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Application of Soil Organic Reconstruction Technology in Sandy Land Improvement

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Abstract: Improving sandy soil by soil organic reconstruction technology can effectively reduce soil permeability and increase soil nutrient content. The results show that the artificial plough bottom layer of 1.7 g·cm-3and 5 cm thick and the tillage layer of 1.2 g·cm^{-3} and 25 cm thick can be constructed on sandy soil with loess as raw material, and the water infiltration rate is reduced to 12 cm·d^{-1}, which is 89% lower than that of sandy soil. After reconstruction, the contents of organic matter, total nitrogen, available phosphorus and available potassium were all abundant, which increased by 1.06 times, 2.07 times, 8.54 times and 1.23 times compared with sandy soil, respectively.

Keywords: Reconstruction; Infiltration Rate; Loess; Nutrient.

1. Introduction

China's arable land resources are insufficient, and the per capita arable land area is less than 0.1 hm^2, which is less than 1/2 of the world's per capita level [1], which is the current situation of China's arable land resources. With the implementation of policies such as returning farmland to forest, industrialization and urbanization process accelerated, cultivated land resources further shrunk, and the reduction rate of cultivated land resources reached 60×10^4 hm^2 per year. According to statistics, from 1998 to 2008, the reduction of grain production due to the reduction of cultivated land area was 2998.5t, although with the vigorous implementation of the policy of promoting grain production, China's grain output has rebounded since 2004, but the per capita grain output is still lower than in 1998 [2]. The quality of cultivated land resources in China is generally not high, and medium and low-yield fields account for 2/3 of the total area, and with the input of chemical fertilizers and pesticides, it has caused a series of problems such as soil compaction, nutrient imbalance, and decline in aggregate stability, and the quality of cultivated land has been further reduced. Therefore, how to effectively protect existing cultivated land resources, develop and supplement new cultivated land resources, and improve the quality of cultivated land is an important issue facing China. With the further adjustment of the national policy and the implementation of the subsidy balance policy, the reduction of cultivated land resources has been effectively suppressed, and the development of the land consolidation industry has been promoted. As a new technology in the land consolidation industry, soil organic reconstruction technology is of great significance to supplement new cultivated land and high-quality cultivated land.

2. Research Methods

2.1. Test Materials

The experimental loess was collected from 6 loess plateaus near the testing site, with a linear distance of<5 km. After collection, it was mixed well for use. The sandy soil used in the experiment is the original soil of the experimental area, which is formed by years of sedimentation of the Yellow River sediment. The experimental fertilizers used were sheep manure (N: 0.90%, P: 0.52%, K: 2.73%), urea (N: 46%), diammonium phosphate (N: 16%, P_2O_5:46%), and potassium sulfate (K_2O: 51%).

Table 1. Basic physical and chemical properties of loess and sandy soil

Index	loess	sandy soil
Texture	Silty loam soil	Sandy loam soil
Unit weight (g·cm^{-3})	1.2	1.5
Saturated hydraulic conductivity (cm·d^{-1})	83.0	109.2
pH	8.02	7.82
Conductivity（dS·m^{-1})	0.23	0.16
Organic matter (g·kg^{-1})	21.28	18.30
Total nitrogen (g·kg^{-1})	0.72	0.72
Effective phosphorus (mg·kg^{-1})	3.39	4.14
Available potassium(mg·kg^{-1})	68.56	70.00

2.2. Experimental Design

The experiment used soil organic reconstruction technology to reconstruct the soil. The original sandy soil in the experimental area was used as the bottom soil layer, and a 5 cm thick artificial plow bottom layer with different bulk densities (1.2 g·cm^{-3}, 1.3 g·cm^{-3}, 1.4 g·cm^{-3}, 1.5 g·cm^{-3}, 1.6 g·cm^{-3}, 1.7 g·cm^{-3}, 1.8 g·cm^{-3}) of loess was constructed on it, and then 25 cm of loess (bulk density 1.2 g·cm^{-3}) was covered as the cultivation layer. Using sheep manure, urea, diammonium phosphate, and potassium sulfate as raw materials, with nutrient content reaching a rich level (organic matter>30 g·kg^{-1}, total nitrogen>1.5 g·kg^{-1}, available phosphorus>20 mg·kg^{-1}, and available potassium>150 mg·kg^{-1}) as the goal, adjust the element content of the cultivation layer.

2.3. Measurement Indicators and Methods

PH shall be determined according to NY/T 1377-2007, conductivity shall be determined using a conductivity meter method, bulk density shall be determined according to Part 4 of NY/T 1121.4-2006, mechanical composition shall be determined according to GB/T 19077.1-2008, saturated hydraulic conductivity shall be determined using the ring knife method, water infiltration rate shall be determined using the disc infiltration meter method, organic matter shall be determined according to Part 6 of NY/T 1121.6-2006, total nitrogen shall be determined according to NY/T85-1988, and effective phosphorus shall be determined according to Part 7 of NY/T 1121.7-2014, Quick acting potassium is determined according to NY/T 889-2004.

2.4. Analysis Methods

Using Excel 2007 to organize data and Sigmaplot 12.0 for plotting.

