Research on soil organic carbon pool and distribution characteristics in farmland

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Abstract. In this paper, the researches on the estimation of cultivgated soil organic carbon storage and its variation trend were conducted in Shayang County, a typical agricultural county in Jianghan Plain in China. The results showed that the order of soil organic carbon density (SOCD) was paddy soil > moisture soil > yellow brown soil, and the mean values were 4.46, 3.12 and 2.55 kg/m2, respectively. No matter which soil type, the organic carbon content of soil decreased gradually from the surface to the deep soil in the form of exponential function. By analyzing and processing the organic carbon data from 2001 to 2018, the average SOCD in the topsoil increased from 3.69 to 4.25 kg/m2, with an increase of 15.18%.

Keywords: soil organic carbon density, cultivgated soil, peddy soil, moisture soil, yellow brown soil.

1. Introduction

At present, cultivated land has become the second largest source of greenhouse gases. However, at the same time, cultivated land carbon sinks have great emission reduction potential and cost advantages. Cultivated land soil carbon pool is an important part of the carbon pool of terrestrial ecosystem. Arable soil is strongly affected by human activities and is the most active in the global soil carbon pool [1]. Therefore, research on the soil organic carbon pool has always been a hot topic of carbon cycle. It is also one of the core contents of research on global change, greenhouse gas emission reduction and food security. Driven by the goal of carbon sequestration and emission reduction, the research on the carbon sequestration potential of cultivated land can also provide a reliable basis for establishing a long-term mechanism of agricultural carbon sequestration and stable productivity [2].

Jianghan Plain is one of the important commercial grain production bases in China. In this study, Shayang County, a typical county in Jianghan Plain, was selected as the research area to carry out research on the spatio-temporal variation trend of cultivated soil organic carbon pool and estimation of cultivated soil organic carbon storage.

2. Materials And Methods

2.1. Research Area

The cultivated land area of Shayang County is 1271.73 km^2, accounting for about 60% of the land area. The land use types of cultivated land are divided into paddy field, dry land and irrigated land. Among them, the paddy field area is 1031.87 km^2, accounting for more than 81.14% of the cultivated land area. The area of dry land is 225.23 km^2, accounting for 17.71%, mainly distributed in the west bank of the Han River. The irrigated land area was 14.63 km^2, accounting for 1.15%. The cultivated soil in the county is divided into four types: purple soil, yellow brown soil, moisture soil and paddy soil, of which paddy soil is widely distributed in the county.

2.2. Computing method

The international soil organic carbon density (SOCD, kg/m^2) usually refers to the soil profile depth of 1m, the quality of organic carbon per square meter of soil [3]. The calculation formula of different soil levels is as follows:

$$SOCD_i = \frac{(1-\theta_i)\times\rho_i\times C_i\times T_i}{100} \quad (1)$$

If the soil mass consists of n layers, the total SOCD is the sum of the SOCDs of each layer.

$$SOCD = \sum_{i=1}^{n} \frac{(1-\theta_i)\times\rho_i\times C_i\times T_i}{100} \quad (2)$$

Among them, θ_i is the gravel content of layer i exceeding 2mm (volume percentage,%. ρ_i is the soil bulk density of layer i (g/cm^3). C_i is the organic carbon concentration of layer i (g/kg). Ti is the thickness of layer i. This study mainly calculated the soil organic carbon density in the surface layer (0-20cm) of cultivated land. Since the study area is in a plain area, its gravel content can be recorded as zero.

3. Results And Discussion

3.1. Distribution status of soil organic carbon density in topsoil layer

According to the land quality geochemical evaluation data of Shayang County, the SOCD of the topsoil layer (0-20 cm) of the main soil types of cultivated land was statistically analyzed (Table 1). The soil organic carbon density in the topsoil ranged from 0.13 to 10.87 kg/m^2, with an average value of 4.25 kg/m^2 and a coefficient of variation of 33.64%.

The order of soil organic carbon density was paddy soil > moisture soil > yellow brown soil, and the mean values were 4.46, 3.12 and 2.55 kg/m^2, respectively. According to the coefficient of variation, paddy soil was close to moisture soil, while yellow brown soil was higher. In order to explore the difference of SOCD in the topsoil of different soil types, independent sample T-test was conducted. The results showed that there were significant differences between paddy soil and moisture soil, between moisture soil and yellow brown soil, and between paddy soil and yellow brown soil (Table 2). The organic carbon density of moisture soil and yellow brown soil was significantly lower than that of paddy soil. Therefore, in the implementation of farmland soil carburization measures, the cultivated soil of moisture soil and yellow brown soil is the key control object [4].

