The Effects of Different Tillage Practices on Soil Aggregate Structural Stability of Newly Added Cultivated Land in Loess Plateau

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Abstract

Tillage practices have an important impact on soil aggregate structural stability in the newly added cultivated land. Through long-term field experiments, we have evaluated that long-term moldboard plow tillage (MT), sub-soiling/moldboard-tillage/sub-soiling rotation (ST) and no-tillage/sub-soiling/no-tillage rotation (NT) treatments on the soil aggregate structural stability of newly added cultivated land. The research results showed that MT reduced the structural stability of soil aggregates. Compared with MT, NT and ST treatments significantly increased the stability of water-stable aggregates of newly added cultivated land, and the average weight diameter (MWD), geometric mean diameter (GMD), macroaggregate content ($R_{0.25}$) and fractal dimension (D) values of soil aggregates were significantly improved. Meanwhile, the content of $R_{0.25}$ and MWD have a very significant positive correlation. These results confirmed that NT and ST treatments improved the soil structural stability, and NT treatment was the most suitable treatment for newly added cultivated land.

Keywords

Newly Increased Cultivated Land; Tillage Practices; Soil Aggregate Structural Stability.

1. Introduction

In recent years, protective tillage practices such as less tillage, no tillage, and straw mulching have received more and more attention. Studies have shown that subsoiling treatment can effectively break the soil plow pan, increase soil porosity, improve soil structure, and increase soil water holding capacity of cultivated layer [1-2]. No-tillage treatment can effectively increase the organic matter content and the number and activity of microorganisms, increase the concent of aggregates, and significantly enhance the stability of the soil structure, creating a stable tillage layer that is conducive to crop growth [3-4]. However, the traditional tillage practice has a great disturbance to the soil, and it is easy to form a dense plow pan [5-6]. Therefore, this paper adopts field experiments to evaluate the traditional long-term moldboard plow tillage (MT), sub-soiling/moldboard-tillage/sub-soiling rotation (ST) and no-tillage/sub-soiling/no-tillage rotation (NT) practices affect the soil aggregate structure stability, and explore the effects of different tillage practices on the soil structure of newly added cultivated land, hoping to provide a theoretical reference for the selection of suitable tillage practices for improving soil quality of newly added cultivated land.

2. Materials and Methods

2.1 Experimental design

The experimental field was a newly built new cultivated land rapid maturation community in 2016. The newly added cultivated land was formed by reclaiming abandoned bare rock and gravel land.

However, the newly added cultivated land had problems with poor soil maturation and structural properties. Different tillage practice experiments were carried out in the raw soil rapid maturation plot in June 2017, and the planting system was summer corn and winter wheat rotation. The experiment set up a total of three tillage practices: MT, ST and NT. A random block design was adopted with 3 replicates of each treatment design, and each tillage treatment plot was 6 meters long and 5.5 meters wide, with a total of 9 test plots, and the total area of the test plot was about 297 square meters.

2.2 Sampling and measurement methods.

The undisturbed soil samples of the aggregates were collected during the corn harvest, which were used to determine the soil aggregates structural stability of the newly added cultivated land under different tillage practices. Each tillage treatment adopts multi-point stratified sampling method, the original soil samples are collected in 0-10 cm and 10-20 cm soil layers, and each treatment is repeated 3 times. We minimised soil disturbance during collection and transport to avoid disrupting the soil aggregate structure. We avoid the impact on the soil structure during sampling and transportation, and then return it to laboratory to remove impurities and dry it naturally. The detailed calculation formulas of MWD,GMD, $R_{0.25}$ and D of soil aggregate stability indexes refer to relevant literature [7].

3. Results and analysis

3.1 Effect of different tillage practices on MWD, GMD, $R_{0.25}$ and D values

The values of MWD, GMD, and $R_{0.25}$ under NT and ST treatment were higher than those under MT treatment, and the D value was lower than that of traditional MT treatment (Table 1). The values of MWD, GMD, and $R_{0.25}$ under NT treatment increased by 17.9%, 11.8% and 48.8% respectively compared with that under MT treatment, and the value of D decreased by 1.34% compared with MT treatment; the ratio of MWD, GMD and $R_{0.25}$ under ST treatment increased by 7.2%, 4.5% and 28.0%, respectively, and the D value was reduced by 0.34% compared with the MT treatment. Aggregate structure stability index data showed that compared with traditional MT treatment, NT and ST treatments both enhance the soil agglomeration and stability of the newly added cultivated land, and the soil structure and anti-corrosion ability were both improved to a certain extent. Due to minimum disturbance and straw mulching, NT had the best effect on improving the stability of soil structure of the newly added cultivated land.

Table 1. Effects of different tillage practices on water-stable aggregate stability

Method	treatments	MWD (mm)	GMD (mm)	D	$R_{0.25}$(%)
Wet sieving	NT	0.40±0.02a	0.34±0.01a	2.93±0.01b	34.07±4.75a
	ST	0.37±0.01ab	0.32±0.01ab	2.96±0.01ab	29.30±3.04b
	MT	0.34±0.02b	0.30±0.01b	2.97±0.02a	22.89±2.19c

Note: Different lowercase letters represent significant differences between different tillage practices (P<0.05).

3.2 Analysis of the correlation between $R_{0.25}$ and MWD

It can be seen from Figure 1 that the content of soil water-stable large aggregates ($R_{0.25}$) and the MWD have a very significant positive correlation (R^2=0.8351, P<0.01). The results of the correlation analysis showed that the ST practices with straw mulching reduce the disturbance to the soil structure and increase the input of organic matter by recycling crop residues, which helped to increase the content of soil organic carbon and improve soil structure. With the increase in the content of $R_{0.25}$ of newly added cultivated land, the MWD of soil aggregates was also gradually increasing, which indicated that the water stability and agglomeration of soil aggregates have been improved to a certain extent.

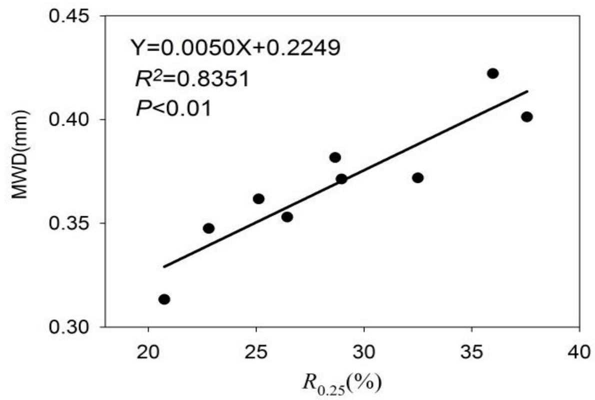

Figure 1. Analysis of the correlation between the $R_{0.25}$ and MWD

4. Conclusions

Compared with traditional MT treatment, the NT and ST treatments under the conservation tillage method both increased the structural stability of the water-stable aggregates. The GMD, MWD, $R_{0.25}$ and D values were the best under NT treatment, and the values of GMD, MWD and $R_{0.25}$ increased significantly, which enhanced the stability of the aggregate structure. The content of $R_{0.25}$ has a very significant positive correlation with MWD. In summary, compared with MT treatment, the NT and ST treatments have produced a certain improvement in the stability of soil structure organic matter, which was conducive to the healthy and sustainable development of the soil quality in the newly added cultivated land.

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