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Regulation Effect of Porous Materials on Soil Quality in Farmland

Yan Li[1, 2, 3, 4, 5, *], Yuhu Luo[1, 2, 3, 4, 5], Xue Wang[1, 2, 3, 4, 5]

[1] Shaanxi Key Laboratory of Land Consolidation, Xi'an-710075, China
[2] Institute of Land Engineering and Technology, Shaanxi Provincial Land Engineering Construction Group Co., Ltd., Xi'an-712100, China
[3] Shaanxi Provincial Land Engineering Construction Group, Key Laboratory of Degraded and Unused Land Consolidation Engineering, Ministry of Natural Resources, Xi'an-710075, China
[4] Shaanxi Engineering Research Center of Land Consolidation, Xi'an-710021, China
[5] Land Engineering Technology Innovation Center, Ministry of Natural Resources, Xi'an-710075, China

Abstract: Porous materials of biomass carbonized products have the characteristics of rich carbon, high porosity, high specific surface area and strong adsorption, and are widely used in fields such as improving soil quality in farmland, improving crop productivity, reducing greenhouse gas emissions and mitigating climate change. Based on previous studies, this paper summarized and analyzed the effect of the application of porous materials on the improvement of soil physical and chemical properties and nutrient content, and explored the change of soil thermal properties under the action of porous materials, in order to provide useful reference for the study of porous materials on the improvement of soil quality and crop yield.

Keywords: Farmland, Porous materials, Nutrients, Thermal properties, Physicochemical properties.

1. Introduction

Farmland quality is the foundation of food security. National construction of high - standard farmland to achieve drought and flood guaranteed harvest, high and stable yield. Building high-standard farmland is a key measure to consolidate and improve grain production capacity and ensure national food security. Porous materials have the advantages of large specific surface area and high porosity stability. The application of porous materials into farmland soil can limit soil shrinkage, promote soil water and fertilizer retention, and affect soil CEC, EC, pH, OM content and other physicochemical properties to varying degrees [1]. As a good passivating agent for heavy metals, porous materials have been widely used in the field of sewage treatment, but little attention has been paid to the research and large-scale application of in-situ remediation of farmland soil. Moreover, affected by the properties of raw materials, preparation conditions, application amount and other factors, the remediation effects of porous materials are also different. In particular, for the modification of different porous materials combined with various methods to improve the quality of soil physical and chemical properties and the long-term stability of the effect need to be further studied [2].

2. Effects of Porous Materials on Soil Physicochemical Properties

Pore material is a carbon-rich solid substance formed by pyrolysis of biomass under anaerobic or oxygen-limited conditions. It is characterized by weak alkalescency, porosity, high stability and high cation exchange capacity, and can improve pH of acidic soil, cation exchange capacity and effective nutrient content after application in soil [3]. In addition, porous materials themselves contain large numbers of highly efficient phosphorus nutrients, which can directly improve the availability of soil phosphorus, and the increase of pH can also promote the release of fixed phosphorus in soil. Meanwhile, porous materials can also change the form and availability of phosphorus by affecting the adsorption and desorption of phosphorus [4]. The researchers found that both the porous material and the lime treatment could significantly improve the pH value and base saturation of the tea garden soil, while the rape straw biochar could increase the pH value and the content of exchangeable base and reduce the content of exchangeable acid in the red soil, and the improvement effect increased with the increase of the preparation temperature and the amount of porous material. The study of Jing Yan et al [5] showed that soil pH and available P contents increased at different growth stages of rape after the addition of porous wheat straw material, and the two were significantly correlated. In addition, studies have shown that porous materials also play an important role in improving soil structure, carbon sequestration, emission reduction and pollution remediation.

Due to the differences in soil type and crop type, as well as the differences in temperature and raw materials, the reasonable application amounts of porous materials as soil amendments to improve crop yield is still controversial [6]. Adding porous materials to soil can play a certain role in water retention, and the adsorption property of its high specific surface area can reduce the leakage and loss of soil water, thus reducing the leaching loss of soil nutrients. At the same time, the adsorption of charged organic matter by high concentration of negative charge on the surface of porous materials makes the soil have stronger nutrient retention ability and inhibits the leaching of soil nutrients [7]. However, under different climate, soil conditions and artificial management, the effect of porous material application level on soil nutrient enhancement has not been uniformly concluded.

