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Effects of Different Fertilizers and Straw Returning on Soil Phosphorus Availability

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Abstract

Phosphate is easy to be fixed by soil, which leads to a low utilization efficiency ofphosphorus fertilizer and limits the exploitation of potential grain yield. Therefore, improving thesoil P availability is the key to solve the scientific issue. The field study included straw returning. soil tillage and P fertilizer type, to promote the efficient use of P. In order to explore the effects of straw returning and fertilizer types on the P utilization efficiency of summer maize.

Keywords

Summer Maize; Straw Returning; Tillage; Organic Fertilizer; Phosphorus Utilization Rate.

1. Introduction

Phosphorus is an essential nutrient element for plant growth and food production. Phosphorus can promote crop growth and production, significantly improve crop resistance, and increase grain yield[1]. However, China's farmland soil is in a state of phosphorus deficiency for a long time, and the application of phosphorus fertilizer can effectively improve the supply of soil phosphorus, so the production and consumption of phosphorus fertilizer in China continue to increase[2]. However, China's grain growth rate did not increase significantly with the increase of phosphorus fertilizer consumption, while the utilization efficiency of phosphorus decreased with the increase of phosphorus application. Irrational application of phosphorus fertilizer leads to a large amount of phosphorus residues in soil, which reduces the utilization rate of phosphorus fertilizer[3]. Phosphorus fertilizer is adsorbed and fixed by soil particles soon after application, and it is easy to form phosphate ineffective to plants with iron, aluminum, calcium and other metal ions in the soil, resulting in 75%-85% of soil phosphorus difficult to use, thus affecting the effectiveness of phosphorus and reducing the use of phosphorus fertilizer in season[4]. Phosphorus in soil is not only absorbed and utilized by plants, but also migrates through leakage, leaching loss also leads to phosphorus loss. The high input and low output of phosphate fertilizer not only increase the production cost, cause the waste of phosphorus resources, but also increase the risk of environmental pollution. Therefore, it is of great significance to improve the utilization efficiency of phosphorus fertilizer for realizing the sustainable development of agriculture and relieving the pressure of phosphorus resource shortage.

The soil phosphorus availability and utilization efficiency of phosphorus fertilizer can be improved through soil tillage and rational fertilization. Reasonable straw returning to field can effectively

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improve the physical and chemical properties of soil, increase the activity of soil phosphorus, promote the uptake of phosphorus by crop roots, increase grain yield, and improve the utilization efficiency of soil phosphorus. In addition, the application of organic fertilizer is one of the effective ways to alleviate the phosphorus deficit of agricultural soil, which can improve the availability of soil phosphorus and improve the soil nutrient fertility[5]. Therefore, reasonable straw returning combined with organic fertilizer can improve the availability of soil phosphorus and increase yield and efficiency.

2. Utilization Status of Soil Phosphorus

Phosphorus is an indispensable nutrient element for crop growth and development, and plays an important role in crop metabolism. Soil phosphorus includes water-soluble phosphorus, weakly acid-soluble phosphorus and insoluble inorganic phosphorus compounds, as well as phospholipids, phytoids and nucleic acid organophosphorus compounds. There is a complex transformation relationship among all forms of phosphorus, and they are in dynamic equilibrium. The chemical behavior of phosphorus in soil includes solution-precipitation, adsorption-desorption and biological transformation, etc. Soil physical and chemical properties, tillage and fertilization management measures all have certain effects on the transformation behavior of soil phosphorus availability, thus affecting the absorption capacity of plants to soil phosphorus.

Phosphorus in farmland soil is mainly inorganic phosphorus, and there are many kinds of inorganic phosphorus compounds in soil, which are generally divided into three forms: water-soluble, adsorbed and mineral. Soil available phosphorus is inorganic phosphorus and small molecule organophosphorus components that can be directly absorbed and utilized by crops, which is directly related to the absorption and utilization of plants. Soil water-soluble phosphorus is a part of soil available phosphorus, which is easily soluble and can be directly absorbed and utilized by plants. It is closely related to plant phosphorus nutrition, and its change can accurately reflect the availability of soil phosphorus to plants. However, after phosphorus fertilizer is applied into the soil, water-soluble phosphorus is easily fixed or transformed into phosphate which is difficult to use under the action of soil environment. Most of the phosphorus fertilizer may be adsorbed and fixed after application into the soil, so when the soil available phosphorus content is at a low level, the crop yield will be significantly increased with the increase of available phosphorus. When the soil available phosphorus level exceeds a certain level, the effect of continued application of phosphorus fertilizer on the increase of crop yield is not obvious. The poor activity of phosphorus applied to the soil results in very low efficiency of phosphorus nutrient for plants and less available phosphorus nutrient for crops to absorb and utilize. The mobility and availability of soil phosphorus depend not only on the availability of its reaction products with soil, but also on the phosphorus form. All kinds of available phosphorus compounds in soil are easily transformed into slow or ineffective states, and the phosphorus fixation of soil makes it difficult for crops to directly use phosphorus in soil. Phosphorus in soil will be released in a suitable soil environment and reused by crops. The conversion of phosphate in different soil types and the mineralization of organophosphates will increase the content of organophosphates in soil to a certain extent. Adsorbed phosphorus and water-soluble phosphorus change dynamically with the change of soil water content. Various forms of phosphorus compounds in soil carry out complex and changeable phosphorus cycles according to the properties of soil and environmental conditions. The fixation and release of soil phosphorus are affected by soil moisture, air, heat, microbial activity and decomposition of organic fertilizer, and are closely related to soil physical and chemical properties. Reasonable tillage methods and fertilization measures can optimize the physical and chemical properties of farmland soil, reduce the adsorption and fixation of soil phosphorus, increase the available phosphorus in soil, accelerate the transformation of phosphate in soil and mineralization of organic phosphorus to promote the release of soil mineral phosphorus, thus improving the availability and mobility of inorganic phosphorus in soil and increasing the supply of soil effective phosphorus. Promote the absorption and utilization of phosphorus by crops, improve the lack of phosphorus in soil, and achieve yield increase and efficiency.

