogen release, and improve nutrient absorption and utilization efficiency of subsequent crops

3.3 Green Manure and Microorganisms in Paddy Fields.

Turning over fields in winter is an important process of using carbon and nitrogen in green manure, in which the content of microorganisms determines the content of soil enzymes, while the content of soil enzymes has a linear relationship with soil nutrients. Guoshun Liu and other studies show that turning over and pressing green manure can reduce soil bulk density and pH value, improve soil organic matter and promote the increase of soil microorganism quantity. Lihong Wang and others showed that planting ryegrass and milk vetch in winter had obvious effects on the population of bacteria, fungi and actinomycetes in paddy soil. Quan Zhou and others also found in their research that green manure intercropping can also improve the soil environment in crop rhizosphere and inhibit the growth of anaerobic bacteria.

3.4 Green Manure in Paddy Fields and Soil Water Retention Capacity.

In general, green manure crop has vigorous growth, large biomass and high surface coverage. It can reduce the erosion of wind and rain on the surface, facilitate the deep infiltration of rainwater, improve soil moisture content, reduce surface runoff and slow down the loss of soil nutrients. Research by Qiaogang Yu and others found that ryegrass, Astragalus sinicus and Pisum sativum in green manure crop can reduce runoff loss by 36.4%, 33.9% and 5.3% respectively, sediment loss by 56.4%, 55.2% and 8.8%, increase soil water retention capacity and strengthen soil consolidation effect.

4. Effect of Green Manure on Rice Yield

Fertilizer application plays a very important role in rice yield. Now the Ministry of Agriculture has put forward the concept of "zero growth of chemical fertilizer", and the effect of green manure application on yield increase must be clear.

The current planting method of green manure in rice fields is mainly the rotation of green manure in winter, which is used in most rice areas. The study found that returning green manure to the field, especially Chinese milk vetch, can release a large amount of N element in the early and middle stages of rice growth after being turned over and decomposed in advance, which can promote the formation of tiller. Na Zhao et al. concluded in the experiment that the application of green manure can increase the yield of early rice and promote the vegetative growth and reproductive growth of the next late rice. In the double-cropping rice rotation experiment conducted by Jusheng Gao and others, green manure rotation significantly increased rice yield, of which Astragalus sinicus was the most effective. In 2018, Huaikang Qu's research proved that under the system of alfalfa-rice rotation and alfalfa returning to the field, a 20% reduction in the amount of nitrogen fertilizer can ensure the formation of high yield of rice. In the conversion tests of green manure and thiamine nitrogen in the last century, Zhimin Liu et al. have already concluded that Arrowhead and Ryegrass can increase the mineralization of organic nitrogen while increasing the nitrogen fixation rate of thiamine. Among them, the green manure nitrogen is beneficial to the fixation of inorganic nitrogen in the early stage, but it is more transported to grains in the later stage, thus increasing the yield.

5. Problems of Green Manure in Rice Fields at Present Stag

There are also a series of problems that need to be solved urgently to replace chemical fertilizer with green manure in rice fields. First of all, farmers do not know enough about green manure. Although China has a large area for planting rice, the utilization rate of green manure is not high. The reason is that the impact of chemical fertilizer industry leads to the lack of attention to green manure by the state and the farmers' enthusiasm for planting green manure is not high. As a kind of crop, green manure also needs high-quality resources. Most of the green manure currently produced are still products from the 1980s. The variety of green manure is too messy to adapt to the complex agricultural environment. The protection of the diversity of green manure is also an urgent problem to be solved. Different from other crops, green manure does not take yield as its main purpose. The

existing agricultural technology cannot meet the needs of large-scale planting of green manure in rice fields, which seriously affects the promotion and utilization of green manure in rice fields.

6. Research Prospect of Green Manure

According to the requirement of sustainable development of agriculture, the planting scale of green manure in rice fields will continue to expand, which is expected to replace chemical fertilizers in the future. This also poses a challenge to agricultural workers studying green manure. In view of the complexity of soil conditions around the country, a single green manure cannot achieve the effect of comprehensive improvement, so it is necessary to adjust measures to local conditions and suit the remedy to the case. Under the guidance of the scientific concept of development, scientific and effective methods should be used, natural laws should be followed, and the principle of adjusting measures to local conditions should be strictly implemented. The problems of insufficient cognition, lack of resources and backward technology in green manure planting should be solved as soon as possible so that green manure planting can truly become a low-cost, low-consumption, sustainable and multi-income agricultural technology. I think there will be great achievements in the following areas:

6.1 Improving the Adaptability of Green Manure.

At present, there are about 3,000 kinds of green manure. Due to the influence of different climates, regions, farming methods and cultivation conditions, not many kinds of green manure can be applied in practice. The main reason is that most green manure cannot adapt to various environments and systems. Therefore, the first thing to do in developing green manure is to improve the ecological adaptability of green manure, to improve green manure varieties and even to cultivate new varieties, to improve the environmental adaptability of various green manure crop, to turn green manure crop into a crop variety that can grow in various harsh environments, to make full use of industrial and agricultural wastes and domestic wastes and other waste materials, and to make contributions to desert greening while managing the environment.

6.2 Increase the Fertilizer Effect of Green Manure.

In order to realize "zero growth of chemical fertilizer", there must be something to replace chemical fertilizer, and the ability of green fertilizer to increase fertilizer must be improved. However, most of the current green manure carries less nutrients, so it is necessary to carry out research on the supplement and activation ability of green manure to various beneficial elements in the soil, launch a comprehensive offensive on the fertilizer market, gradually replace the role of chemical fertilizers in agriculture, and eliminate the adverse effects of chemical fertilizers while increasing crop yield.

6.3 Looking for Suitable Cultivation Methods.

In the 1980s or so, there was a fault in the study of green manure and the cultivation techniques did not advance with other crops. Aiming at the problem of backward application technology of green manure, special research is carried out, previous research experiences are summarized, a series of agricultural machinery suitable for green manure are designed in combination with land improvement and crop yield increasing methods, and a set of systematic methods suitable for green manure production are sorted out.

6.4 Popularize Relevant Knowledge of Green Manure.

Achieving "zero growth of chemical fertilizer" in 2020 is a national indicator. It is not enough to rely solely on the research of scholars, but also requires the joint efforts of the vast number of agricultural workers. In order to thoroughly solve the problem of insufficient understanding of green manure, demonstration bases of green manure with spots in flour will be launched throughout the country so that farmers can understand and be familiar with green manure, understand the advantages of green manure and the possibility of replacing chemical fertilizers, and change the

idea that crops can only be used for food and clothing.

Acknowledgements

This research was financially supported by the project of Tianjin agricultural science and technology achievements transformation(17YFNZNC00050);Innovation and entrepreneurship training program for college students of Tianjin agricultural (201810061044,201810061073).

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