

Effects of Different Amount of Biochar on Nitrogen, Phosphorus and Potassium Nutrients in Soil

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Abstract. This paper takes the biochar application test at scientific research bases where a piece of an area for the test in Shenyang Agricultural University as the research object. Seven fertilization treatments are selected, combined with field experiments and indoor analysis methods to study the effects of biochar with nitrogen, phosphorus and potassium on soil nutrient and corn yield. The results showed that: application of biochar can significantly increase soil organic matter content, and increase with the content of biochar added; application of biochar can obviously increase the content of available N and rapid available P in the soil; under the conditions of this experiment, biochar with nitrogen and phosphorus potassium treatment can increase soil available potassium content. There were no significant effects that different amounts of biochar on soil total nitrogen, total phosphorus and total potassium.

1. Introduction

Biochar is a product with high carbon content formed by pyrolysis and carbonization of biomass under complete or partial anoxic conditions [1]. Biochar itself can be used for direct absorption of nutrients from crops, however, under some interactions in the soil, it will slowly release some nutrients into the soil, supplementing the source of soil nutrients for plant absorption and uses. Study has shown that the porous structure, large specific surface area, and charge density of biochar increase the ability to hold soil moisture and nutrients, delay the release of fertilizer nutrients, and reduce the loss of fertilizer and soil nutrients, which indirectly influences soil fertility [2-3]. It is believed that biochar with higher ph., larger surface area, more surface negative charge, and higher charge density has a greater ability to adsorb cations per unit carbon than other soil organic materials and that is also relative for small molecule gases and other ions. Strong adsorption capacity is conducive to keeping soil fertility, increasing soil field water capacity and cation exchange [4]. Study reported biochar can effectively reduce the ammonia volatilization in field soil and reduce ammonia volatilization, thereby improving the utilization of nitrogen in soil and it also effectively reduce the loss of soil farmland N, P and other nutrients, except for adsorption by keeping N element, biochar can also regulate nitrification and denitrification processes to reduce the loss of N, thereby reducing the amount of fertilizer applied [5]. Studies by Lehmann et al. [6] and Taghizadeh-Toosi et al. [7] and Ding et al. [8] showed that biochar



can reach the adsorption of NO_3^- and NH_4^+ by cation exchange, reducing the volatilization of soil ammonia, and thus make the element of available nitrogen increase in the soil, improving soil fertility. However, there are also studies [9] showed that high-yield farmland in North China continuous application of biochar for 3 years, the soil nitrogen content in the plow layer decreased, but there are not express significant differences. This may be related to the material, characteristics and soil type of biochar itself. Novak et al. [10] showed that after adding 2% biochar to the soil, the content of P and K in the soil after 67 days increased significantly. Fu et al. [11] showed that the physical and chemical properties of soils treated with bamboo charcoal particles were improved, and the contents of soil effective P, available K, exchangeable Ca and Mg were significantly increased. Glaser et al. [12] found that using biochar could reduce the content of active Al and increase the content of available P, K, Mg and Ca.

Different kinds of soil properties, crop types, climatic conditions, biochar materials, and preparation conditions affect the soil N, P, and K nutrients. Now biochar in agriculture applications is still in its infancy, about biochar research report on soil physical properties, chemical properties, biological properties, etc., are mostly based on theoretical researches. In this study, a field positioning experiment was conducted to study the effects of different amounts of biochar on N, P, and K nutrients in soils, and to explore the role of biochar in improving soil's fertility, thus offering theoretical and practical reference for the rational application of biochar.

2. Materials and Methods

2.1. Test Site Overview

The experiment was conducted in the scientific research bases of Shenyang Agricultural University. The area is situated at the center of southern Songliao Plain and belongs to the temperate humid-semi-humid monsoon climate. The annual rainfall is 574-684 mm, the annual evaporation is 1435.6 mm, the average temperature is 7.0-8.1°C, and the accumulated temperature above 10°C is 3300-3400°C, the frost-free period of 148 to 180 days, the whole growth period of 130 to 150 days. The area has little rainfall in spring and has abundant rainfall in June, July and August which is the peak season for crops growth. In the growing season, the average rainfall is 547 mm and the average temperature is 20.7 °C, which is suitable for crops growth. The soil is a simple moist leaching soil (cultivated brown soil) developed on the Quaternary loess parent material. The experiment was planted with corn.

A total of 7 fertilization treatments were conducted in this study, including CK, C1, C1NPK, C2, C2NPK, C3, and C3NPK, in which CK was not fertilized; and the amount of biochar treated by C1, C2, and C3 was 1500 kg/hm² and 3000 kg/hm² respectively; 6000 kg/hm² for bio-char; N 195 kg/hm² for N, P, K, P₂O₅ 90 kg/hm², and K₂O 75 kg/hm². Each treatment was repeated for 3 times, each treatment cell area was 27 m² (3.6 m×7.5 m), and each treatment was repeated for 3 times. Fertilizers to be tested: normal urea (N 46.3%), superphosphate (P₂O₅ 12%), potassium chloride (K₂O 59%). Biochar is made from corn straw as raw material. The tested corn variety was "Zhengdan 958".

