The research on the effect of different of straw instead of nitrogen fertilizer on soil fertilizer efficiency

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Abstract. To look for alternative fertilizer products, the application of wheat straw was explored in different forms instead of chemical fertilizer. The N, P, K, organic matter, humus, pH, germination rate in soil were determined to observe the effect on soil fertility. The results indicate that biochar had the best effect on soil fertility when straw was returned to the field in different forms; the effect of biochar on increasing the content of soil organic matter and humus was more obvious than the nitrogen fertilizer; biochar has little difference in total potassium; biochar has the most obvious effect on increasing the content of total nitrogen and available phosphorus. As a new type of fertilizer, biochar can replace chemical fertilizer which causes damage to soil environment. Biochar has the ability of fixing carbon and can slow down the greenhouse effect.

1. Introduction

In China, it is necessary to add some essential elements in the process of plant growth to increase the fertility of soil in the process of the development of agriculture and landscaping, which can increase the yield of cash crops and improve the growth conditions of plants. The long-term application of chemical fertilizer will lead to the change of soil physical and chemical properties, the loss of soil fertilizer efficiency, which is not conducive to the long-term development of soil. In China, the utilization rate of nitrogen fertilizer in the current season is only 30% - 50%. The loss of nitrogen will be discharged into the atmosphere in the form of NO₂. It can cause air pollution and other problems [1]. As a protective cultivation measure to reduce agricultural pollution, straw returning can improve soil structure and increase soil nutrients. It can also achieve the purpose of increasing crop yield and reducing the application of chemical fertilizer [2-4]. There are many ways of straw returning, such as burning, direct returning, composting and fermentation [5-7]. Incineration returning to the field will not only cause air pollution and aggravate haze, but also easily lead to air traffic accidents [8-9]. In recent years, the management of straw burning in the open air has been gradually strict. The incineration returning to the field has been basically controlled. Biochar refers to the carbon rich products obtained from biomass (such as wood, feces, leaves) under hypoxia and hypoxia environment [10]. It has the characteristics of high carbon content, porous structure, large specific surface area, large surface charge, high charge density and strong adsorption [11]. Compared with traditional fertilizers, biochar will not cause problems such as eutrophication [12]. According to the research, the application of biochar is conducive to the increase of available nutrients in the soil, such as realizing the circulation of phosphorus and other nutrient elements [13-14]. The application of biochar can increase the content of nitrogen, phosphorus and potassium in peanut; can adsorb heavy metal ions in
soil and improve soil organic matter [15]. As a new fertilizer, biochar has obvious effect on fixing carbon and slowing down greenhouse effect.

This paper studied the different ways of straw returning to the field. By analyzing the data, a new method to improve the effect of soil fertility was obtained. It can solve the problem of soil pollution caused by chemical fertilizer and make up for the defects of existing straw returning methods. It can not only increase the fertilizer efficiency of soil, but also improve the physical and chemical properties of soil. At the same time, it also solved the problem of disposal of a large number of waste straw, and improved the utilization rate of resources.

2. Experimental materials and methods

2.1. Experimental materials

The wheat straw was broken into 1700um; the soil was collected from the vegetable garden in Binhai New Area of Tianjin. The sampling depth is 10-20 cm. The soil original values are shown in Table 1.

| pH | Total humus content (%) | Total nitrogen contents (%) | Available phosphorus content (mg/kg) | Total potassium content (%) | Organic matter content (%) |
|----|-------------------------|-----------------------------|-------------------------------------|-----------------------------|---------------------------|
| 8.41 | 0.1079                  | 0.06                        | 12.21                               | 3.2573                      | 29.22                     |

2.2. Experimental scheme

The experiment was divided into 6 groups, there were 2-3 parallel experiments in each group. The control group was the first group, which was called group K. The crushed straw group was the second group, which was called group F. The incineration residue group was the third group, which was called group C. The biochar group was the fourth group, which was called group S. The urea group was the fifth group, which was called group N. The straw and urea group were the sixth group, which was called group NF. Before the experiment, the soil was crushed and air dried. The materials mass in each group is shown in Table 2.

| Group                  | Soil | Incineration residues | Biochar | Urea | Straw |
|------------------------|------|-----------------------|---------|------|-------|
| The first group / group K | 2kg  | 0                     | 0       | 0    | 0     |
| The second group / group F | 2kg  | 0                     | 0       | 0    | 30g   |
| The third group / group C | 2kg  | 30g                   | 0       | 0    | 0     |
| The fourth group / group S | 2kg  | 0                     | 30g     | 0    | 0     |
| The fifth group / group N | 2kg  | 0                     | 0       | 30g  | 0     |
| The sixth group / group NF | 2kg  | 0                     | 0.2g    | 15g  |       |

2.3. Testing methods and instruments

The test items and methods are as follows: humus was determined by NY/T-1867-2010 Determination of humus composition in soil; total nitrogen was determined by GB-7173-1987 Determination of total nitrogen in soil; available phosphorus was determined by NT/T 1121.7-2014 Molybdenum antimony anti chromogenic method; total potassium was determined by NYT 87-1988 Determination of total potassium in soil; organic matter was determined by GB-9834-1988 Determination.

