Response characteristics of organic carbon storage in sandy soil to sandstone

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Abstract. The soil structure and quality can be improved by the improvement of the sand by using the weathered material of the sandstone. In this study, four kinds of mixed soils with mixed sandstone and sand ratios of 0: 1 (CK), 1: 5 (C1), 1: 2 (C2), and 1: 1 (C3) were selected as research objects. The results showed that the soil organic carbon showed a difference only in the 10-20 cm soil layer. Compared with the CK treatment, the content of organic carbon in the sandstone treatment was significantly reduced by 30.06% - 46.36%. The bulk density in each soil layer increases with the increase of the proportion of sandstone. There was no significant difference in soil organic carbon storage in each soil layer. The organic carbon storage in C1 treatment was 13.87% lower than that in CK treatment, and the organic carbon storage in C2 and C3 treatments increased by 4.40% and 3.22% respectively compared to CK treatment. Therefore, when the mixed ratio of sandstone and sand is 1: 2, the improvement effect on sandy soil is better.

1. Introduction
As one of the four major deserts in China, the Mu Su desert is widely distributed in the bordering areas such as Shaanxi, Shanxi and Mongolia. In recent years, with the large-scale exploitation of local resources and man-made irregular activities, the soil and water loss in the area has become serious, and the desertification has intensified [1,2]. Soil organic carbon, as an organic carrier of plants and animals, microorganisms, cementing substances, minerals and soil enzymes in soil, is closely related to soil porosity, soil spatial structure and soil permeability. Increasing organic carbon content can significantly improve soil buffering and water holding and corrosion resistance [3]. Research on soil organic carbon storage is a hot issue in assessing soil quality, and has been an important area of current carbon cycle research, and soil organic carbon also plays an important role in regulating carbon balance [4,5].

Sandstone and sand are two widely distributed substances in the Mu Su desert, among which the sandstone is hard as stone when it is dried, soft as mud when it meets water, rich in mineral elements and more fine particles, while the sand is leaky and loose, mainly composed of sand grains [6]. Guo et
al. [7] studied the cementation force between the sandstone and the sand composite soil, and the results showed that the interaction between soil particles increased with the increase of the ratio of the sandstone. Li et al. [8] studied the water and fertilizer benefits of mixed sandstone and sand, and the results showed that when the ratio of mixed sandstone and sand was 1:1, the water and fertilizer conservation benefits of the mixed soil were significantly improved. However, due to the complexity of the composition of the compound soil and the diversity of environmental impacts, and the low fertility of the compound soil, the comprehensive evaluation of the quality of compound soil and the results of carbon storage have not been clearly defined. Therefore, in this study, a 3-year experiment plot composed of sandstone and sand was used as the research object to analyze the effects of different proportions of sandstone addition on the organic carbon storage of sand soil. The research results can provide a theoretical basis for the improvement of sand soil quality and ecosystem.

2. Experiment design and method

The mixture of sandstone and sand in different proportions is laid in the 0-30 cm soil layer, and the 30-70 cm is filled with sand. The test plot was set up in 2016. In this study, only four treatments with a volume ratio of 0:1, 1:5, 1:2 and 1:1 (CK, C1, C2 and C3) were selected. Each treatment was repeated for 3 times, with a total of 12 plots.

After the wheat is harvested in early June 2019, soil samples of different soil layers (0-10 cm, 10-20 cm, 20-30 cm) are collected. Each plot uses a five-point method to collect a mixed sample. Soil bulk density was measured using the ring knife method, and soil organic carbon was measured using potassium dichromate-external heating method [9].

Soil organic carbon storage [10]:

\[
SOC_{stock} = \sum_{i=1}^{m} C_i \times D_i \times E_i \times 0.1
\]

In the formula, \(SOC_{stock}\) is the soil organic carbon storage (t/hm\(^2\)), \(i\) is the soil layer code, \(C_i\) is the content of organic carbon in layer \(i\) (g/kg), \(D_i\) is the bulk density in layer \(i\) (g/cm\(^3\)), \(E_i\) is the thickness of the \(i\)-th soil measurement layer (cm), 0.1 is the unit conversion factor.

3. Results and discussion

3.1. Soil organic carbon

The addition of different proportions of sandstone has a certain effect on the content of organic carbon in the sand (Table 1). There was no significant difference in the organic carbon content of all treatments in the 0-10 cm soil layer \((P>0.05)\). The organic carbon content of CK treatment in the 0-20 cm soil layer was the highest at 2.70 g/kg, which was significantly higher than other treatments \((P<0.05)\). However, there was no significant difference in organic carbon content between C1, C2 and C3 treatments, which were 30.00%, 33.33% and 46.30% lower than that of CK treatment. In the 20-30 cm soil layer, there was no significant difference in organic carbon content among all treatments. In comparison, the average soil organic carbon content of the 0-10 cm soil layer is 2.25 g/kg, followed by the 10-20 cm soil layer, 1.96 g/kg, and the organic soil content of 20-30 cm the lowest carbon content is 1.79 g/kg. The analysis of variance showed that there was no significant difference in the organic carbon content among the soil layers, and the effect of the two-factor effect of different compounding ratios and soil layers on the organic carbon content was not significant (Table 2).
### Table 1. Soil organic carbon content and soil bulk density in different treatments under different soil layers.

