Characteristics of Soil Texture Changes of Soft Rock and Sand Compound Soil with Different Planting Years

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Abstract. As a new type of compound soil of soft rock and sand in Mu Us Sandy Land, whether the texture state can maintain stable development is the primary concern. In this paper, the Mastersizer 2000 laser particle size analyzer method was used to analyze the variation characteristics of particle composition of mixed soil with different volume mixing ratios (1:1, 1:2, 1:5) in field tests from 2010 to 2016. The results show: With the increase of planting years, the content of clay and silt increases, the content of sand decreases, and the texture of the compound soil presents a benign development trend. With the ratio of 1:1, 1:2, and 1:5 of soft rock and sand compound soil, the C/F value of the compound soil tends to decrease, and the tillage layer tends to refine, which improves the stability of the compound soil. Therefore, the compounded soil can maintain a good and stable state of development during the utilization period, and it does not need to be compounded after many years.

1. Introduction

Soil texture category is one of the important indicators in the process of desertification monitoring and evaluation in northern China, and the particle composition and gradation of soil have a crucial influence on the biological, physical and chemical properties of soil [1-2]. The composition proportion and existing form of soil particles directly affect the abundance and shortage of soil nutrients [3]. The research results of scholars such as Gao Yajun and others show that the change of soil particle composition and the formation process of clay particles are the development process of soil. In clay-rich soil, the more colloid content, the stronger the ability to adsorb soil nutrients [4]. Zou Cheng and other researchers believe that one of the most important factors causing soil nutrient differences is the difference in soil mechanical composition [5].

Mu Us Sandy Land is one of the four major sandy lands in China, with serious wind erosion and desertification. It is distributed with about 25 million mu of soft sandstone. It is the main source of coarse sand in the Yellow River and is called "Earth Ecological Cancer". However, the area has sufficient light conditions, relatively abundant precipitation, and shallow groundwater, which provides environmental conditions for the development of ecological high-value agriculture. Han Jichang and
others [6] took Mu Us sandy land as the research object, explored the scientific mechanism of soft rock and sand compounding into soil, and put forward the key technology of soft rock and sand compounding into soil and making land. However, as a new type of compound soil, whether its particle composition is stable and whether its texture can develop stably and be used sustainably in the later agricultural management is the first concern. At present, there are many researches on the nutrient characteristics and crop yield of the soil compounded with arsenic sandstone and sand [7], but there are few researches on the change characteristics and stability of soil particle composition after the arsenic sandstone and sand are compounded into soil. In this paper, the change characteristics of particle composition of different proportions of mixed soil in Mu Us sandy land from 2010 to 2016 were studied, which objectively reflected the texture and stability of soft rock and mixed soil, provided technical support and theoretical basis for the new mixed soil to improve the physical structure of aeolian sandy soil and the land remediation in Mu Us sandy land, and had guiding function for realizing the sustainable utilization of newly-built soil.

2. Materials and Methods

2.1. Overview of Research Areas

This study was carried out at Yulin Field Science Observation and Test Station of Shaanxi Land Engineering Construction Group. Based on the requirements of the project and relying on the land development project undertaken by the Land Construction Group in Xiaoji han Township, Yuyang District, Yulin City, which is representative in the management of Mu Us sandy land due to its geographical location, climate, hydrology and other conditions, has been selected as a demonstration project site to construct a field scientific observation test station and test community. The study area is located in the southern margin of Maowusu desert, in the middle reaches of Wuding River, and belongs to a typical semi-arid continental monsoon climate area in the mid-temperate zone. Precipitation is unevenly distributed in time and space, with annual precipitation ranging from 250 mm to 440 mm, concentrated in July to September, accounting for 60 to 75% of the annual precipitation, especially in August. The interannual variability of precipitation is large, the rainy year is 2~4 times of the rainy year, and the maximum daily precipitation can reach 100 ~ 200 mm. Sand-lifting wind speed greater than 5m/s is 220 ~ 580 times per year. The soil type in the project area is mainly aeolian sandy soil, with uniform sandy soil texture, loose structure and relatively uniform distribution of water in the soil layer space. Once water supply decreases and evapotranspiration increase, there will be overall water shortage. The nutrient content of aeolian sandy soil is 0.075% of total nitrogen, 0.63 g/kg of total phosphorus, 26.51 g/kg of total potassium and 0.03% of organic matter. There are a large number of purplish red arsenic sandstones distributed around the project area. Although arsenic sandstones have low diagenesis degree, low structural strength, easy weathering, low degree of cementation between particles and poor permeability, they have good water holding capacity and water holding capacity, and the rock stratum has more water storage, which can provide water for plant growth. The purple arsenic sandstone soil used in the test contains 6.2 g/kg of organic matter, 0.125g/kg of total nitrogen, 0.379g/kg of total phosphorus, 1.25g/cm³ of bulk density and 52.7% of capillary porosity.