2.2. Test Soil

The soil samples were taken from the tillage (0 to 20 cm) soil after the harvest in 2014, dried and sieved through 20 and 100 mesh sieve.

2.3. Measurement Items and Methods

(1) Determination of soil organic carbon and total nitrogen: elemental analyzer (Elemental III, Germany); (2) Total phosphorus in soil: Sodium hydroxide melting-molybdenum-barium colorimetric method; (3) Total potassium in soil: Sodium hydroxide melt-flame spectrophotometry; (4) Soil available N: 1.0 mol L⁻¹ NaOH alkali diffusion method; (5) Available phosphorus in soil: using 0.5 mol L⁻¹ NaHCO₃ molybdenum antimony anti-colorimetric method; (6) Soil available potassium: 1.0 mol L⁻¹ NH₄OAC-flame photometric method.

2.4. Data Processing and Analysis

The Microsoft Excel and SPSS 19.0 were used for data processing and statistical analysis.

3. Results and Analysis

3.1. Different amounts of biochar effects of NPK fertilizer on soil nitrogen

Nitrogen is an important part of organic compounds in crops and which is an indispensable element of all organisms. Most of the nitrogen in the soil is organically bound. Total nitrogen is usually used to measure the basic fertility of soil nitrogen, and the amount of available nitrogen in the soil is related to crop growth closely.

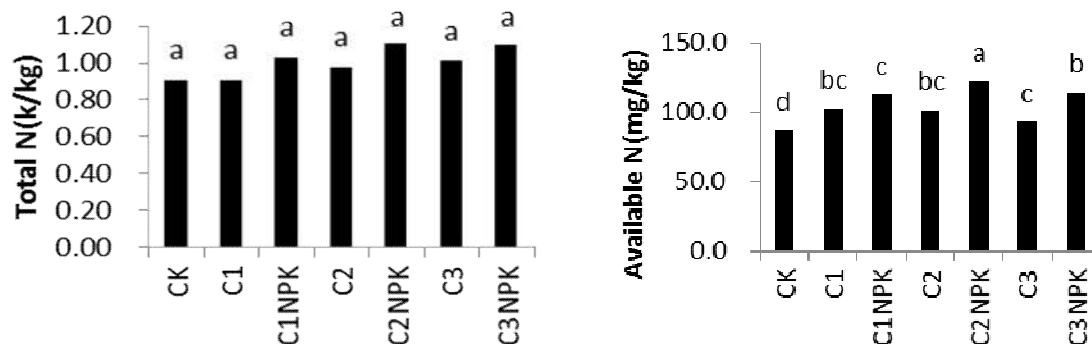


Figure 1. Effects of different treatments in soil total nitrogen and available nitrogen.

It can be seen from figure 1 that the content of total nitrogen in soil with different amounts of biochar with N, P and K is higher than that of single biochar treatment, but the differences are not significant. It also shows that there are no significant differences between fertilization and no fertilization.

Alkaline nitrogen is the available nitrogen that can be directly absorbed and used by plants. It can reflect the nitrogen supply status in recently and is the sum of ammonium nitrogen, nitrate nitrogen, amino acids, amides, and easily decomposable protein nitrogen [13].

As can be seen from Figure 1, the soil available nitrogen levels of different amounts of biochar treatment (including biochar treatment alone) are higher than those of the control treatment significantly, showing that the application of biochar can increase the content of available nitrogen in the soil, among all treatments the content of available nitrogen in C2NPK was the highest. There was no significant difference in the levels of available nitrogen between the individual biochar treatments (C1, C2, C3) and their corresponding biochar treatments. The possible reason was that biochar could increase the content of available nitrogen in the soil. On the other hand, combined with yield data analysis, crop yields were lower, and nutrients were fewer carried from the soil.

3.2. Different amounts biochar with NPK fertilizer effects on Soil phosphorus

The total phosphorus content of the soil refers to the sum of various forms of phosphorus in the soil. In the case of low total phosphorus, the supply of available phosphorus in the soil is often insufficient, but soil with higher total phosphorus content does not necessarily shows that it has enough available phosphorus to supply the needs of growing seasonal crops, due to most of the phosphorus is present as a poorly soluble compound in the soil.