3. Effects of Porous Materials on Soil Thermal Properties

The application of porous materials will deepen the soil color and change the soil texture, affect the surface soil albedo and thermal properties, and thus may affect the soil

temperature and its variation range, and indirectly interfere with the internal activities of soil and the growth and development of crops [8]. After solar radiation reaches the ground, the storage, conduction and distribution of soil heat depend on soil thermal properties. Soil thermal property parameters mainly include: soil thermal conductivity, soil heat capacity, soil thermal diffusivity. Different soil thermal properties are different, heat conduction and heat storage capacity were different, so different soil after absorbing a certain amount of heat its temperature increase or decrease range is different. The thermal properties of soil are mainly affected by texture, bulk density, and hydraulic characteristics. The water movement and heat transport in soil are an inseparable unified system. The application of porous materials into soil will change soil texture, bulk density, and hydraulic properties, indirectly leading to the change of soil thermal properties, but in field conditions, it is not clear how porous materials mainly affect soil thermal properties. The loess Plateau region is a transitional zone between arid and humid areas in China, with serious soil and water loss, sparse vegetation and sensitivity to climate change. Soil thermal status is an important factor affecting the surface energy balance and thus the underlying surface structure of the loess region, and soil thermal status is reflected by temperature [9]. For example, the loess plateau region is a transitional zone between arid and humid areas in China, with serious soil and water loss, sparse vegetation and sensitivity to climate change. Soil thermal status is an important factor affecting the surface energy balance and thus the underlying surface structure of the loess region, and soil thermal status is reflected by temperature.

Porous materials have a higher heat capacity than soil mineral particles, and the application of porous materials can significantly improve the heat capacity of soil [10]. However, the increase of soil porosity and the decrease of soil bulk density can also lead to the decrease of soil heat capacity. Studies have shown that under natural field conditions, the effect of porous materials added to soil-on-soil temperature does not simply increase or decrease, but has the effect of "peak cutting and valley filling", that is, reducing soil temperature at noon in summer, but increasing soil temperature in winter. Studies show that porous materials significantly reduce soil thermal conductivity and thermal diffusivity, that is, soil temperature changes slowly after applying porous materials under the same heat condition [6]

At present, there are few researches on the effect of the application of porous materials on soil thermal properties and soil temperature, which are mainly simulated in laboratory. The researches based on the field experiment of northwest loess in fallow period are also scarce.

4. Effects of Porous Materials on Soil Nutrients

Soil nutrient is the essential material basis for crop growth and yield increase, and is also the main index to measure soil fertility. It is also another important factor limiting crop growth in the dry area of the Loess Plateau. Soil chemical nutrients will change with soil type, crop type and fertilizer application. The addition of porous materials will generally make all indexes in soil develop in a positive direction. The porous material itself contains some water-soluble mineral nutrients which are directly absorbed by plants and some unstable organic-nutrient complex substances which can be mineralized to produce mineral ions. The special physical and chemical properties of porous materials can adsorb nutrient ions and then reduce nutrient leaching. Meanwhile, their high pH can change the availability of nutrient elements such as Al, Ca, Mg, B and Mo in soil [11]. In addition, the structure of porous materials will provide a favorable habitat for microorganisms, which is conducive to the retention of N, P and S elements in the soil. The addition of porous materials can increase the content of total available nutrients, organic matter, and total nutrients in soil, and provide good environmental resources for the growth of crops, the survival of microorganisms and micro-animals.

Porous materials directly or indirectly participate in soil nutrient cycling in farmland ecosystems and have important effects on soil nutrients through their physical and chemical properties or interactions with soil. Application of porous materials can significantly increase soil organic matter and total K content. With the increase of the amount of porous materials applied, the increase of soil organic matter content was the highest. The main reason was that the amount of porous materials applied increased greatly, which greatly increased the amount of carbon sources imported into the soil. In particular, the porous materials added in the experiment were waste fruit wood branches, and the content of carbon and volatile substances was generally higher than that of the porous materials prepared by agricultural waste. Jinfeng et al [12] pointed out that with the increase of the application amounts of porous materials, soil C/N increased, which was conducive to improving soil nitrogen uptake, and the same trend of increasing soil total nitrogen content was also obtained in this experiment. The relationship between soil total P content and porous materials was not significant, which may be because the effect of phosphorus fixation was weakened with the increase of soil organic matter content, and the soil total P content remained around 1.00 g/kg.

5. Conclusion

Poor soil structure and low water and fertilizer retention capacity are another major factor restricting agricultural production in this area. In the face of the challenge of increasing food demand, optimizing field management and cultivation practices is important for improving crop productivity in the region. However, the application and research of porous materials in China is still in the initial stage. The reports on porous materials mainly focus on the acidic or severely weathered soil in the low latitude tropical and subtropical regions, while there are few reports on the effects of neutral and alkaline soil and its agricultural use in temperate regions. Whether the application of porous materials can be used as a new regulation measure for the exploitation of production potential and efficient crop water use in the dry farming area of the Loess Plateau is worth further investigation.

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