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Analysis of Cultivated Land Quality Improvement Technologies

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ABSTRACT

This paper comprehensively reviews the research status of cultivated land quality improvement technologies, elaborates on the existing technical achievements in detail, deeply analyzes the difficulties in the application process, and puts forward prospects for the future development direction. Through a comprehensive analysis of the research progress in key fields such as soil improvement, irrigation and drainage, fertilization, and farmland ecological protection, it aims to provide a theoretical basis and practical reference for further promoting the improvement of cultivated land quality, ensuring national food security, and sustainable agricultural development.

KEYWORDS

Cultivated land quality; Improvement technologies; Literature review; Technical difficulties.

1. INTRODUCTION

Cultivated land, as the core element of agricultural production, its quality is directly related to the yield and quality of agricultural products, and plays a decisive role in national food security and sustainable agricultural development. Under the dual pressure of global population growth and economic development, improving the grade of cultivated land quality has become a key issue to be urgently solved in the agricultural field. Many scholars have carried out extensive and in - depth research on cultivated land quality improvement technologies and accumulated rich theoretical and practical achievements [1]. However, the technologies still face many challenges in the actual application process, which restricts their promotion and application effects. Therefore, systematically summarizing the existing technical achievements and deeply analyzing the technical difficulties are of great significance for promoting the innovation and development of cultivated land quality improvement technologies.

2. CULTIVATED LAND QUALITY IMPROVEMENT TECHNOLOGIES AND THEIR EFFECTS

2.1. Soil Improvement Technologies

Deep ploughing and subsoiling technology is an important means to improve the physical structure of the soil. Through a series of field experiments and data analysis, scholars such as Wang Xingren have confirmed that increasing the tillage depth from the traditional 20 cm to 30 - 40 cm can significantly reduce the soil bulk density by 0.1 - 0.2 g/cm³, and at the same time, the porosity increases by 5% - 10%, effectively enhancing the air permeability and water permeability of the soil and creating a more favorable space for crop root growth [2]. The practical application in the wheat - growing area of the North China Plain shows that after adopting deep ploughing and subsoiling technology, the root penetration depth of wheat increases by 10 - 15 cm, and the root distribution becomes more uniform, thus effectively improving the absorption capacity of wheat for soil nutrients and water, laying a solid foundation for high and stable wheat yields.

For acidic soils, scholars such as Xu Minggang have found through research that precise application of lime can effectively adjust the soil pH and significantly improve the availability of nutrients such as phosphorus and potassium in the soil. When the soil pH value increases from 4.5 to 5.5, the available phosphorus content in the soil increases by 3 - 5 mg/kg, and the available potassium content increases by 10 - 20 mg/kg [3]. This process is mainly due to the exchange reaction between calcium ions in lime and hydrogen ions in the soil, which reduces the soil acidity and further promotes the dissolution and release of phosphorus, potassium and other nutrients in the soil. In the improvement of saline - alkali land, the use of chemical modifiers such as gypsum can effectively reduce the soil salt content through ion - exchange effects, improve the soil physical and chemical properties, and create a suitable soil environment for crop growth.

Lu Rukun's research provides important theoretical and methodological basis for the research on the effects of green manure returning to the field [4]. Practices have shown that planting green manure crops such as Chinese milk vetch and alfalfa and turning them over and returning them to the field during their vigorous growth period can effectively increase the soil organic matter content. It is measured that for every 1000 kg of fresh Chinese milk vetch returned to the field, the soil organic matter content can be increased by 0.05% - 0.1%. During the decomposition and transformation of green manure in the soil, it not only provides rich carbon and nitrogen sources for soil microorganisms, promotes the reproduction and activities of microorganisms, optimizes the soil microbial community structure, but also produces a large amount of humus, improves the soil aggregate structure, and enhances the water - retaining and fertilizer - retaining capacity of the soil, achieving the sustainable improvement of the soil.

