Effects of returning materials on the electrical conductivity of reclaimed soil and crop yield

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Abstract. In order to explore the maturation effects of different returning materials in the soil reclamation of abandoned homesteads, this paper studied the characteristics of the soil conductivity profile distribution after adding fly ash, organic fertilizer and curing agent three kinds of returning materials, and the three consecutive years of crops yield. The results showed after three consecutive seasons, the soil conductivity of the cultivated layer decreased by applying organic fertilizer treatment, and the deep soil conductivity increased, which can reduce the possibility of secondary salinization. Crop yields of different returning materials are different. Compared with the other two returning materials, the application of organic fertilizer can better mature the abandoned homesteads and reclaim the soil, and promote the growth of winter wheat and summer corn.

1. Introduction

With the development of economy and society, more and more abandoned homesteads appear in rural areas, which waste land resources and hinder the sustainable development of rural areas [1]. Reclamation of abandoned rural housing sites through land reclamation has become one of the ways to increase the amount of cultivated land [2]. However, in the process of engineering reclamation, stripping of the topsoil or digging collapse and filling makes the cultivated layer soil bare, low soil nutrient content, poor water and fertilizer retention performance [3], adding returning materials to the reclaimed soil can quickly improve soil properties. Adding curing agent can improve soil structure and soil moisture environment, and increase crop yield [4], adding fly ash can reduce soil capacity and increase porosity, and applying appropriate amount of fly ash can improve clay, sand, etc.; The application of organic fertilizer can maintain the balance of trace elements in the soil, promote the reproduction of microorganisms, and maintain and improve soil fertility. Added improvers and organic fertilizers to the soil fertility in Hollow Village, soil nutrients increase rapidly after three crops of corn-wheat-corn are
planted [2]. The balanced application of organic fertilizers, amendments and inorganic fertilizers has a greater effect on the rapid maturation of new farmland good results.

Since the conductivity of the soil solution can reflect the actual status of soil salt and nutrients under certain water conditions, the amount of soil cation exchange, organic matter and soil conductivity have a significant correlation [5], which includes soil salt and ion composition, moisture content, etc. At the same time, electrical conductivity is used as an evaluation index of soil production potential, which can be used to evaluate crop yield and provide variable prescription management, and the measurement of soil solution conductivity is simple and fast, and the data is highly comparable [6]. Therefore, in order to further determine reasonable rapid soil maturation measures and improve the quality of farmland production after the reclaiming of abandoned homesteads, this paper studies the addition of different materials to the reclaimed soil of abandoned homesteads, and analyzes the distribution characteristics of soil electrical conductivity after the materials are returned to the field, in order to provide a scientific reference for the efficient restoration of abandoned homesteads.

2. Materials and methods

2.1. Study Area

The test is located in the pilot plant of Chuyuan Village, Ducun Town, Fuping County, Weinan City, Shaanxi Province. The area has a warm temperate semi-humid climate, with an average annual rainfall of 472.97 mm. The rainfall from July to September accounts for 49% of the annual rainfall. The annual evaporation is 1000-1300 mm and the annual total light energy radiation is 518.6 - 535.0 KJ/cm², the frost-free period is 225 days, the annual average temperature is 13.40°C, the lowest temperature in winter is -22°C, and the highest temperature in summer is 41.80°C.

2.2. Test Design

The experiment started in June 2015. In order to simulate the actual land situation of the reclaimed land of abandoned homesteads in the project implementation area, the test plot was filled with raw soil thickness of 30 cm on the basis of 30 cm of in-situ test soil excavation, and the raw soil bulk density was 1.5-1.6 g/cm³. After the raw soil is backfilled returning materials are evenly sprayed on the ground surface and mixed evenly by hand. Raw soil used in the experiment came from the demolition of old soil from abandoned homesteads in Yuzihe Village, Chengcheng County.

The materials used in the experiment were organic fertilizer, curing agent and fly ash. There were 3 groups of experiments. Each group was repeated three times. The experimental design is shown in Table 1.

| Serial number | Treatment     | Application amount |
|---------------|---------------|--------------------|
| 1             | Curing agent  | TS 600 kg·hm⁻²     |
| 2             | Organic fertilizer | TF 22.5 m³·hm⁻² |
| 3             | Coal ash      | TC 300 m³·hm⁻²     |
| 4             | No addition   | T0 /               |

2.3. Sample Collection

The soil samples were collected four times, and the sampling time was the idle period after the winter wheat harvest and before the summer corn planting. Soil samples of 0-105 cm soil layer were collected by the soil drilling method. One sample was collected every 15 cm. The soil samples were air-dried and ground and passed through a 1 mm sieve. The conductivity of the samples was measured by a Mettler S230 conductivity meter.
2.4. Data Analysis
Use Microsoft Excel to descriptively analyze the conductivity data, draw the profile scatter plot, and use Sigmaplot to draw the output box plot.

