ISSN: 2664-9640

Influence of straw returning to farmland soil carbon sequestration

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Abstract

At present, with the country's vigorous promotion of straw returning to the field, straw returning has become one of the important ways to increase soil organic matter and improve soil fertility, but a considerable part of the carbon in the process of decomposition of straw is released in the form of CO2. How to make more straw carbon sequester in the soil is of great significance for the carbon sequestration and emission reduction of farmland soil.

Keywords

Straw returning; low and medium yield fields; soil quality; crop yield; carbon sequestration.

1. Introduction

There are many land resources in China, but the per capita cultivated land resources are less than half of the world average level, and affected by various obstacles such as poor soil nutrients, salinization, acidification, drought and water shortage, about 70% of the existing 128 million hm^2 of cultivated land % belong to low- and medium-yield fields, with poor soil cultivability, low overall quality of cultivated land, and low grain productivity. For a long time, the implementation of the strictest cultivated land protection system has been a major national strategy to ensure the basic elements of material production in my country and promote sustainable economic development. In his speech at the Central Economic Work Conference, General Secretary Xi Jinping emphasized that "the fundamental guarantee of national food security lies in arable land, and arable land is the lifeblood of food production." However, the degradation of cultivated land quality caused by multiple obstacles, the low comprehensive grain productivity, and the large number of low- and medium-yielding fields pose arduous tasks for the protection and quality improvement of cultivated land resources in my country.

Agricultural production is closely related to climate change and greenhouse gas emissions. As of 2018, China's agricultural carbon emissions have reached 90.8 billion tons, of which agricultural greenhouse gas emissions account for 11% of the country's total, and nitrogen fertilizer production, transportation and application, irrigation, CH4 and agricultural machinery fuel emissions account for 90% of the total agricultural carbon emissions. The agricultural carbon emission per unit area has far exceeded that of developed countries. A large number of studies have shown that the return of organic fertilizer to the field, the addition of biochar, and reasonable and efficient field management measures can achieve a certain degree of agricultural carbon fixation, which is conducive to promoting the major strategic layout of carbon neutrality. How to improve the quality of cultivated land under the background of carbon neutrality will be a major research task in the field of agriculture and land engineering in my country.

China is a big grain-producing country. The total amount of straw produced by crop planting reaches 700 million tons each year. The random disposal, inefficient use and direct burning of

ISSN: 2664-9640

straw are important carbon sources that cause environmental pollution and increase greenhouse gases. Due to the poor quality of cultivated land, backward management mode, low soil fertility and low utilization of crop straws, the soil carbon sequestration ability of low- and medium-yield fields is weak. Since crop straw is a renewable resource and rich in N, P, K and other nutrients required for crop growth, returning straw to the field can improve soil physical structure and enhance soil nutrients. It is a carbon sink material that is degraded by microorganisms and absorbed and utilized by crops. If it can be used effectively, it is also an effective measure to achieve optimal allocation of resources, improve the quality of cultivated land, reduce pollution and achieve carbon sequestration and emission reduction.

2. Straw returning on soil carbon sequestration potential of farmland

Straw returning to the field mainly achieves carbon sequestration by increasing soil organic carbon. my country's annual agricultural straw production exceeds 6.1×10^{6} t, and straw returning to the field has a huge carbon sink potential. It is estimated that the current cropland holding potential of straw returning in my country is 2.3×104 Tg Ca^{-1}. If the agricultural measures of straw returning are comprehensively promoted nationwide, the carbon sequestration potential of cropland soil in my country will be 4.2×104 Tg Ca^{-l}. If straw is returned to field in all European farmland, the carbon sequestration potential of European farmland soil can reach 34 Tga^{-l}, and the average carbon sequestration rate per unit area is 150 $kg{:}hm^{-2}.a^{-l}$. The area of farmland suitable for straw returning in the EU is 66.21 Mhm'. From this, it can be calculated that the total carbon sequestration potential of European straw returning farmland soil is 1.09Tg a^{-l}, and the average carbon sequestration rate per unit area is 20 $kghm^{-2}.a^{-1}$. The total carbon sequestration capacity of farmland soils with straw returning can reach 200 Tg a^{-1}. It can be seen that straw returning has considerable carbon sequestration potential.

