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Effects of Tillage and Straw Management Methods on Soil Properties

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Abstract

Soil tillage and straw returning measures are important agronomic measures, and the agricultural management measures combining conservation tillage and crop straw returning play an important role in improving soil structure and physicochemical properties, improving fertilizer retention and fertilizer supply performance, and achieving high and stable crop yield. In recent years, the state has actively promoted straw returning technology, but the effect is not very ideal, one of the main reasons is that the straw returning method can not effectively take into account the problem of non-coordination between water and heat in production, and different straw returning technologies have advantages and disadvantages, and the effect of straw returning to the field is also very different. Therefore, exploring the effects of tillage and straw management on soil properties is conducive to promoting the utilization of agricultural waste resources and the sustainable development of straw returning technology.

Keywords

Conservation tillage; Straw returning to field; Soil moisture; Soil structure; Soil carbon component.

1. INTRODUCTION

In the context of global warming, the intensification of spatial and temporal variation of water resources, the surge of population and the increasing improvement of living standards, coupled with regional conflicts such as Russia and Ukraine, the global food security situation and nutrition situation are becoming increasingly severe. Therefore, it also poses a greater challenge to continuously improve the productivity of cultivated land. Crop straw returning to field is the most direct and effective agricultural technical measure to supplement soil organic carbon. Agricultural management measures combining conservation tillage and crop straw returning to field play an important role in improving soil structure and physical and chemical properties, enhancing the performance of fertilizer preservation and supply, and achieving high and stable crop yield [1,2].

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As the natural support and biological barrier of farmland ecosystem, soil is vulnerable to factors such as agricultural management measures and climate change, which ultimately affect the improvement of crop yield and sustainable agricultural development [3]. Studies [4] have shown that straw returning to field can improve soil physical and chemical properties and biological properties of soil to fertilize soil, promote crop growth and development and increase yield. However, different straw returning methods have great differences in short-term effects, sometimes showing negative effects. In the dry area, straw overturning and returning to the field will cause excessive pores in the soil surface, air leakage, moisture runoff, and lower soil temperature, which will affect the sowing quality [5]. Subsowing straw returning to the field can effectively break the plough bottom formed for many years, improve soil aeration, create sufficient growth space for roots, and promote root sinking [6]. By creating good soil structural conditions for crop growth, no-tillage under straw mulch can reduce the temperature difference between day and night, promote crop root development, improve crop yield and water use efficiency [7]. However, some scholars [8] believe that although mulch no-tillage can play a positive role in preventing erosion and consolidating soil and soil temperature changes, it is not conducive to crop sowing and emergence. Therefore, different straw returning technologies have advantages and disadvantages, and the effects of straw returning are also very different with different environment and limiting factors.

As the basic means of agricultural production, soil is the central link of material and energy circulation in terrestrial ecosystem. Based on domestic and foreign research literature and engineering practice, this study explored the main indexes of soil properties, such as the spatio-temporal distribution of soil water, soil structure and stability, and soil carbon composition, etc. influenced by tillage and straw management, in order to provide scientific basis and theoretical support for improving soil structure, enhancing soil stability, and increasing soil fertility. Tillage and straw management are of great significance for improving soil productivity, increasing crop yield, ensuring food security and realizing grain storage in the ground.

2. RESEARCH PROGRESS OF TILLAGE AND STRAW RETURNING TO FIELD

2.1. Effects of tillage and straw management on soil moisture

As an important agronomic measure, soil tillage and straw returning have an important effect on soil moisture retention capacity and yield. Studies [9] have shown that conservation tillage measures such as no-tillage and subsoiling, combined with straw returning, can reduce surface exposure, inhibit soil evaporation, increase in-place precipitation infiltration, improve soil environment, and thus improve crop yield and water use efficiency. Straw returning to the field can not only improve the soil surface water status, improve the water use efficiency of crops, but also promote the growth and development of crops, and ultimately increase the yield. Some scholars [10,11] believe that no-tillage or subsoiling combined with straw mulching can improve soil water status and regulate crop water consumption during potato growth period, which is conducive to the improvement of potato yield and water use efficiency. Autumn deep tillage combined with straw returning increased soil water content, yield and water use efficiency at seedling stage by 1.9%, 12.2% and 5.4%, respectively [12]. At present, according to the organic combination of conservation tillage and straw returning, there are few reports on the effects of straw returning on the temporal and spatial distribution of soil water under different regional tillage methods. As an important agronomic measure, soil tillage and straw returning have an important impact on soil water storage capacity and structural improvement. In particular, it plays an important role in improving the efficient water utilization of crops in arid areas or wind-blown sandy areas.