2.2. Irrigation and Drainage Technologies

Scholars such as Kang Shaozhong have pointed out that precision irrigation technologies such as drip irrigation and micro - sprinkler irrigation, based on the water - demand requirements of crops at different growth stages, can achieve accurate water supply by installing sensors in the field to monitor soil moisture and crop water - demand information in real - time and using intelligent control systems to automatically control the irrigation time and water volume [5]. In the application practice in the cotton - growing area of Xinjiang, after adopting drip irrigation technology, the irrigation water use efficiency of cotton has increased by 30% - 40%, and the yield has increased by 15% - 20%. It effectively reduces the waste of water resources and avoids soil compaction and nutrient loss caused by over - irrigation, providing a successful example for the efficient utilization of agricultural water resources in arid areas.

For low - lying and water - logged farmland, the construction of open - ditch drainage or underground pipe drainage facilities is a key measure to ensure the quality of cultivated land. When the groundwater level is reduced to an appropriate depth of 0.8 - 1.2 meters through drainage facilities, the soil air permeability is significantly improved, and the redox potential increases, which is conducive to the aerobic respiration and nutrient absorption of crop roots. In the application in paddy fields in the south, reasonable drainage effectively prevents rice roots from lacking oxygen, reduces the occurrence of diseases and pests, and improves the yield and quality of rice, fully demonstrating the important role of reasonable drainage technology in improving the farmland ecological environment and increasing crop yields.

2.3. Fertilization Technologies

Research by scholars such as Jin Jiyun shows that the soil - testing and formula fertilization technology, based on soil nutrient testing and crop nutrient - demand laws, formulates personalized fertilization plans, which can effectively avoid blind fertilization [6]. In the application in the corn - growing area of Northeast China, this technology has increased the fertilizer utilization rate by 10% - 20%, reduced the amount of chemical fertilizers by 10% - 15%, and at the same time increased the crop yield by 8% - 12%, significantly improving the quality of agricultural products. Through precise fertilization, not only the fertilizer utilization efficiency is improved, the agricultural production cost is reduced, but also the pollution of chemical fertilizers to the environment is reduced, achieving a win - win situation of economic and ecological benefits in agricultural production.

Slow - controlled - release fertilizers, through special coating materials or production processes, enable the fertilizer nutrients to be slowly released according to the growth needs of crops, effectively reducing the leaching and volatilization losses of fertilizers. Research shows that the nutrient utilization rate of slow - controlled - release fertilizers is 20% - 30% higher than that of ordinary chemical fertilizers, and the fertilizer - effect period can be extended by 30 - 60 days, providing continuous and stable nutrient supply for crop growth. Bio - fertilizers contain a large number of beneficial microorganisms, such as rhizobia, phosphorus - solubilizing bacteria, and potassium - solubilizing bacteria. These microorganisms multiply and act in the soil, can transform the insoluble nutrients in the soil into forms that can be absorbed and utilized by crops, and at the same time secrete plant growth hormones to promote crop growth, enhance soil fertility, and improve the soil ecological environment, providing strong support for the green development of agriculture.

2.4. Farmland Ecological Protection Technologies

A large number of studies and practices show that building shelterbelts around farmland can effectively reduce the wind speed by 30% - 40%, reduce the soil wind erosion by 40% - 60%, increase the air humidity in the farmland by 5% - 10%, promote crop growth, and increase the crop yield by 10% - 15%. In the wind - sand area of the northwest, the farmland shelterbelt is like a green barrier, blocking the invasion of wind - sand, protecting the farmland from wind - sand hazards, improving the farmland micro - climate, creating a good external environment for crop growth, and ensuring the stability of agricultural production.

Implementing crop rotation (such as corn - soybean rotation) can make full use of the differential nutrient demands of different crops on the soil, achieving the balanced utilization of soil nutrients. Research shows that corn - soybean rotation can increase the nitrogen content in the soil by 10% - 15% and reduce the incidence of diseases and pests by 20% - 30%. Fallowing can let the cultivated land rest and recover. In some areas with long - term high - intensity cultivation, through fallowing, the soil organic matter content can be increased by 0.1% - 0.2%, and the soil microbial activity is enhanced, effectively restoring the soil fertility and achieving the sustainable utilization of cultivated land.

