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EFFECTS OF ENVIRONMENT FRIENDLY SOIL REMEDIATION MATERIALS ON SOIL QUALITY AND MAIZE PRODUCTION

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Abstract

In the present, the reclaimed raw soil of newly renovated abandoned homestead was considered as the research object, and studied the effects of different environmentally friendly soil remediation material combinations on the quality of reclaimed raw soil and maize crop production. A total of 6 improved material treatments were set up, including decomposed chicken manure (YJ), fly ash (FMH), ferrous sulfate curing agent (SHJ), ferrous sulfate curing agent + organic fertilizer (SYJ), fly ash + decomposed chicken manure (FYJ), and control treatment (CK). The research results showed that, the organic carbon content and water storage of new reclaimed raw soil exhibited a significant increasing trend after the application of different environmentally friendly modified materials ($P < 0.05$). Among them, the organic carbon and water storage of reclaimed soil under FYJ improved, which increased by 132.3 and 14.4%, respectively compared with CK. During the growth period of summer maize, the plant height and yield exhibited a trend of FYJ > SYJ > YJ > FMH > SHJ > CK. The yield of maize under SYJ and FYJ treatments increased by 38.8 and 53.4 %, respectively, compared with CK. The appropriate combination of environmental friendly soil remediation materials is helpful to improve the quality of new reclaimed raw soil, promote soil carbon sequestration, increase the comprehensive utilization rate of waste resources, increase the production performance of crops, and help rural revitalization and beautiful rural construction.

Introduction

China is a country with a large output of livestock and poultry manure and other waste resources. Wastes are excellent soil improvement materials. Promoting the efficient utilization of waste resources can not only improve the ecological environment, but also promote carbon sequestration and fertilization to improve the soil, improve land productivity and grain yield, and is one of the important ways for the healthy and sustainable development of agriculture (Chen *et al.* 2001, Zhang *et al.* 2012). The new reclaimed raw soil of the abandoned homestead mainly comes from the unripe raw soil after the demolition of the rammed earth wall, which has lost the excellent property of the cultivated soil itself to supply and preserve water and fertilizer, and has problems such as poor physical structure and lack of soil nutrients (Liang *et al.* 2012, Lei *et al.* 2019). The combination of suitable environmentally friendly soil improvement materials is a key agricultural management measure affecting soil properties and crop growth. The application of soil improvement materials can not only increase the level of soil nutrients and fertility, but also

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reduce some pollution risks caused by the irrational use of the improved materials, which is of great significance for improving agricultural production conditions, promoting the utilization of rural waste resources and the coordinated development of urban and rural areas (Zheljazkov and Warman 2004, Fonte *et al.* 2009).

At present, the selection of different environment-friendly materials and how to improve the processed soil quality and grain yield of abandoned homestead reclamation have been one of the hot issues in the reclamation and utilization of abandoned homestead reclamation in Loess highland (Liu *et al.* 2022). Therefore, this study selected soil improvement materials of organic fertilizer (decomposed chicken manure), fly ash and ferrous sulfate curing agent, and compared and analyzed the effects of single or combined application of different environment-friendly soil improvement materials on soil quality and grain production performance of abandoned homestead reclamation in hollow village. The effect of different environment-friendly soil remediation agents on the maturing and fertilizing of abandoned homestead reclamation soil and the improvement effect on crop growth were discussed. In order to improve the structural properties and water storage and fertilizer supply characteristics of homestead reclamation soil in hollow village, improve the productivity of reclaimed land, and promote the increase of new reclaimed raw soil productivity and human settlement environment in the hollow village were also considered.

Materials and Methods

In order to carry out the new reclaimed raw soil ripening improvement test and reduce the obstacles of reclamation soil, the abandoned house land reclamation soil restoration test plot was set in Chuyuan village, Fuping County, Weinan City, Shaanxi Province (34º42′N, 190º12′E). The experimental plot was set on the background of the hollow village land renovation project, simulating the reclamation and improvement of the abandoned house site in the hollow village. After the soil layer of 30 cm on the surface was peeled off, the old wall soil of the house site with a thickness of 30 cm was backfilled, and the environment-friendly soil improvement materials were mainly applied and mixed in the 0-30 cm soil layer.