3. Experimental data results and analysis

In this paper, the parallel experiment is selected. The number of samples in each group is 2-3. The average value of the measured data is used for analysis, so as to reduce the error and avoid contingency of the experiment.
3.1. Effect on total nitrogen in soil
The content of total nitrogen in soil is shown in Figure 1.

![Figure 1. The content of total nitrogen in soil.](image)

It can be seen from Figure 1 that the effect of S Group on the increase of total nitrogen content in soil is the most significant. Biochar has a strong adsorption capacity for ammonium and nitrate nitrogen in soil. The adsorption and fixation of NH$_4^+$ in soil are enhanced obviously. The loss of nitrogen from mineralization of fertilizer nitrogen in soil decreased, and the retention of nitrogen increased. The content of total nitrogen shows group S > group N = group NF > group F > group C > group K. Compared with Group K, other groups have played a certain role in promoting the content of total nitrogen in soil; compared with group C, the promotion of total nitrogen in soil by group N is more obvious. Compared with group F and group N, the two groups had a promoting effect on total nitrogen in soil. But the combined application of NF did not get the double effect, indicating that nitrogen fertilizer and crushed straw in increasing the content of total nitrogen in soil were not synergistic.

3.2. Effect on soil organic matter
Organic matter in soil mainly comes from life groups and organic fertilizers in soil, which plays an important role in plant growth. Soil readily oxidizable carbon mainly comes from crop roots and activation of soil organic carbon. The addition of exogenous organic materials to the field can increase the source of organic matter and have a significant impact on soil readily oxidized carbon. The increase of organic matter content can improve the nutrient elements and structural characteristics of soil, and increase the activity of soil microorganisms. The content of Organic Matter in Soil is shown in Figure 2.

![Figure 2. Content of organic matter in soil.](image)

According to the analysis of organic matter content in Fig. 2, it can be seen that the increasing effect of organic matter in soil is group S > group C > group F > group NF > group K > group N. In addition to group N, the effect of other groups on the increase of soil organic matter is obvious, especially in
group S, group N did not promote the content of organic matter in soil, but inhibited it. Compared with group F, group n and group NF, it is concluded that the crushed straw, not nitrogen fertilizer, plays an important role in promoting the content of organic matter in soil.

3.3. Effect on Humus in soil
Straw returning increased the content of aromatic and carboxyl compounds, but decreased the content of polysaccharides. It can enhance soil humus activity. Humus content in soil is shown in Figure 3.

![Figure 3. Humus content in soil](image)

It can be seen from Figure 3, compared with other groups, the content of humus in soil of group NF increased significantly, and other groups had little effect on Humus in soil; group N had stable and controllable effect on Humus in soil; Group F had great difference in change of humus content in soil, but there was little difference between group S and group C in increasing humus content. However, group F and NF increased the humus content in soil obviously, which indicated that crushed straw promoted the humus content in soil. Straw returning combined with nitrogen fertilizer could increase soil organic carbon content and soil fertility.

3.4. Effect on available phosphorus in soil
Straw returning can increase the content of soil available phosphorus mainly by promoting the transformation of other forms of phosphorus into available phosphorus, which can provide direct absorption and utilization of phosphorus source for the next crop. Straw returning increased the content of stable organic phosphorus and decreased the content of medium active organic phosphorus. Available phosphorus content in soil is shown in Figure 4.

![Figure 4. Available phosphorus content in soil](image)

It can be seen that except for group F, the available phosphorus in soil is increased. Compared with group K, group C and group S promote the accumulation of available phosphorus in soil; the effect of group N is not obvious. The release rate of phosphorus in group C was better than that in other groups.
3.5. Effect on total potassium in soil
Due to the interception of straw, straw returning can reduce the amount of potassium carried by runoff and leaching water, which can increase soil water and fertilizer retention. The contents of water-soluble potassium, exchangeable potassium and total potassium in soil layer increased. The total potassium content in soil is shown in Figure 5.

![Figure 5. Total potassium content in soil](image)

It can be seen that the effect of all groups on the total potassium content in the soil is improved; the effect of group F on the increase of total potassium is the most obvious, and group C is better than that of group S. The results showed that incineration residue was better than biochar in fertilizer efficiency. The comparison of group N, group F and group NF showed that crushed straw and nitrogen fertilizer had a synergistic effect on the increase of total potassium.

4. Conclusion
Different forms of straw returning to the field could promote the accumulation of organic matter and humus in soil; biochar had an obvious effect on increasing the content of organic matter and humus in soil, while nitrogen fertilizer had an inhibitory effect on organic matter in soil; biochar had a significant effect on increasing the content of total nitrogen, but had little difference in pH and total potassium; biochar has an obvious effect on the increase of available phosphorus. Comprehensive evaluation of different forms of straw returning to the field, the effect of biochar on soil fertility showed obvious advantages.
Straw returning can greatly reduce the amount of nitrogen, phosphorus and potassium fertilizer, and can effectively realize the recycling of organic waste. It can save energy and reduce environmental pollution. Considering the benefits of production, economy and ecological environment, it is suggested that the incorporation of straw biochar with reduced chemical fertilizer should be adopted in the planting area of north China.

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