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At present, the supply of phosphorus in farmland soil is generally insufficient in China. Increasing the amount of phosphorus fertilizer input in the process of farmland management is an effective means to improve the lack of phosphorus in soil in China. However, the low availability of soil phosphorus still limits the absorption and utilization of phosphorus by crops and the efficient utilization of phosphorus fertilizer, resulting in the low utilization efficiency of phosphorus fertilizer in crops in China. Although the soil total phosphorus content is high in some areas, the lack of available phosphorus content for plants will still lead to phosphorus deficiency, which also makes phosphorus become one of the important factors limiting crop yield. In addition, excessive fertilizer input will cause soil phosphorus enrichment, reduce the utilization rate of phosphate fertilizer, waste resources, increase costs, and cause environmental pollution. Therefore, rational application of phosphorus fertilizer and improving the effectiveness of soil phosphorus is an effective way to achieve grain yield increase and efficiency and efficient utilization of phosphorus fertilizer, which is conducive to agricultural production and sustainable development.

3. Effect of Straw Returning to Field on Soil Phosphorus Content and Availability

Straw returning is an important and widely used farmland soil management measure, which can regulate soil water and nutrients and soil microbial community, affect the physical and chemical properties of farmland soil, and promote the ecological health and sustainable development of farmland soil. On the one hand, crop straw contains a lot of nutrients, which can effectively supplement the phosphorus supply of soil ecosystem, provide phosphorus nutrients needed by the next crop to a certain extent, increase food yield and efficiency, promote the efficient recycling of agricultural resources, and alleviate the current shortage of soil phosphorus. Pan Shichun et al. showed that straw returning to the field supplemented soil phosphorus supply and significantly increased soil available phosphorus content. On the other hand, straw returning to the field can improve the physical and chemical properties of soil, increase the availability of soil phosphorus, and promote the absorption of phosphorus by crops. In addition, straw returning to the field is also an effective measure to increase soil organic matter content and improve soil structure. After the straw is returned to the field, the straw is crushed and buried in the soil during the cultivation process, which improves the soil permeability, increases the soil oxygen content, effectively inhibits the conversion of available phosphorus into fixed phosphorus and increases the available phosphorus content. Soil organic matter and available phosphorus are obviously enriched in the surface layer, and soil organic matter is one of the important factors affecting the adsorption and fixation ability of soil. The higher the content of organic matter, the weaker the adsorption and fixation effect of soil on phosphorus, and the higher the availability of phosphorus. The results showed that the addition of straw could significantly increase the accumulation of soil available phosphorus, promote the growth of plants and the absorption and accumulation of phosphorus, and the return of straw to the field had a certain activation of soil phosphorus.

Returning straw to the field can not only provide organic materials and nutrients for the soil, but also change the adverse effects of traditional farming on the soil. Straw returning to field can improve soil physical and chemical properties, improve soil water retention, reduce water loss and increase crop water use efficiency. The results showed that different tillage methods would accelerate the leaching loss of phosphorus to a certain extent, and straw returning to the field could effectively reduce the loss of nitrogen and phosphorus. Straw returning to field can not only effectively improve soil nutrient status, but also prevent soil phosphorus leaching loss, especially after no-tillage straw mulching. However, some studies show that soil tillage has no significant effect on soil leaching loss. In short, straw returning to the field is conducive to increasing soil available phosphorus content, enriching soil nutrients, and reducing the adverse effects of traditional soil tillage on phosphorus. Therefore, reasonable tillage measures combined with straw returning can optimize soil phosphorus supply and water voltage, and promote the efficient use of water and fertilizer.