Table 1. Statistical characteristics of soil organic carbon density in topsoil of different soil types in Shayang County

Soil type	Sample size	Minimum kg/m^2	Maximum kg/m^2	Mean kg/m^2	SD kg/m^2	CV %
Paddy soil	9819	0.13	10.87	4.46	1.39	31.07
Moisture soil	1423	0.42	10.29	3.12	0.96	30.86
Yellow brown soil	293	0.51	8.22	2.55	0.97	38.12
Total	11535	0.13	10.87	4.25	1.43	33.64

Table 2. Statistical characteristics of soil organic carbon density test results of different soil types in Shayang County

Projects		Levene test of variance equation		T-test for mean equation						
		F	Sig.	t	DOF	Sig.	Mean difference	Standard error value	95% confidence interval for the difference	
									Lower limit	Upper limit
Paddy soil-Moisture soil	Equal variances assumed	269.151	0.000	35.394	11240	0.000	1.346	0.038	1.272	1.421
	Equal variances not assumed			46.267	2376.413	0.000	1.346	0.029	1.289	1.403
Paddy soil-Yellow brown soil	Equal variances assumed	59.348	0.000	23.42	10110	0.000	1.912	0.082	1.752	2.072
	Equal variances not assumed			32.659	328.46	0.000	1.912	0.059	1.797	2.027
Moisture soil- Yellow brown soil	Equal variances assumed	0.001	0.974	9.146	1714	0.000	0.566	0.062	0.444	0.687
	Equal variances not assumed			9.079	417.962	0.000	0.566	0.062	0.443	0.688

3.2. Vertical distribution characteristics of soil organic carbon content in cultivated land

A total of 38 vertical soil profiles were collected in Shayang County, including 24 paddy soil profiles, 8 moisture soil profiles and 6 yellow brown soil profiles. According to the average depth of each development level of the soil profile, the paddy soil profile was divided into 0-20 cm, 20-50 cm, 50-60 cm, 60-70 cm, 70-80 cm, 80-100 cm, and the moisture soil and yellow brown soil profiles were both divided into 0-20 cm, 20-50 cm, 50-100 cm. Statistical analysis was conducted on the organic carbon content of different soil layers, and it was found that the organic carbon content level of the three soil types followed an exponential distribution with the depth of the profile (Figure 1), and the correlation was all above 80%. This showed that no matter which soil type, the organic carbon content of soil decreased gradually from the surface to the deep soil in the form of exponential function. The soil organic carbon content was the highest when the soil depth was 0-20 cm. When the soil depth was 20-50 cm, the organic carbon content of paddy soil, moisture soil and yellow brown soil decreased sharply, decreasing by 59.8%, 49.5% and 17.0%, respectively. The organic carbon content of paddy soil decreased the most, and the difference of organic carbon content of 0-20 cm and 20-50 cm soil was significantly greater than that of moisture soil and yellow brown soil. It proved that the cumulative effect of organic carbon in topsoil was better than the other two soil types.

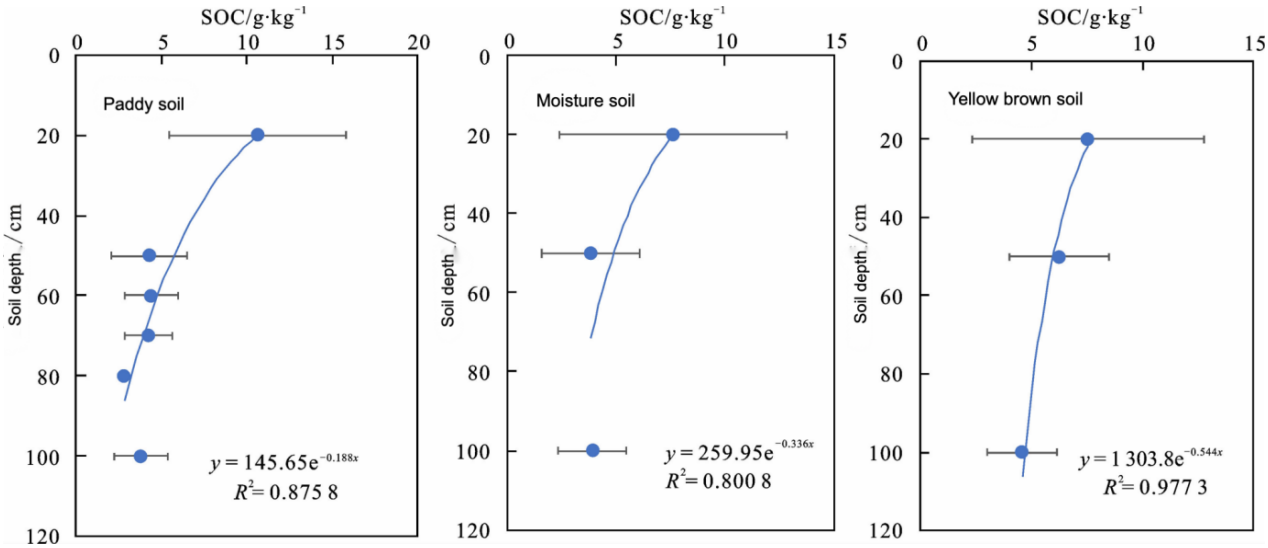


Fig. 1 Vertical distribution of cultivated soil profiles of different land types in Shayang County