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2.2. Effects of tillage and straw management on soil structure and stability

The cultivation method affects the formation, turnover and stability of aggregates. No tillage reduced the damage to soil structure by mechanical tillage, promoted the formation of large particle size aggregates, and increased the geometric mean diameter of aggregates. Some scholars et al. [13] analyzed the particle size composition of water-stable aggregates under different tillage methods under whey-jade rotation system and found that no-tillage significantly increased the mass proportion of 0.25-2mm particle size aggregates in 0-40 cm soil layer, while tilling increased the mass proportion of micro-aggregates in 0-40 cm soil layer. However, some scholars [14] found that compared with no-tillage, tilling increased the mass proportion of aggregates with a diameter of > 2 mm in 0-40 cm soil layer, and increased the average weight diameter and geometric average diameter of aggregates. In addition, it was reported [15] that compared with traditional tillage, no-tillage increased the mass proportion of large particle size aggregates in 0-5 and 5-10 cm soil layers, but decreased the mass proportion of large particle size aggregates in 10-30 cm soil layers. Therefore, the influence of tillage methods on the particle size composition and stability of soil aggregates is still controversial. So far, there is still no consistent conclusion on the influence of straw returning to the field on soil aggregate structure. To study the influence of tillage and straw management methods on soil structure and stability is the research direction to further explore the measures to improve soil quality.

2.3. Effects of tillage and straw management on soil carbon components

Soil organic carbon pool is easily affected by agricultural management measures, and farming methods affect the mineralization and sequestration of soil organic carbon. It is generally believed that the high tillage intensity of traditional farming methods causes soil organic carbon to be exposed to the air, accelerates the mineralization and degradation of organic carbon, thus promoting soil carbon emission and reducing soil carbon sequestration. Compared with traditional tillage, no-tillage reduces mechanical disturbance to soil, improves soil stability, and is conducive to the increase of organic carbon content. The contents of active organic carbon components such as dissolved organic carbon (17.6%), easily oxidized organic carbon (14.8%), granular organic carbon (11.7%) and microbial biomass carbon (16.0%) were increased by no-tillage [16]. However, a long-term study on conservation tillage by some scholars [17] found that no-tillage only increased the content of organic carbon and easily oxidized organic carbon in 0-5 cm soil layer and improved the carbon pool management index, but had no significant impact on the content of organic carbon in deep soil. A large number of existing studies have found that although no-tillage and shallow rotary tillage can increase the content of soil organic carbon and active organic carbon components, they are only limited to the surface soil, and different tillage methods significantly affect the spatial distribution of soil organic carbon [18]. Therefore, there is still no consistent research result on the effects of different tillage methods on soil organic carbon and organic carbon component content up to now. The reason for this phenomenon may be that the effects of tillage methods on soil organic carbon and organic carbon component vary with climatic conditions, soil types and planting systems.

Crop straw is the main by-product in agricultural ecosystem, which contains a lot of organic matter and mineral nutrients, and is an important renewable material resource. Straw returning to the field can effectively replenish and balance soil nutrients, and has an important impact on soil carbon pool. A large number of studies have shown that straw can be used as natural organic fertilizer to be injected into soil, and the input of fresh carbon source is the main reason for the increase of soil carbon content, and the soil organic carbon content and storage can be improved by increasing carbon input [19,20]. Some studies have found through long-term experiments [21] that soil organic carbon content is significantly increased after straw returning to field, and within a certain range, soil organic carbon content is usually linearly

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positive correlated with straw returning amount. Straw returning to field can also provide soil microorganisms with carbon and nitrogen sources necessary for life activities, and cause changes in the content of soil active organic carbon. Straw returning to field can effectively increase the content of soil easily oxidized organic carbon and microbial biomass carbon. However, some studies have found that straw returning to the field may not necessarily promote the increase of soil organic carbon content, and may even cause the decrease of organic carbon content [22]. Therefore, the effects of straw returning on soil carbon content may be different in different agroecosystems.

3. CONCLUSION

Straw is the main by-product of crops, but also a very valuable renewable resource, and improving the comprehensive utilization rate of straw is very important to establish a long-term mechanism for green and sustainable development of agriculture. Among them, straw returning technology is one of the important measures to improve the agricultural ecological environment and develop sustainable agriculture. Through straw returning to the field, soil can be effectively improved, soil fertility can be raised, and environmental pollution caused by straw burning can be avoided while the use of fertilizer can be reduced. In recent years, the state has actively promoted straw returning technology, but the effect is not very satisfactory, one of the main reasons is that the straw returning method fails to effectively take into account the problem of water-heat disharmony in production, especially in arid and semi-arid areas and dry areas with wind and sand. Spring drought is the main problem that causes crops to be unable to be sown on time, resulting in a substantial reduction in production. Therefore, how to conserve soil moisture to ensure timely sowing is the primary problem solved by straw returning to the field.

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