In this study, fly ash, organic fertilizer (chicken manure) and amendment (ferrous sulfate $FeSO_4$) were used as environmentally friendly soil improvement materials. Experiments of improved material combinations with different proportions were carried out, and 6 kinds of improved material combinations were designed (Table 1), and 3 replicates were set separately. These environment-friendly improvement materials were used to improve the reclaimed soil of hollow village, and the effects of different combination treatment of improved materials on soil organic matter, soil water storage and crop production performance of abandoned homestead reclamation were analyzed, in order to screen out the recommended combination treatment of improved materials suitable for improving soil quality and grain yield in loess tableland.

In the present experiment, after the summer maize harvest in early October 2020, 5~6 sampling points were selected according to the test treatment sampling plum point method, and 0~30 cm soil samples were collected in stratified layers, and about 1 kg soil samples were retained according to the quarter method after being mixed evenly. Soil organic carbon (SOC) was detected by classical methods in soil science (Stanislaw *et al.* 1973). The soil water storage was calculated by using time domain reflectometer (TDR) to measure the soil of every 15 cm thickness of the reclaimed soil layer. In reclaimed soil restoration area, 5 representative maize plants with consistent growth were selected for each treatment test plot, and the height of corn plants was measured regularly according to the growth cycle, once every 15 days on average. The plant height and yield were measured by random sampling method.

Table 1. Combined treatment and application amount of environmentally friendly restoration materials.

Number	Treatment	Environment-friendly soil improvement materials	Application amount (t/ha)
1	CK	Control (no improvement materials)	0
2	SHJ	Maturing agent (ferrous sulfate)	0.6 g/ha
3	FMH	Fly ash	45
4	YJ	Organic fertilizer (chicken manure)	30
5	SYJ	Maturing agent + Organic fertilizer	(0.6 + 30)
6	FYJ	Fly ash + Organic fertilizer	(45+30)

Results and Discussion

During the crop growth and development period, the application of six reclaimed soil improvement materials significantly increased the soil water storage in the 0-105 cm soil layer (Fig. 1). Among the 6 improved material treatments, FYJ treatment has the most obvious effect on the increment of soil water storage. On the 65th day of summer maize growth cycle, compared with CK, FYJ treatment with different restoration materials had the hight increase in reclaimed soil water storage. SHJ, FMH, YJ, SYJ, and FYJ treatments increased the soil water storage by 5.64, 8.11, 10.60, 11.21 and 14.14% compared with CK treatment, respectively. In the later stage of maize growth and development, soil water storage under the treatment of SHJ, FMH, YJ, SYJ and FYJ increased by 4.67, 6.82, 7.24, 8.92 and 11.10%, respectively, compared with CK. Soil water storage under the treatment of different improved materials gradually decreased compared with the water storage in the early stage of maize growth, and the increase rate was also relatively small compared with CK.

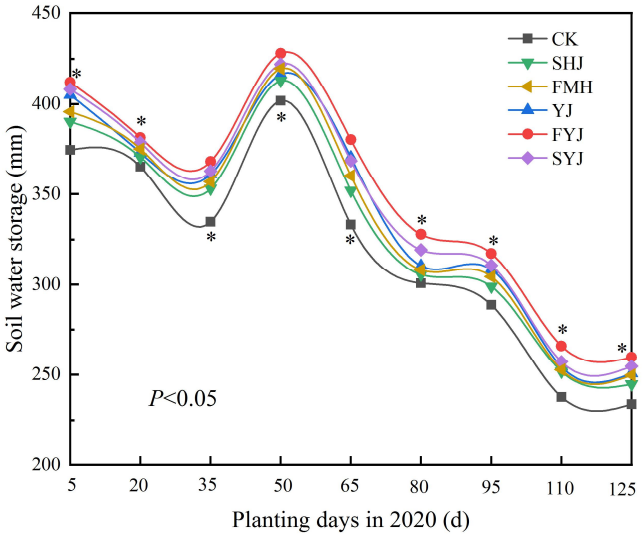

Fig. 1. Changes of water storage during the growth cycle of summer maize after modified material repair. Asterisks indicate the significance of the difference between soil representative indexes under the application of different environmentally friendly soil remediation materials (P < 0.05).

The order of the reclaimed soil water storage under the treatment of different remediation materials was FYJ > SYJ > YJ > FMH > SHJ > CK. The effect of organic modified materials on soil water storage was better than that of inorganic modified materials, and the effect of the combination of organic and inorganic modified materials was better than that of single application of modified materials, and the effect of FYJ and SYJ treatment of organic and inorganic combination was better than CK. Soil moisture is one of the most active factors of soil productivity, and the change of soil reclamation water storage after the restoration of the abandoned homestead will directly affect the cultivated land productivity and crop growth. Which corroborates with the related report by Singh *et al.* (2011), who studied that the combined application of fly ash and organic remediation materials had more advantages in improving soil water absorption and water storage performance.