3. DIFFICULTIES IN THE APPLICATION OF CULTIVATED LAND QUALITY IMPROVEMENT TECHNOLOGIES

3.1. Difficulties in Soil Improvement Technologies

During the promotion of deep ploughing and subsoiling technology, it faces the problem of high costs of large - scale mechanical equipment, which makes it difficult for many small - scale farmers to afford. At the same time, this technology has relatively strict requirements for soil moisture conditions. In different regions with complex soil conditions and diverse planting patterns, how to reasonably select the operation time and determine the operation parameters increases the difficulty of technology application. In the chemical improvement process, the dosage and application method of modifiers need to be accurately controlled. Otherwise, it is easy to lead to negative effects such as soil compaction or environmental pollution. Green manure planting is restricted by factors such as climate and land resources. There are differences in the suitable green manure varieties in different regions, and the turning - over time and methods of green manure have a great impact on the improvement effect. Currently, the related technologies still need to be further optimized and improved.

3.2. Difficulties in Irrigation and Drainage Technologies

Although precision irrigation technology has significant water - saving and yield - increasing effects, the equipment investment is relatively large, and the requirements for equipment maintenance and management are also relatively high, which to a certain extent restricts its promotion and application in economically underdeveloped areas. The construction of drainage systems needs to comprehensively consider many factors such as terrain, soil texture, and hydrogeology. Unreasonable design is likely to lead to poor drainage or over - drainage, which not only affects the quality of cultivated land but also may have an adverse impact on the surrounding ecological environment.

3.3. Difficulties in Fertilization Technologies

The promotion of soil - testing and formula fertilization technology requires the establishment of a complete soil nutrient monitoring system and a professional technical service team. However, in some rural areas, due to the lack of farmers' awareness of this technology and the lack of technical services, the application effect of this technology has not been fully exerted. Although new fertilizers have many advantages, their production costs are relatively high, and the market prices are relatively expensive, so the acceptance of farmers needs to be improved. In addition, the effects of new fertilizers are greatly affected by soil environment and application methods. How to reasonably apply new fertilizers according to different soil conditions and crop demands still requires further research and practice.

3.4. Difficulties in Farmland Ecological Protection Technologies

The construction of farmland shelterbelts requires reasonable planning of tree species selection, shelterbelt structure, and layout. At the same time, it is necessary to fully consider the coordination with farmland tillage and irrigation to avoid adverse effects on agricultural production. However, in actual operation, due to the comprehensive consideration of many factors, the planning difficulty is relatively large. In the implementation of the crop rotation and fallowing system, it is necessary to fully consider issues such as farmers' economic benefits and land transfer. Currently, a reasonable compensation mechanism and policy support system are still not perfect, which to a certain extent affects the enthusiasm of farmers to participate in crop rotation and fallowing.

4. CONCLUSIONS AND PROSPECTS

In summary, a series of remarkable technical achievements have been made in the improvement of cultivated land quality, covering key fields such as soil improvement, irrigation and drainage, fertilization, and farmland ecological protection. These technologies have played an important role in improving cultivated land quality and ensuring food security. However, each technology faces different degrees of difficulties in practical applications, restricting the wide promotion and application effects of the technologies. In the future, it is necessary to increase the intensity of scientific and technological innovation, develop low - cost, high - efficiency, and adaptable cultivated land quality improvement technologies; strengthen technical training and promotion, improve farmers' awareness and application ability of new technologies; improve the policy support system, establish and improve the long - term mechanism for cultivated land quality protection, and promote the collaborative application of various technologies, so as to comprehensively improve the quality of cultivated land and promote the sustainable development of agriculture. At the same time, with the acceleration of the agricultural modernization process, it is necessary to further strengthen the cross - integration of multiple disciplines and carry out comprehensive research to provide a more scientific and comprehensive technical support for the improvement of cultivated land quality.

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