2.2. Test Methods

Field soil samples were collected after corn harvest every year from 2010 to 2016. The field test site is 15 m× long by 12 m wide, and the surface layer of the local original sandy soil is covered with 30 cm volume ratio of mixed soil according to the experimental requirements. When considering the mixing ratio of mixed soil, the plot is divided into three sub-plots of 5 m×12 m on average, and three volume mixing ratios of arsenic sandstone and sand of 1: 1, 1: 2, 1: 5 (arsenic sandstone is crushed to a diameter ≤4 cm) are considered respectively, with one repetition for each ratio. The "S" shape sampling method was adopted to collect soil samples of 0~30 cm under each treatment in three sub-plots. Three repetitions were set up, and a total of 9 soil samples were collected each time. Then the
samples were brought back to the laboratory to measure the physical and nutrient contents of the compound soil and other indexes. The average value of the data obtained from the three repetitions was calculated. The collected soil samples were removed from grass roots and other impurities, dried naturally, ground through a 2mm sieve, and the composition of soil particles was determined by malvin Laser Particle Size Analyzer Mastersizer 2000 (UK). The ratio C/F of soil large particles (sand content) to soil small particles (silt content+clay content) was calculated to characterize the change characteristics of soil particle size composition.

3. Results and Analysis

3.1. Dynamic Change Characteristics of Mixed Soils with Different Planting Years

Planting years have a very significant impact on the texture category of the mixed soil. From the composition of mixed soil particles with the volume mixing ratio of 0-30 cm in the field test from 2010 to 2016 being 1: 1, 1: 2 and 1: 5 (Table 2), with the increase of planting years of the mixed soil, the 1: 1 mixed soil of 0-30 tillage layers presents a texture transition from loam sand-sandy soil-silty sand soil-loam, from 2010 to 2016. Sand content decreased by 46.6%, silt content increased by 173.0%, clay content increased by 27.5% at the minimum and 178.8% at the maximum. There were significant differences in clay and silt content in different planting years, but sand content was not obvious. The texture of the 1: 2 mixed soil topsoil changed from loam sand to sandy soil. From 2010 to 2016, the sand content decreased by 12.3%, the silt content increased by 83.3%, the clay content increased by 8.2% at the minimum and 90.2% at the maximum. The texture of the 1: 5 mixed soil topsoil changed from loam sand to sandy soil. From 2010 to 2016, the sand content decreased by 18.1%, the silt content increased by 132.6%, the clay content increased by 12.4% at the minimum and 72.6% at the maximum. From the above analysis, it can be seen that with the increase of the planting years of the compound soil, the content of clay and silt in the three proportions of compound soil increases, while the content of sand decreases, and the texture changes to fine and benign direction. The silt and clay content of 1: 1 to 1: 2 and 1: 5 mixed soils increased greatly, and the texture category and structural state of the compound soil show good and stable development.

| Volume ratio | 2010  | 2011  | 2012  | 2013  | 2014  | 2015  | 2016  |
|--------------|-------|-------|-------|-------|-------|-------|-------|
| 1:1 Sand%    | 76.29 | 68.46 | 69.20 | 67.34 | 63.50 | 40.82 | 40.73 |
| Silty%       | 18.20 | 24.02 | 27.36 | 29.02 | 30.54 | 50.67 | 49.68 |
| Clay%        | 5.51  | 7.52  | 3.44  | 3.64  | 5.96  | 6.50  | 9.59  |
| Texture      | Loamy sand | Sandy loam | Sandy loam | Sandy loam | Sandy loam | Silt loam | Loam |
| 1:2 Sand%    | 82.43 | 81.96 | 75.94 | 74.15 | 67.38 | 67.79 | 72.25 |
| Silty%       | 13.17 | 13.58 | 21.40 | 23.03 | 27.58 | 31.55 | 24.14 |
| Clay%        | 4.40  | 4.46  | 2.65  | 2.82  | 5.04  | 4.66  | 3.61  |
| Texture      | Loamy sand | Loamy sand | Loamy sand | Loamy sand | Sandy loam | Sandy loam | Sandy loam |
| 1:5 Sand%    | 83.34 | 81.02 | 70.51 | 78.18 | 76.91 | 71.71 | 68.23 |
| Silty%       | 11.79 | 14.48 | 25.84 | 19.30 | 19.67 | 27.74 | 27.42 |
| Clay%        | 3.87  | 4.50  | 3.64  | 2.52  | 3.42  | 3.55  | 4.35  |
| Texture      | Loamy sand | Loamy sand | Sandy loam | Loamy sand | Loamy sand | Loamy sand | Sandy loam |
3.2. Particle Size Composition Analysis of Mixed Soils with Different Planting Years