SOC content is an important index to characterize soil productivity and other nutrient supply. With the application of different environment-friendly remediation materials, the SOC content of reclaimed soil exhibited a significant increase trend ($P < 0.05$). Among them, compared with CK, the SOC content of reclaimed soil under YJ, FMH, SHJ, FYJ and SYJ treatment increased by 91.2, 84.7, 11.8, 132.3 and 120.2%, respectively (Fig. 2). Organic fertilizer, fly ash and other environmentally friendly soil restoration materials applied individually or in combination can significantly improve the SOC content and nitrogen, phosphorus and potassium content of reclaimed soil. After more than 5 years of application of restoration materials and crop planting experiments, it was found that the organic and inorganic coupling in FYJ and SYJ had a significant effect on the SOC content of reclaimed soil. The results of this study are consistent with those of Wei *et al* (2016), who pointed out that the combination of organic and inorganic restoration materials treatment is more conducive to the improvement of soil nutrients and crop production performance.

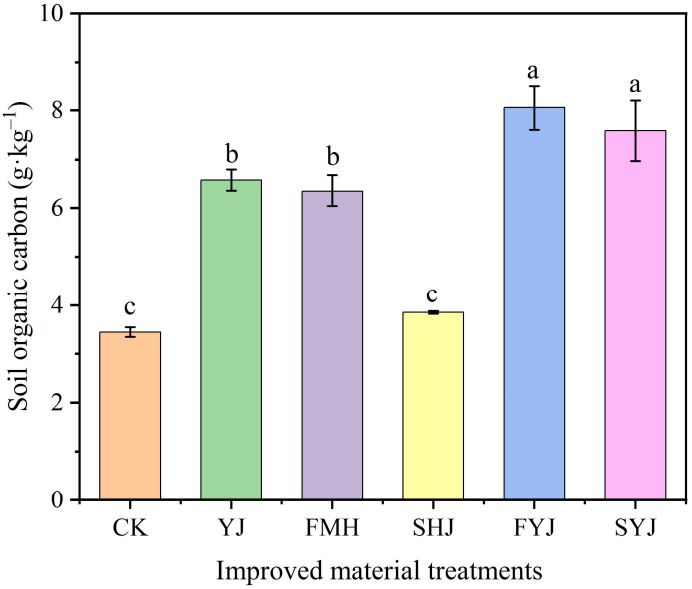

Fig. 2. Changes of reclaimed soil organic carbon under the treatment of different environmentally friendly soil improvement materials. Different lowercase letters indicate the significance of the difference between soil representative indexes under the application of different environmentally friendly soil remediation materials ($P < 0.05$), the same below.

Compared with the control treatment, the plant height of summer maize at all stages under different improved materials showed a significantly increased trend (Fig. 3). The plant height as a whole showed the order of FYJ > SYJ > YJ > FMH > SHJ > CK. The height value of summer maize plant under FYJ treatment was the highest, and the seven growth periods of corn under FYJ treatment were increased by 54.51, 35.34, 21.52, 45.83, 21.14, 15.38, and 13.82%, respectively, compared with CK. The monitoring results of summer maize plant height were basically consistent with the increasing trend of SOC content of reclaimed soil and soil water storage data.

On the basis of improving the physical properties of reclaimed soil and the level of fertility water in abandoned homestead, the application of different environment-friendly remediation materials promoted the water absorption and growth of summer maize roots. The plant height of summer maize at each stage showed a significant increase trend under the application of environment-friendly remediation materials. Among them, the combination of organic and inorganic modified materials in FYJ treatment had the highest summer maize plant height value.