3. Results and analysis

3.1. Soil conductivity profile distribution of different returning materials
With the increase of planting years, the profile distribution of soil electrical conductivity showed distinctive characteristics. The profile distribution of soil electrical conductivity under different treatments of returning materials is shown in Figure 1.

![Soil conductivity profile distribution of different returning materials](image)

**Figure 1.** Soil conductivity profile distribution of different returning materials

It can be seen from the figure that in the first year of planting, the soil conductivity of the 0~45 cm soil layer of different treatments gradually decreased, and the conductivity values of different treatments were very different. The surface soil conductivity showed TC>TF>TS>T0. The soil conductivity of 30~45 cm soil layer is TC>TF>T0>TS. The soil electrical conductivity of the 60-105 cm soil layer in different treatments has little difference, with an average value of 208 µs/cm. This is because 0~45 cm is the soil cultivation layer. After the raw soil is back filled and returned to the field, the cultivation layer is rich in nutrients. Under the action of crop absorption and irrigation precipitation, soil salinity migrates
downwards, and the electrical conductivity gradually decreases. The soil is undisturbed in-situ soil, so the conductivity is relatively small.

In the second year of planting, the soil conductivity first increased and then decreased. The conductivity of the 0-45 cm soil layer gradually increased, with a peak at the depth of 45 cm soil layer, and the conductivity was basically the same between different treatments. Compared with 2015, the soil electrical conductivity of the 0-30 cm soil layer has greatly decreased, which may be related to the nutrient absorption of the crop during the growth season. The soil electrical conductivity of the soil layer below 60 cm has a small increase in TC, TS and TF treatments, indicating that soil salt has a tendency to migrate to the depth of the soil layer. In the second year of planting, the electrical conductivity of the surface soil is TC>TS>T0>TF, and the electrical conductivity of the 30 cm soil layer is TC>TS>TF>T0, indicating that the application of organic fertilizer can reduce the electrical conductivity of the surface soil and reduce the salt Risk.

In the third year of planting, the distribution of soil electrical conductivity along the depth of the soil layer showed an "S" shape. The electrical conductivity of the soil layer of 15~30 cm decreased, the lowest value of electrical conductivity appeared at the depth of 30 cm, and the electrical conductivity of soil layer of 30~45 cm increased. The highest peak is formed at a depth of 45 cm, and it gradually decreases below the 45 cm soil layer. Compared with 2016, the conductivity distribution map in 2017 has a significant increase in the peak value of the conductivity distribution map in 2017. Except for T0, the average conductivity peak value of the treatment of returning to the field increased by 36%. During the three-year planning period, the soil conductivity of T0 treatment did not change much along the depth of the soil layer.

3.2. Yield of wheat of different returning materials
In this study, the use of different return-to-field materials improved crop yields to varying degrees.

After three consecutive years of planting, the highest yields of wheat and corn were treated with organic fertilizer. The output of winter wheat in 2016 was TF>TS>TC>T0. The output of winter wheat in 2017 was higher than that in 2016, and the yield of different treatment materials was TF>TC>TS>T0, which shows that the application of organic fertilizer is better than the other two. Materials returned to the field have obvious effects on increasing the yield of winter wheat.

The summer corn in 2015 was TF>TC>TS>T0. The summer corn in 2016 was TF>TS>TC>T0 was slightly lower than that in 2015. This may be attributed to the fertilizer efficiency in the first year of organic fertilizer application. Obviously, with the passage of time, the improvement effect of fly ash and curing agent gradually appears, but the application of organic fertilizer gets the best curing effect on raw soil and the highest yield.
4. Conclusion
(1) After three consecutive seasons of planting, the water retention of the cultivated soil in the treatment of organic fertilizer is improved compared with the other two treatments, the electrical conductivity decreases more, and the electrical conductivity of deep soil increases, which can reduce the risk of secondary salinization.

(2) Crop yields of different returning materials are different. Compared with the other two returning materials, the application of organic fertilizer can better mature the waste homesteads and reclaim the soil, and promote the growth of winter wheat and corn.

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