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Research Progress on Soil Carbon Sequestration in Dry Farmland

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Abstract

Dry farming is a kind of agricultural production mode widely existed in the world, and its soil carbon sequestration potential has attracted much attention. The paper discussed the influencing factors, carbon sequestration process and effect of soil carbon sequestration in dryland farmland. It was concluded that protective tillage measures such as application of organic fertilizer, no-tillage, deep tillage and straw returning could increase the carbon sequestration in surface dryland soil, biodegradable film mulching could promote soil organic carbon fixation, and rational arrangement of crops could improve soil carbon sequestration capacity.

Keywords

Dry Farming; Conservation Tillage; Soil Organic Carbon; Carbon Fixation; Tillage Practice.

1. Influencing Factors of Soil Carbon Sequestration in Dry Farmland

The global climate change is getting more and more serious, and the measures to mitigate the impact of climate change have received more and more attention[1]. Carbon sequestration is considered to be an important carbon sink for sustainable climate change mitigation, and soil plays an important role in carbon sequestration[2]. People divide cultivated land into paddy field and dry land, among which, the farmland that does not always maintain water layer, including irrigated farmland and dry farmland, is collectively referred to as dry land[3]. As one of the main types of agricultural land in China, dryland farmland soil contains the largest inorganic carbon reservoir and has great carbon sequestration potential. Carbon sequestration in drylands is essential for maintaining soil quality, improving agricultural productivity and maintaining a harmonious ecosystem.

The main factors affecting soil carbon sequestration in dry farmland are complicated, including temperature, precipitation, irrigation, planting system, agricultural tillage measures and fertilization. The influence of soil carbon sequestration is mainly reflected in the influence of soil carbon input and output. Temperature and precipitation affect the type, distribution and growth of crops, and thus affect the carbon input of crop residues to soil. Temperature and precipitation also affect the activity of soil microorganisms, thus affecting the decomposition and release of soil organic carbon. Irrigation can replenish water for crops, improve the productivity of farmland ecosystem and increase the input of soil organic matter. Planting system affects the input of organic carbon into soil by crop residues. Agricultural practices can increase the frequency of soil disturbance, change the physical and chemical properties of soil,

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and increase soil carbon output. Fertilization will supplement soil carbon and other nutrients, reducing soil nutrients will affect the normal growth of crops, reduce the carbon sequestration capacity of crops, aggravate the oxidation and mineralization of soil organic matter, resulting in increased carbon dioxide emissions, which is also one of the culprits of the greenhouse effect.

2. Soil Carbon Sequestration Process in Dry Farmland

There are two ways to sequester carbon, one is physical fixation and the other is biological fixation. The physical carbon sequestration method is to store carbon dioxide underground (such as oil, natural gas, coal seam, deep sea) for a long time through certain technical means to prevent carbon dioxide from entering the atmosphere, thus slowing down the occurrence of the greenhouse effect. Biological carbon sequestration means that plants and microorganisms transform carbon dioxide into organic matter through photosynthesis, chemical synthesis and other processes, and fix it in plants, soil and other environments. Common biological carbon sequestration pathways include photosynthesis by green plants and photoautotrophs, and chemosynthesis by nitrifying bacteria using ammonia oxide to synthesize organic matter. Therefore, carbon sequestration is an important means of environmental protection and needs to be widely used in human activities. The adsorption of carbon dioxide by matter, that is, the energy of natural [5] organisms to fix carbon dioxide, is largely derived from photocooperation. Biological carbon sequestration is when crops naturally absorb carbon from the atmosphere through photosynthesis, and then convert sunlight, water and carbon dioxide into sugars for growth and energy accumulation. Some of the carbon-containing sugars are released through the roots, feeding soil microbes and increasing their numbers. Throughout the life cycle of crops, these microbes contribute to the formation of soil organic carbon. When soil is undisturbed, most of the carbon is stored. Soil beneficial microorganisms can ensure soil health, expand root growth, facilitate nutrient absorption, promote crop yield, improve photosynthetic efficiency and agricultural productivity. Some microbial techniques can also be used in conjunction with other soil tillage practices to store more soil carbon. Soil carbon sequestration capacity depends on both soil carbon sequestration capacity and soil organic carbon stability. Soil organic carbon is the key to microbial energy conversion, and microorganisms play a decisive role in soil ecological environment, and their diversity plays a key role in maintaining the stability of soil ecological environment.