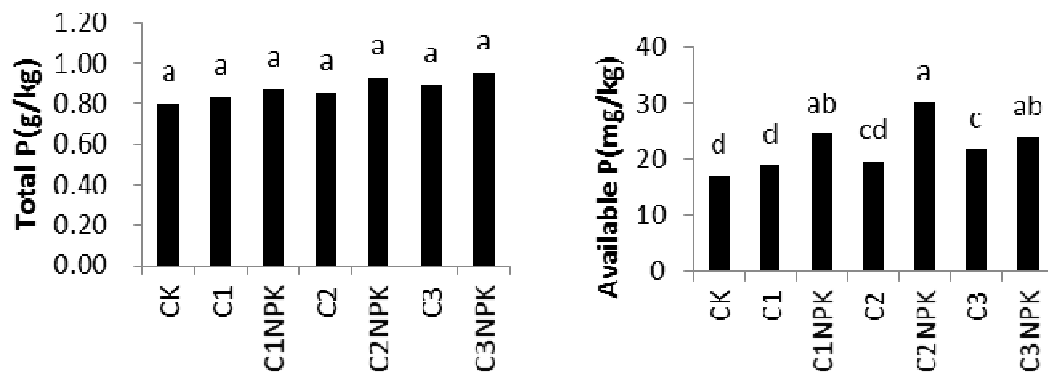


Figure 2. Effects of different treatments on soil total phosphorus and available phosphorus

From figure 2 could show that there is no significant difference between CK and each treatment. Compared with the single application of biochar treatment, the corresponding different amount of biochar with NPK treatment was higher, but the difference between treatments did not reach significance level.

It can be concluded that the available phosphorus content of different amounts of biochar with NPK is higher than that of the single biochar treatment, respectively are 81.8%, 81.5%, 94.3%, of which C2NPK own highest content of treatment. It showed that the application of biochar with NPK treatment could increase soil available P content.

Measuring the content of available phosphorus in soil is a kind of method to evaluate the ability of soil to supply phosphorus for the crop of the current season. It can offer a theoretical basis for the rational distribution and application of phosphate fertilizer. Common available phosphorus includes water soluble phosphorus, weak acid soluble phosphate, and colloid ally adsorbed phosphorus.

3.3. Different amounts of biochar effect of NPK fertilizer on soil potassium

The amount of total potassium in the soil is much higher than that of nitrogen and phosphorus, however, it does not mean the soil has enough potassium to supply plants. This is because most of the potassium minerals in the soil are in a state of insolubility. Therefore, although the stock is high, the plants may still lack of potassium.

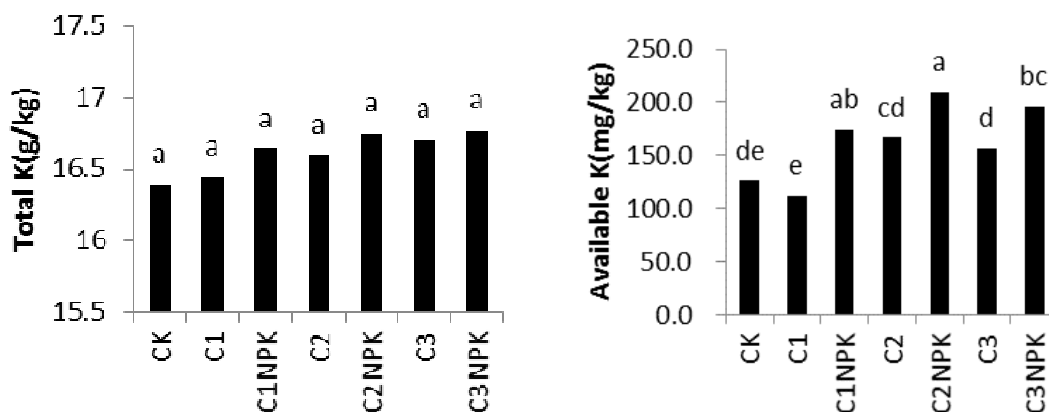


Figure 3. Effects of different treatments on soil total K and available K

It can be seen from figure 3 that different amounts of biochar with NPK treatment (C1NPK, C2NPK, C3NPK) are higher than their corresponding application of biochar treatment (C1, C2, C3),

but during treatment (including CK) did not show a significant difference; there was no significant difference in total potassium content between fertilized and non-fertilized treatments.

About 95% of the soil available potassium is exchangeable potassium, and water soluble potassium accounts for only a small part. Testing the content of available potassium in soil has great significance in deciding soil fertility, guiding rational fertilization and meeting nutrient requirements for crop yield. Figure 3 shows that analysis of variance of available potassium content in different treatments shows that the treatment with different amounts of biochar with NPK treatment (C1NPK, C2NPK, C3NPK) is significantly higher than the corresponding application of biochar treatment alone (C1, C2, and C3) were higher by 46.3%, 29.2%, and 10% respectively; while the differences in available K content between soils treated with biochar (C1, C2, and C3) and control (CK) were not significant, indicating that biochar needed combined application of nitrogen, phosphorus, potassium and nutrients so that could increase the content of available potassium in soil.

4. Conclusion

The application of biochar has a certain influence on the continuous brown soil nutrient of maize. The application of biochar significantly increased soil organic matter content and it increased with the increase of biochar content. In the study of total nitrogen, total phosphorus and total potassium, the treatments did not show significant differences; biochar application could improve soil available nitrogen and available phosphorus content significantly; under the conditions of this experiment, biochar combined with NPK treatment can increase available potassium content in the soil.

Acknowledgments

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