3. Analysis on factors of soil carbon sequestration potential in farmland under straw returning

In farmland ecosystems, the level of soil organic carbon accumulation mainly depends on the balance between input (such as field crop residues and addition of exogenous organic materials, etc.) and output (decomposition of original soil organic matter), that is, the humification of soil organic matter The balance between the two main processes of mineralization and mineralization. After the straw is returned to the field, on the one hand, the straw increases the soil organic carbon through the humification of organic carbon; on the other hand, the mineralization of the original organic carbon in the soil is caused by the excitation effect of the straw carbon. The excitation effect (that is, the mineralization of the original soil organic carbon caused by exogenous organic materials entering the soil) is one of the important mechanisms affecting the input and output of organic carbon. The addition of straw may accelerate the mineralization of the original organic carbon in the soil. Decomposition, resulting in a positive excitation effect, may also slow down the mineralization and decomposition of the original soil organic carbon, resulting in a negative excitation effect. At present, there is little research on the negative excitation effect. It is generally believed that the size of the excitation effect is related to the biochemical composition, C/N, application amount, soil properties and soil microorganisms of exogenous additives.

ISSN: 2664-9640

4. Carbon sequestration and emission reduction potential of biochar prepared from straw pyrolysis

4.1. The effect of biochar on soil carbon sequestration

The loss of farmland soil carbon pool is the main driving force for the increasing concentration of atmospheric greenhouse gases. Studies have shown that the black soil in the central Amazon Basin has been formed for 600~7000 a, while the biochar in the discovered soil has been preserved for 500~3000 a without being destroyed. mineralization. Although the stability of various biochars varies with their biological raw materials, soil texture, and soil environment, in general, biochar is a more stable and longer-lasting carbon sequestering material than other materials. Studies have shown that 25% of the amount of CO_2 emitted by human activities can be stored in the form of biochar, which can reduce the concentration of CO_2 in the air by 40 mL.m. The socio-economically feasible increase in foreign exchange by using biochar technology can reach 9.5Pg. It is estimated that if 3.7×10^5 t of crop straw and biomass waste are thermally made into 7.7×10^4 t of biochar and applied to the soil in Indonesia every year, the emission of CO_2 can be reduced by 2.3×10^5 t per year. It can be seen that the carbon sequestration potential of biochar is very large.

4.2. Effects of Biochar on Greenhouse Gas Emissions from Farmland Soils

Atmospheric CO_2 and CH4 are the most important greenhouse gases for global climate change. Among them, CO, which contributes the most to the greenhouse effect, accounts for about 60%, and is the most important greenhouse gas (IPCC 2000). Secondly, although the content of CH_4 is very low, its greenhouse effect potential is 20 times that of CO_2, and its increase rate to the greenhouse effect accounts for 15%. According to research, the greenhouse gas released by terrestrial soil accounts for 15% to 30% of CH_4 and 5% to 20% of CO_2 in the atmosphere. Farmland soil is the most important emission source of CO_2 and CH_4. As a highly aromatic structure and highly stable carbon-rich substance, biochar can fix the carbon in biomass during its production and application, avoid the influence of microorganisms and other ways to decompose into the atmosphere, thereby Effectively play the role of soil carbon sequestration, play a role in carbon sequestration and emission reduction, thereby affecting global climate change.

The total annual output of crop straw in my country's farmland is more than 500 million tons, and about 1/4 of the crop straw and other agricultural biomass wastes are incinerated, abandoned and decomposed every year, causing environmental pollution. Only a small part of the biomass straw was returned to the soil. After the biomass straw enters the soil, it is mineralized into CO_2 and released into the atmosphere within a few years, and the accumulation of organic carbon in the soil is relatively slow. According to relatively conservative statistics, if 500 million tons of carbonized, agricultural and forestry waste organic materials can be pyrolyzed each year, this is equivalent to absorbing 730 million tons of CO_2 from the atmosphere. According to the Millennium Development Goal Indicators, a website of the United Nations, China's total CO_2 emission capacity in recent years is about 3.3 billion tons. In other words, if 500 million tons of agricultural and forestry biomass waste is prepared into biochar every year, it can theoretically reduce the total amount of CO_2 emissions by 22% for the country's social and economic development. It can be seen that the carbon sequestration potential of biochar is huge.