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4. Effects of Organic Fertilizer Application on Soil Phosphorus Content and Availability

The insufficient supply of phosphorus fertilizer will affect the growth and development of plants, and crops will consume a lot of nutrients in the soil ecosystem during the growth process. The addition of chemical fertilizer is an important source of soil phosphorus. The effect of fertilization on soil phosphorus is mainly manifested in two aspects: one is to directly increase the content of soil available phosphorus through fertilization; Second, it can change the activity of phosphatase and accelerate the decomposition of organophosphorus in soil[6]. China has become the world's largest producer and consumer of chemical fertilizer. Long-term over-application of chemical fertilizer not only destroys the soil structure, but also pollutes the environment, which is not conducive to the sustainable utilization of resources and the sustainable development of agriculture. Excessive dependence on chemical fertilizers leads to increased phosphorus concentration in soil, which increases the risk of leaching loss and reduces the efficiency of phosphorus use. In order to improve the utilization efficiency of phosphate fertilizer, we should not only pay attention to the application of phosphate fertilizer chemical fertilizer, but also pay attention to the input of organic fertilizer.

It is very important to study the conversion and migration of phosphorus in soil by organic and inorganic phosphorus fertilizers to improve crop yield and guide efficient and balanced fertilization. Compared with the application of phosphorus fertilizer, organic fertilizer can increase the content of soil available phosphorus and promote the absorption and utilization of phosphorus by crops. The fixation and release of phosphorus in farmland soil are affected by the physical and chemical properties of soil, and the application of organic fertilizer will cause changes in the physical and chemical properties of soil to further affect the adsorption characteristics of soil phosphorus. The effect of organic fertilizer on soil available phosphorus is that, on the one hand, organic fertilizer itself contains a large amount of available phosphorus; on the other hand, organic matter mineralization and decomposition releases available phosphorus; at the same time, organic acids and other substances produced in the process of organic matter decomposition can prevent the precipitation of phosphorus and dissolve insoluble phosphorus in the soil. Organic acids and other substances produced in the process of organic fertilizer decomposition can form complexes with iron and aluminum, thereby reducing the adsorption and fixation of phosphorus in soil. Studies have shown that organic fertilizer can significantly activate the phosphorus in the soil itself and reduce the adsorption of phosphorus. In terms of soil nutrients, the available phosphorus content increases with the increase of the amount of organic fertilizer, and shows an increasing trend year by year. Song Xiao et al. proposed that increasing the application of organic fertilizer could significantly increase the content of available phosphorus in surface and subsoil. Zhang Li's research suggested that both subtillage and rotary tillage combined with organic fertilizer treatment increased the soil available phosphorus content to varying degrees, and the interaction effect between subtillage and farm fertilizer was more obvious. In addition, rotary tillage combined with organic fertilizer also promoted the uptake of phosphorus by plants. In agricultural production, improving the availability of water and the supply of organic fertilizer can improve the availability of soil root layer phosphorus to a certain extent, promote root growth, and thus improve the utilization efficiency of phosphorus. The phosphorus content of soil components changed significantly with long-term fertilization. Long-term use of organic fertilizer could significantly increase the content of total phosphorus and available phosphorus in soil, and multi-year application of organic fertilizer could significantly increase the content of organic phosphorus in soil. Active, medium-active and medium-stable organophosphorus increased significantly, and there was a significant positive correlation with available phosphorus.

In short, reasonable fertilization is conducive to improving the physical and chemical properties of soil, promoting the transformation of active phosphorus in soil, reducing the surplus amount of soil phosphorus, reducing the environmental pollution caused by the phosphorus rich state of soil caused by excessive fertilization, improving the availability of soil phosphorus, promoting the phosphorus absorption and utilization of crops, and improving the utilization efficiency of phosphorus fertilizer.

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In addition, the application of organic fertilizer can improve the effectiveness and utilization efficiency of phosphorus under different farming conditions. Therefore, more in-depth and systematic studies are needed on the distribution of organic fertilizer and the overall planning of farming methods.

5. Conclusion

Different straw returning to field have different effects on soil phosphorus availability. Reasonable tillage methods and straw returning to field combined with organic fertilizer are conducive to improving soil total phosphorus and available phosphorus content, and to a certain extent, improving soil phosphorus availability and utilization efficiency. Combined organic fertilizer can activate soil phosphorus and reduce phosphorus adsorption, thus improving soil phosphorus availability and utilization efficiency. It is conducive to the sustainable development of agriculture. Therefore, this experiment took the effects of different tillage methods, straw returning combined with organic fertilizer on soil phosphorus availability as an innovative entry point, and selected no-tillage, rotary tillage, subtillage, rotary tillage + subtillage and straw returning combined with fertilization to study the response mechanism of soil phosphorus availability, so as to coordinate different tillage methods and fertilization types to promote the utilization of soil phosphorus. Therefore, the use of farmland management technology to improve the availability of soil phosphorus and phosphorus fertilizer in agricultural production and improve the availability of soil phosphorus have practical significance for coordinating agricultural production, improving the utilization rate of phosphorus fertilizer and effectively utilizing phosphorus resources.

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