| Index                     | Soil layer/(cm) | CK       | C1        | C2        | C3        |
|---------------------------|-----------------|----------|-----------|-----------|-----------|
| Soil organic carbon       |                 |          |           |           |           |
| / (g/kg)                  | 0-10            | 2.65±0.23 a | 2.07±0.29 a | 2.04±0.30 a | 2.23±0.23 a |
|                           | 10-20           | 2.70±0.12 a | 1.89±0.31 b | 1.80±0.20 b | 1.45±0.17 b |
|                           | 20-30           | 2.03±0.31 a | 1.49±0.08 a | 1.90±0.29 a | 1.75±0.15 a |
| Soil bulk density         |                 |          |           |           |           |
| / (g/cm³)                 | 0-10            | 1.43±0.11 c | 1.70±0.17 b | 1.94±0.08 ab | 2.00±0.16 a |
|                           | 10-20           | 1.63±0.10 c | 1.95±0.11 b | 2.13±0.12 ab | 2.27±0.08 a |
|                           | 20-30           | 1.79±0.07 d | 2.00±0.05 c | 2.33±0.05 b | 2.61±0.19 a |

Note: Different lowercase letters on each line indicate significance of 0.05 level, the same below.

### Table 2. The variance analysis of organic carbon, bulk density and organic carbon storage in compound soil under the influence of two factors.

| Index                     | Variation source | Square sum | Degrees of freedom | Mean square | F      | P      |
|---------------------------|------------------|------------|--------------------|-------------|--------|--------|
| Soil organic carbon       | Compound ratio   | 2.5994     | 3                  | 0.8665      | 3.919  | 0.0207 |
| / (g/kg)                  | Soil layer       | 1.2635     | 2                  | 0.6317      | 2.857  | 0.0771 |
|                           | Compound ratio × | 1.1151     | 6                  | 0.1859      | 0.841  | 0.5511 |
| Soil layer                | Compound ratio   | 2.3746     | 3                  | 0.7915      | 46.326 | 0.0002 |
|                           | Soil layer       | 1.016      | 2                  | 0.508       | 29.733 | 0.0008 |
|                           | Compound ratio × | 0.1025     | 6                  | 0.0171      | 1.293  | 0.2978 |
| Soil layer                | Compound ratio   | 2.9539     | 3                  | 0.9846      | 1.033  | 0.3955 |
|                           | Soil layer       | 0.1030     | 2                  | 0.0515      | 0.0540 | 0.9475 |
|                           | Compound ratio × | 5.0631     | 6                  | 0.8439      | 0.8860 | 0.5205 |

#### 3.2. Soil bulk density
Different compounding ratios and soil layers all had significant effects on soil bulk density (P <0.05) (Table 2). As the soil layer deepens, the soil bulk density increases in turn, and the average bulk density of each soil layer is 1.77 g/cm³ (0-10 cm), 1.99 g/cm³ (10-20 cm), and 2.18 g/cm³ (20-30 cm). The change of soil bulk density in each soil layer is consistent, all of them show the trend of increasing with the increase of sandstone. In the 0-10 cm and 10-20 cm soil layers, there was no significant difference between C2 treatment and C3 treatment, and the soil bulk density of each compound ratio treatment increased by 18.60%-39.71% and 20.03%-39.55%, respectively, compared with that of CK treatment. In the 20-30 cm soil layer, the soil bulk density increased significantly in the treatments of CK, C1, C2 and C3 (Table 1). The results of variance analysis showed that the effects of different compound proportions and soil layers on soil bulk density were not significant (Table 2).

#### 3.3. Soil organic carbon storage
The analysis of variance shows that there is no significant difference in the effects of the compound ratio and the soil layer on the organic carbon storage, and the effects of the two factors of different compound ratios and soil layers on the organic carbon storage are not significant (Table 2). There was no significant difference in organic carbon storage between all treatments under each soil layer (P>0.05),
but there were certain changes. In the 10-20 cm soil layer, the organic carbon reserves of C1, C2, and C3 treatments were all lower than those of CK treatment, and the decrease ranged from 12.04% to 25.50%. In 0-10 cm and 20-30 cm soil layers, the organic carbon reserves of C1 treatment were also lower than those of CK treatment, while the organic carbon reserves of C2 and C3 treatments increased by 5.79% -22.99% and 16.05% -24.65%, respectively (Fig. 1).

4. Conclusion
In the 0-10 cm and 20-30 cm soil layers, the addition of sandstone has no significant effect on the organic carbon content, but in the 10-20 cm soil layer, the addition of sandstone significantly reduces the soil organic carbon content. The bulk density of the compound soil increases with the increase of the proportion of the sandstone, and the deeper the soil layer, the larger the bulk density. Soil layer and compound ratio have no significant difference in organic carbon storage. Among them, 0-10 cm soil layer has the highest organic carbon storage, followed by 20-30 cm soil layer, and 10-20 cm soil layer has the lowest. In the 0-30cm soil layer, C2 treatment has a large organic carbon storage.

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