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5. Research direction of straw returning to the field for carbon sequestration

In the past period of time, in my country's wheat/corn rotation cropping twice-a-year grain planting area, due to the highly intensive utilization of farmland soil, especially under the condition of high chemical nitrogen fertilizer input, the organic fertilizer source was far away from the farmland, and a large number of crop straws were burned or destroyed. Disposal has caused the content of soil organic matter in farmland ecosystems to continue to decline, and soil organic matter is considered to be the heart of soil life. It has a very core function in ensuring soil fertility and providing nutrients for crops. It can be seen that increasing the content of soil organic matter is crucial to ensuring farmland soil fertility and promoting sustainable agricultural production. In recent years, driven by the relevant national policies and the continuous improvement of the level of agricultural production mechanization, the wheat and jade - annual second crop rotation area has vigorously promoted the direct return of wheat and corn straw to the field, and the crop straw has replaced the traditional organic fertilizer. The most important source of organic fertilizer for soil fertility in grain fields. Studies have shown that returning straw to the field not only increases the amount of soil organic carbon, but also significantly improves the quality of soil organic carbon. However, as the straw decomposes in the soil, most of the straw carbon will be decomposed by mineralization and released into the atmosphere in the form of CO_2. Therefore, keeping as much straw carbon as possible in the soil to increase soil organic matter in grain fields, improve soil fertility and carbon sequestration and emission reduction is a more worthy concern of straw returning.

6. Outlook

China is a major food producer. The total amount of straw produced by crop planting reaches 700 million tons each year. The random disposal, inefficient use and direct burning of straw not only cause environmental pollution, but also an important carbon source that increases greenhouse gases. Low- and medium-yielding fields often have weak soil carbon sequestration capacity due to poor arable land quality, backward management methods, low soil fertility, and low utilization of straw. Crop straw is a renewable resource and rich in N, P, K and other nutrients required for crop growth, which can reduce soil bulk density, improve soil porosity, and improve soil moisture conservation and soil nutrients. If carbon sink materials that are degraded by soil and microorganisms and absorbed and utilized by crops can be efficiently utilized, it is also an effective measure to achieve optimal resource allocation, improve the quality of cultivated land, reduce pollution, and achieve carbon sequestration and emission reduction. However, at present, the implementation of crop straw returning in my country is relatively slow, the national straw returning rate is less than 2%, and the existing straw returning technologies are mainly incineration, crushing, stubble and mulching, and the methods are relatively simple. Due to the difficulty in controlling soil moisture content and temperature, straw cannot be fully degraded and the risk of pests and diseases increases when straw is returned to the field; during the degradation process, soil sugar and potassium content decreases, resulting in a decrease in soil nitrogen and potassium fertilizer supply capacity; in addition, straw Direct or indirect return to the field also leads to aggravation of soil N_2O emissions. Studies have shown that straw returning to the field not only increases the organic carbon content of farmland soil, but also increases the annual N_2O emissions. Under traditional fertilization management, farmland is already a carbon sink for greenhouse gases. Although there is a relationship between soil carbon sequestration rate and N_2O emissions due to straw returning, it is still more conducive to greenhouse gas emission reduction. Therefore, it is necessary to vigorously develop measures such as returning decomposed straw to the field,

making charcoal and returning it to the field, and returning the carbon-based compound fertilizer to the field to improve the quality of cultivated land and increase the soil carbon sink.

Fund project:

The internal scientific research project of Shaanxi Provincial Land Engineering Construction Group Co., Ltd. (DJNY2022-54).

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