The C/F value of the ratio of large soil particles (sand content) to small soil particles (silt content + clay content) is used to represent the change characteristics of soil particle size composition, thus objectively reflecting the development state of soil texture. According to the research on the change characteristics of the ratio of large particles to small particles (C/F value) of the mixed soil with volume mixing ratios of 1:1, 1:2 and 1:5 from 2010 to 2016 (Figure 1), with the increase of planting years of the mixed soil, the arsenic sandstone particles gradually weathered, the coarse particles decreased, and the fine particles increased. The ratio of large particles to small particles (C/F value) of the soil with different mixed ratios showed a decreasing trend. Among them, the maximum reduction of C/F value for 1:1 composite soil is 78.6%, the maximum reduction of C/F value for 1:2 composite soil is 60.1%, the maximum reduction of C/F value for 1:5 composite soil is 147.4%. The C/F values of the three kinds of mixed soils decreased by 1:5 > 1:1 > 1:2, which indicates that with the increase of planting years of the mixed soils, the tillage layer of the mixed soils with different proportions tends to be refined, which is more conducive to the full mixing of arsenic sandstone and sand, thus the texture state of the mixed soils achieves good and stable development.

![Figure 1. Variation characteristics of the ratio of large particle to small particle (C/F value) in three proportions of soils with different planting years](image)

4. Conclusion

Soil texture is one of the most basic physical properties of soil, and stability is an important property of soil structure. It mainly shows the ability of soil to maintain its original state or develop towards a good texture state in the later agricultural management. Its main function is to measure the healthy and stable development degree of soil texture. This paper is aimed at the problem that the stability and sustainable utilization of the follow-up compound soil after sand remediation by using the compound soil technology of arsenic sandstone and sand are still unclear. When arsenic sandstone and sand are compounded into soil, the first thing is to optimize the composition of aeolian sand particles. After many years of planting, the compounded soil develops to a compound state of inorganic and organic colloids. The 1:1, 1:2 and 1:5 compounded soils all show an increase in clay and silt content, a decrease in sand content, and a good stable development state in texture and structure. In addition, the coarse particles of the soil with different compounding ratios decrease, the fine particles increase, the ratio of large particles to small particles, that is, the C/F value, shows a decreasing trend, the soil tillage layer tends to be refined, the physical structure of the compounded soil is improved. Therefore, the compounded soil can maintain a good and stable development state of the compounded texture and does not need to be compounded for many years.
References

[1] SU Zhizhu, LIU Rong, LIANG Aimin, et al. Study on mechanical composition and organic matter of desertification land in Northwest of Shanxi province. Research of Soil and Water Conservation, 2018, 25(6): 61-67.

[2] ZHANG Haiou, XIE Jiancang, NAN Haipeng, et al. The Interaction of Freezing-thawing on Soil Aggregates and Organic Matter of Pisha Sandstone and Sand Compound Soil. Journal of Soil and Water Conservation, 2016, 30(3): 273-278.

[3] DENG Tingfei, LIU Yan, YAN Qiuxiao, et al. Mechanical composition and soil nutrient characteristics and their relationships in typical Loniceracinfusa soil of Guizhou. Journal of Soil and Water Conservation, 2014, 28(5): 209-214.

[4] GAO Yajun. The study of quality evaluate and evolvement mechanism of soil desertification between agriculture and husbandry interlace zone in north of Shannxiprovince. Yangling, Shaanxi Province: Northwest University of Agriculture and Forestry Science and Technology, 2003.

[5] ZOU Cheng, XU Fuli, YAN Yadan. The analysis of soil mechanical composition and available nutrient under different land uses patterns in the loess Hilly Gully region. Chinese Agricultural Science Bulletin, 2008, 24(12): 424-427.

[6] SUN Zenghui, HAN Jichang. Effect of soft rock amendment on soil hydraulic parameters and crop performance in Mu Us Sandy Land, China. Field crops research, 2018, (222): 85–93.

[7] HAN Jichang, LIU Yansui, ZHANG Yang. Sand stabilization effect of feldspathic sandstone during the fallow period in Mu Us Sandy Land. Journal of Geographical Sciences, 2015, 04: 428-436