3. Result Analysis

3.1. Change Trend of Saturated Hydraulic Conductivity with Unit Weight

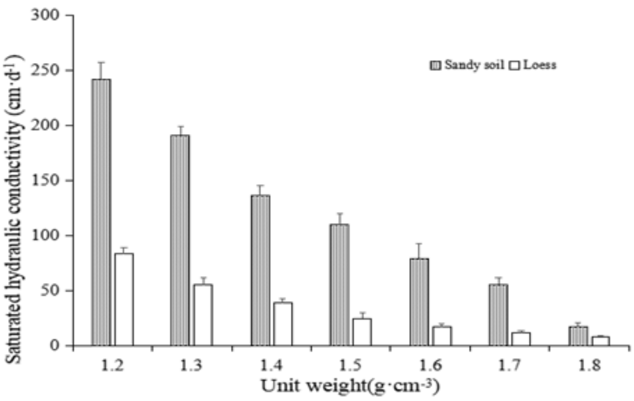

Fig 1. Saturated hydraulic conductivity of soil with different bulk density

Under various bulk densities, the saturated hydraulic conductivity of sandy soil is greater than that of loess. This is because the content of sand and gravel in sandy soil is higher, and the saturated hydraulic conductivity of soil is significantly positively correlated with the content of sand particles [3]. That is, the higher the proportion of sand particles, the higher the saturated hydraulic conductivity of soil. Under the same bulk density, the porosity of sandy soil is greater than that of loess, allowing more water to pass through. Therefore, one of the keys to reducing saturated hydraulic conductivity is to reduce the content of sand particles in the soil. Choosing loess as the artificial plow bottom layer has a better effect than sandy soil. As the bulk density increases, the saturated hydraulic conductivity of both sand and loess gradually decreases, which is consistent with previous research [4]. When the unit weight is 1.2 $g \cdot cm^{-3}$, the saturated hydraulic conductivity of sand and loess is 242 $cm \cdot d^{-1}$ and 83 $cm \cdot d^{-1}$, respectively. When the unit weight reaches 1.8 $g \cdot cm^{-3}$, the saturated hydraulic conductivity of sand decreases to 16.64 $cm \cdot d^{-1}$, which is 93% lower than that of 1.2 $g \cdot cm^{-3}$; The saturated hydraulic conductivity of loess decreased to 7.94 $cm \cdot d^{-1}$, which is 90% lower than the bulk density of 1.2 $g \cdot cm^{-3}$. However, in practical production, it is difficult to achieve soil pressure above a unit weight of 1.7 $g \cdot cm^{-3}$, so the saturated hydraulic conductivity at a unit weight of 1.8 $g \cdot cm^{-3}$ is only of reference value. When the unit weight is 1.7 $g \cdot cm^{-3}$, the saturated hydraulic conductivity of sandy soil is 55 $cm \cdot d^{-1}$, which is 77% lower than that of 1.2 $g \cdot cm^{-3}$. The saturated hydraulic conductivity of loess is 11 $cm \cdot d^{-1}$, which is 86% lower than that of 1.2 $g \cdot cm^{-3}$, only 20% of the saturated hydraulic conductivity of sandy soil. Based on the evaluation of water and fertilizer retention performance, the effect of constructing artificial plow bottom layer with 1.7 $g \cdot cm^{-3}$ loess is the best.

3.2. Soil Moisture Infiltration Rate after Reconstruction

Reconstruct the soil to construct a 5cm artificial plow bottom layer with 1.7 $g \cdot cm^{-3}$ loess, and cover it with 25 cm of 1.2 $g \cdot cm^{-3}$ loess as the cultivation layer. To further explore the water retention performance of the reconstructed soil, 6 sample points were selected in the experimental area and the water infiltration rate was measured using a disc infiltration meter. At the initial stage of the experiment, the infiltration rate of various points remained at a high level, with the highest infiltration rate reaching 68 $cm \cdot d^{-1}$. As the infiltration time prolonged, the saturated hydraulic conductivity gradually decreased, and gradually stabilized after 40 hours of infiltration. As of the end of the experiment, the minimum infiltration rate was 12 $cm \cdot d^{-1}$, which is close to the results of the saturated hydraulic conductivity experiment, indicating that soil reconstruction technology can greatly enhance the soil's water and fertilizer retention performance.