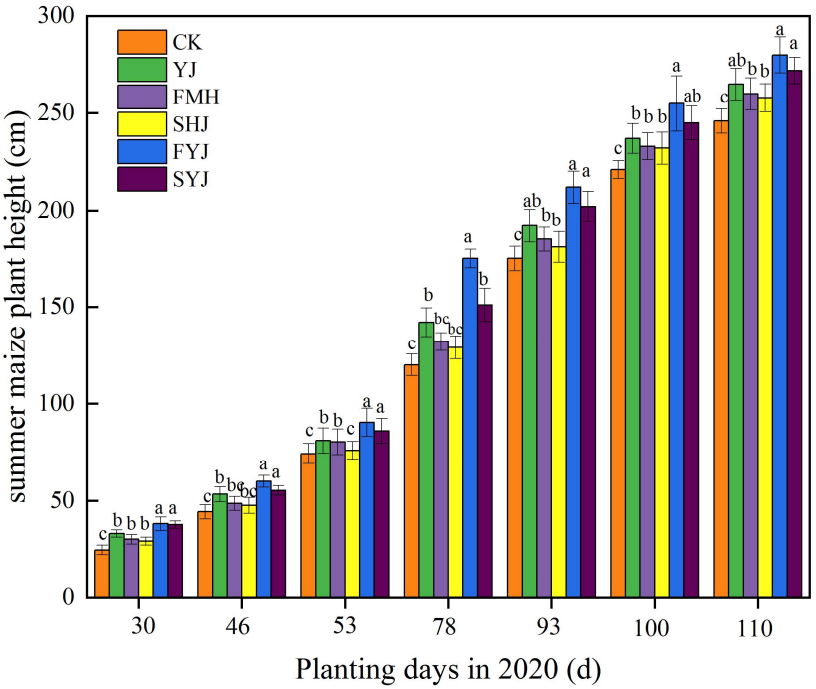

Fig. 3. Effects of different environment friendly soil improvement materials incorporation on summer maize plant height.

There was a significant difference in yield under improved material repair, and the overall trend of yield under five different combinations of improved materials was FYJ > SYJ > YJ > FMH > SHJ > CK (Fig. 4). Compared with CK, different environmentally friendly remediation materials significantly increased the yield ($P < 0.05$). The yield under SHJ, FMH, YJ, SYJ and FYJ treatments was increased by 10.1, 18.2, 34.1, 38.8 and 53.4%, respectively, compared with control treatments. Fly ash + decomposed chicken manure (FYJ) and SYJ treated with organic and inorganic combination had higher corn yield, and the yield exceeded 10451.27 kg ha^{-1}.

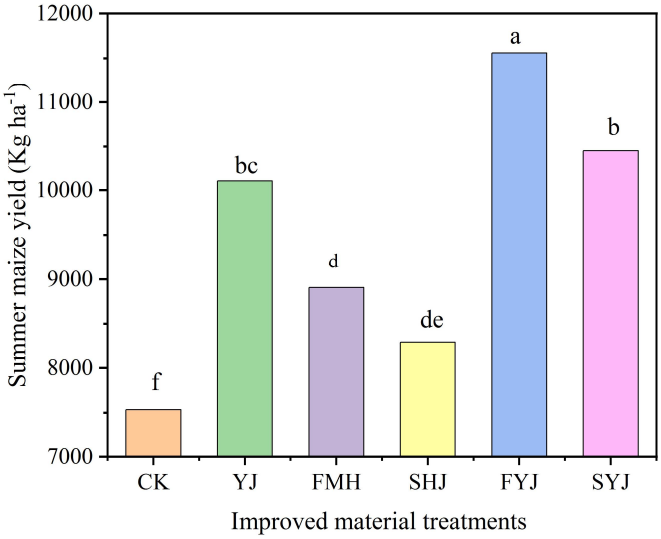

Fig. 4. Effects of different environment friendly soil improvement materials incorporation on summer maize yield.

In conclusion, the combination of SYJ and FYJ environmentally friendly improved materials had the best effect on improving the yield of summer maize in reclaimed soil. The reasonable explanation for these improvement effects is that the combination of organic and inorganic remediation materials can effectively increase the nutrient content of SOC and total nitrogen, promote the agglomeration and stability of excellent structures, increase the water storage capacity of reclaimed soil, and enhance the storage and supply capacity of water and fertilizer in reclaimed soil of hollow village, and finally promote the improvement of the growth index and yield. The soil fertility level and comprehensive productivity of the abandoned homestead reclamation soil were improved.

After 5 years of application of environmentally friendly soil improvement materials, the organic carbon content and water storage of new reclaimed raw soil exhibited a significant increase trend ($P < 0.05$). The SOC and water storage under FYJ treatment increased by 132.3 and 14.4%, respectively, compared with CK. On the basis of improving the water and fertilizer retention ability of reclaimed soil, the improved materials promoted the improvement of production performance, height and yield of summer maize, which increased significantly. The maize yield under SYJ and FYJ treatment was 38.8 and 53.4% higher than that under CK (control), respectively. Decomposed chicken manure + fly ash is an environmentally friendly combination of soil improvement materials suitable for reclaimed soil quality and high crop yield, which can effectively promote regional food security and high-quality development of rural revitalization.

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