3. Carbon Sequestration Effect of Dry Farming Techniques

Conservation tillage is an important technical measure in dry farming. More and more scholars began to pay attention to the effects of conservation tillage such as no-tillage, subsoiling and straw returning on soil carbon sequestration. Li Jing et al. 's study showed that both no-tillage straw mulching and deep-loose straw mulching could increase the organic carbon content of aggregates, and the organic carbon content would also increase with the increase of age. Yang Ke used the geochemical background value method to estimate that the higher the straw return rate, the higher the soil carbon sequestration efficiency. Liu Weiji conducted long-term positioning observation on the rotating farmland in central China, and verified, validated and evaluated the Century model by using the actual yield and soil organic matter data. The results showed that straw returning to the field could significantly improve soil organic matter and enhance soil carbon sequeeration capacity, and the organic carbon in the soil could increase by 1932.77 g/m2 after straw returning to the field completely. Zhao Xin concluded through mata analysis that conservation tillage could enhance soil carbon sequeering capacity, but it was mostly limited to the surface 0-10 cm. Wang Chengji et al. concluded that the integrated conservation tillage measures combined with straw returning could prolong the effective carbon sequestration time of rice field for 27 years and dry land for 23 years, and maintain a

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higher carbon sequestration rate and extend the effective carbon sequestration time. Xu Fengyi believed that the combination of subsoil-no-tilling-return-subsoil-rotation was beneficial to the stability of soil organic matter under the condition of drought and less tillage. Lu Xingli's research shows that no-tillage and mulching film can improve soil carbon sequestration under the ecological environment of winter wheat-summer corn. Wu Jun et al. found that no-tillage and straw returning increased soil organic carbon content compared with conventional tillage, and the effect of no-tillage and straw returning was the best through studying different tillage methods in dry farmland in Longzhong area. Xu Yingde believed that the establishment of a virtuous cycle between aggregates and organic carbon through reasonable farming methods was conducive to improving the carbon sequeering capacity of soil. Any removal of crop residues in dryland agriculture means a loss of soil organic carbon, and the use of no-till practices in field crops and cover crops in tree crops has great potential in dryland areas because of the associated benefit of maintaining the soil surface covered by crop stubble. No-till reduces soil erosion by 80 percent compared to conventional tillage, and long-term maintenance of no-till increases soil macroporosity and offsets nitrous oxide emissions from the large amounts of water stored in the soil when no-till is used. It also shows that sequestering large amounts of carbon in dryland soils is an achievable goal and will yield social and environmental benefits.

Many of the world's drylands are characterized by soil degradation, high poverty rates and low investment capacity in agriculture, and the most effective measure to address this problem is to maximize organic matter inputs. Based on the observation data of long-term positioning test sites, Wang Shuhui et al. improved the mechanism process model SPACSYS. Combined with the regional database and ArcGIS, they simulated three different fertilization scenarios from 2010 to 2050: single fertilizer, 50% fertilizer with 50% fertilizer, and 30% fertilizer with 70% fertilizer. The average carbon sequestration rate and average annual N2O emission in dryland soil of North China Plain were obtained, and the average net climate warming potential of dryland soil in North China Plain was analyzed. It was found that the combination of chemical fertilizer and organic fertilizer was more beneficial to soil carbon sequestration than the traditional single fertilization. Liang Feng concluded that long-term application of chemical fertilizer or combined application of chemical fertilizer and organic fertilizer could increase soil organic carbon storage. Liu Kailou et al. believed that long-term application of organic fertilizer could significantly increase soil organic carbon content and storage.

In the semi-arid tropical monoculture region, the combined use of fertilizer and organic fertilizer is crucial to improve organic carbon sequestration. Biodegradable film mulching and planting cover crops are generally considered to be beneficial to soil organic carbon fixation. HUANG Fangyuan et al believe that biodegradable film covering can increase soil carbon nitrogen ratio and promote soil organic carbon fixation, and the use of biochar to fix carbon in soil is a relatively promising carbon fixation and emission reduction technology at present. LI Shuailin et al. found that the addition of biochar in 0-10 cm soil layer may accelerate carbon loss, while the addition of biochar in 10-20 cm underground soil can effectively avoid serious interference to the surface soil environment, which is conducive to long-term carbon sequestration in soil.

Proper adjustment of planting methods can also improve the carbon sequestration capacity of soil. In an analysis of three tropical dryland agriculture systems in Africa and Latin America, Farage et al. found that with proper management, soils can become carbon sinks, and that the most effective measures are to maximize organic matter inputs. Some scholars have also found that the combination of multiple agricultural measures is more conducive to soil carbon sequestration. Gao Hongjun et al. believed that corn straw returning to field could significantly promote the accumulation of organic carbon in chernozem soil and aggregates, and the content of organic carbon in soil increased with the amount of straw returning to field and the extension

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of the experimental period, and organic carbon was mainly concentrated in large aggregates, which also indicated that straw returning to field was an important cultivation measure for improving soil fertility in black soil area, and organic carbon in large aggregates could be used as an evaluation of soil organic One of the important indicators of the rapid response of carbon change to different soil fertilization measures. South America leads the world in the application rate of conservation agriculture, especially through the combination of crop rotation and planting of cover crops, which generally promote soil organic carbon fixation.

4. Peroration

Soil organic carbon fixation is an important driving force to mitigate global climate change and maintain farmland ecosystem productivity, and farmland carbon emission and sequestration is of great significance to reduce greenhouse gas emissions. At present, there are still many shortcomings in the study of soil carbon pool in dryland farmland in China. It is still necessary to systematically, comprehensively and objectively assess the impact of different emission reduction measures on soil carbon pool, food security and ecological environment, and explore more effective countermeasures for soil carbon pool management, so as to provide scientific basis for the sustainable development of soil carbon pool in farmland and response to climate change in China.

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