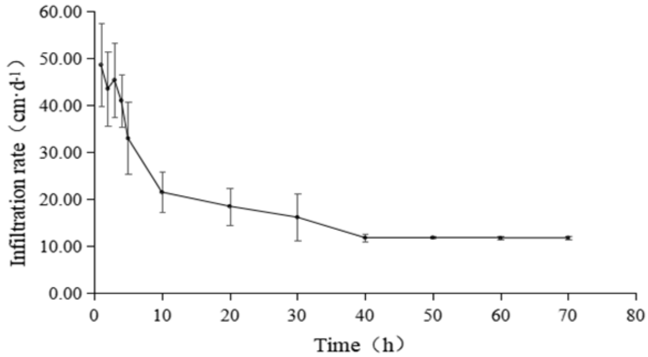

Fig 2. Infiltration rate of reconstructed soil mass

3.3. Reconstruct the Physical and Chemical Properties of Soil

According to the analysis of soil nutrient abundance and deficiency indicators, the organic matter of sandy soil and loess nutrients (Table 1) in the experimental area is at a moderate level, and the contents of total nitrogen, available phosphorus, and available potassium are all in a state of deficiency or extreme deficiency. The lack of nitrogen, phosphorus, potassium and other nutrients is not conducive to the growth of crops such as wheat, corn, rice, and cotton [5,6]. In order to achieve high and stable crop yields, it is necessary to regulate soil nutrients. The experiment aims to achieve a rich level of nutrients by adding sheep manure, urea, diammonium phosphate, and potassium sulfate to the soil. The reconstructed soil physicochemical properties are shown in Table 2. After reconstruction, the soil texture is silty loam soil, with an increase in the content of silt and clay particles and a decrease in the content of sand particles, which is more conducive to water and fertilizer conservation and crop root growth. After reconstruction, the pH and conductivity of the soil remained basically unchanged. After reconstruction, the soil organic matter, total nitrogen, available phosphorus, and available potassium all reached rich levels (organic matter>30 $g \cdot kg^{-1}$, total nitrogen>1.5 $g \cdot kg^{-1}$, available phosphorus>20 mg·kg^{-1}, and available potassium>150 mg·kg^{-1}). Compared to the sandy soil before reconstruction, the organic matter increased by 1.06 times, the total nitrogen content increased by 2.07 times, the available phosphorus increased by 8.54 times, and the available potassium increased by 1.23 times. After reconstruction, the soil is rich in organic matter, nitrogen, phosphorus, and potassium, making it suitable for the growth of most crops.

Table 2. Physical and chemical properties of reconstructed soil mass

Index	Location					Average
	1	2	3	4	5	
Texture	Silt loam	Silt loam	Silt loam	Silt loam	Silt loam	Silt loam
pH	8.1	8.1	8.1	8.1	8.2	8.12
Conductivity (dS·m^{-1})	0.22	0.24	0.29	0.32	0.27	0.27
Organic matter (g·kg^{-1})	32.89	35.55	33.66	39.12	45.42	37.33
Total nitrogen (g·kg^{-1})	1.53	1.91	1.64	2.42	3.32	2.16
Effective phosphorus (mg·kg^{-1})	33.25	37.73	34.68	48.65	31.47	37.16
Available potassium (mg·kg^{-1})	151.66	151.34	156.9	153.76	160.74	154.88

4. Conclusion

Applying soil organic reconstruction technology, a 5 cm thick artificial plow bottom layer was constructed using 1.7 g·cm^{-3} loess, and a 25 cm thick cultivation layer was constructed using 1.2 g·cm^{-3} loess, which had the best water and fertilizer retention performance. The saturated hydraulic conductivity of the artificial plow bottom layer was 11 cm·d^{-1}, which decreased by 86% compared to the unit weight of 1.2 g·cm^{-3}. The water infiltration rate of the cultivation layer is 12 cm·d^{-1}, which is 89% lower than the initial state of sandy soil. After reconstruction, the content of organic matter, total nitrogen, available phosphorus, and available potassium in the soil was at a rich level, which increased by 1.06 times, 2.07 times, 8.54 times, and 1.23 times compared to sandy soil, respectively. Applying organic soil reconstruction technology to improve sandy land can effectively increase arable land area and increase grain yield while ensuring irrigation water use.

Acknowledgments

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References

[1] Zhou Jianmin. “Protection of arable land resources and increase of soil productivity in China”. Bulletin of Chinese Academy of Sciences. 2013, Vol. 28(2), p269-274.

[2] Wang Yumeng, Wu Juan, Zhang Anlu. “Study on problems of cropland resources and realize effective protection by using compensation mechanism in China”. Research of Agricultural Modernization. 2010, Vol. 31(1), p29-33.

[3] Yao Rongjiang, Yang Jinsong, Zhang Tongjuan, Li Furong, Wang Xiangping, Wu Xiaowei. “Influencing factors and pedo-transfer functions of topsoil saturated hydraulic conductivity in the coastal farmlands of reclaimed tidal flats”. Chinese Journal of Eco-Agriculture, 2014, Vol. 22(7), p790-797.

[4] Candemir F, Gülser C. “Influencing factors and prediction of hydraulic conductivity in fine-textured alkaline soils”. Arid Land Research and Management, 2012, (26), p15-31.

[5] Hou Yunpeng, Han Liguo, Kong Lili, Yin Caixia, Qin Yubo, Li Qian, Xie Jiagui. “Nutrient absorption, translocation in rice and soil nitrogen equilibrium under different nitrogen application doses”. Journal of Plant Nutrition and Fertilizer. 2015, Vol. 21(4), p836-845.

[6] Zhang Xiuzhi, Cai Hongguang, Yan Xiaogong, Liu Jianzhao, Peng Chang, Gao Hongjun, Ren Jun, Zhu Ping. “Characteristics of accumulation and distribution of N, P and K of spring maize under different fertilizer methods”. Journal of Soil and Water Conservation. 2014, (5), p209-313.