3.3. Variation trend of topsoil organic carbon density in recent 15 years

By analyzing and processing the organic carbon data in Shayang County from 2001 to 2018, the average SOCD in the topsoil increased from 3.69 to 4.25 kg/m^2, with an increase of 15.18% (Table 3). The change trend of organic carbon density of different soil types was different. Except for the decrease of yellow brown soil, the organic carbon density of the other two types increased, especially the increase of paddy soil was the largest, reaching 17.37%.

In order to have a more intuitive understanding of the variation degree of topsoil organic carbon density in Shayang County in the past 15 years, interpolation analysis was carried out (Figure 2). The results showed that the variation trend of SOCD in topsoil was different in different regions of Shayang County. The decrease of SOCD in the topsoil layer was mainly distributed in the northeast, especially in the urban area. Nearly 70% of the areas in Gaoyang Town and Shenji Town had a large decrease, with a decrease of 0.5 to 2.7 kg/m^2. The SOCD in other regions increased to varying degrees, and the cultivated land in Hougang Town, Shihuiqiao Town and Jishan Town in the southwest increased by 1.5 to 3.5 kg/m^2, covering an area of about 50 km^2. In 56.6% of cultivated land, the SOCD increased by 0.5 to 1.5 kg/m^2. The comparison with the current situation map of land use type in Shayang County showed that the area with a large increase of organic carbon was basically paddy field, while the area with a small increase was dry land along the Hanjiang River.

Table 3. Changes of topsoil organic carbon in Shayang County from 2001 to 2018

Agrotype	Organic carbon density in 2004 kg/m^2	Organic carbon density in 2018 kg/m^2	Density change value kg/m^2	Amplitude of density change %	Change in reserves Tg
Paddy soil	3.80	4.46	0.66	17.37	0.68
Moisture soil	2.96	3.12	0.16	5.41	0.03
Yellow brown soil	3.78	2.55	-1.23	-32.54	-0.07
Total	3.69	4.25	0.56	15.18	0.64

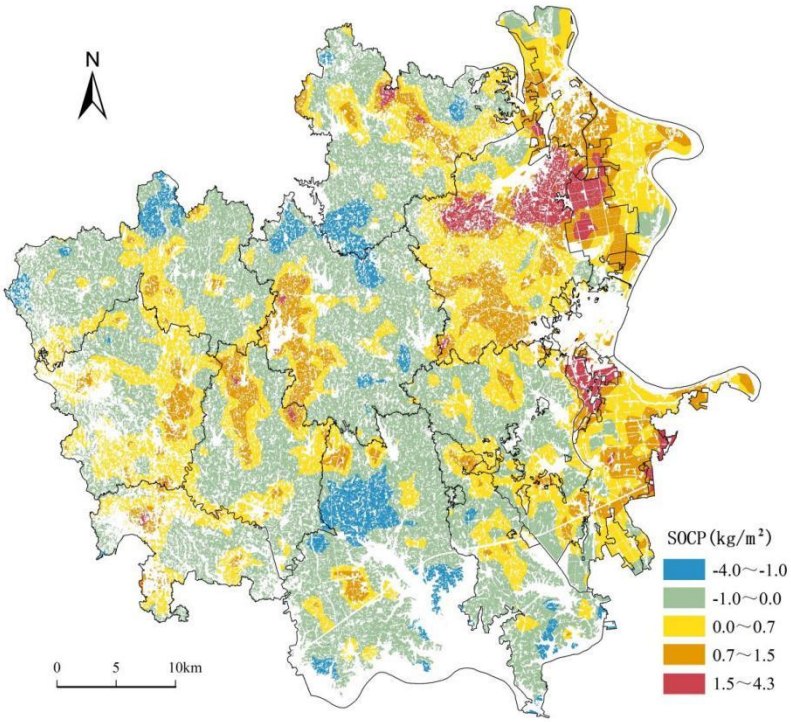


Fig. 2 Variation trend of topsoil organic carbon density in Shayang County from 2004 to 2018

4. Conclusion

Based on the analysis of the distribution status, vertical distribution characteristics and the change trend of soil organic carbon density in topsoil of Shayang County in recent 15 years, the storage and temporal and spatial distribution characteristics of cultivated soil organic carbon density in Shayang County were clarified, which provided relevant basic data and theoretical basis for the prediction of soil carbon sequestration potential of cultivated land.

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