

# Elevation and Land Use Types Have Significant Impacts on Spatial Variability of Soil Organic Matter Content in Hani Terraced Field of Yuanyang County, China



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**Abstract:** Soil organic matter (SOM) content is one of the most important indicators of the sustainability of soil. To maintain sustainable soil utilization and management in fragile Hani terraced field, it is meaningful to investigate the effects of topography and land use type on SOM content. Descriptive statistics and geostatistics were used to analyze the data and the kriging method was applied to map the spatial patterns of SOM content. The results showed that the mean SOM content was 32.76 g/kg, with a variation coefficient of 40%. The SOM content was affected by elevation and land use type. As the increase of elevation, the SOM content in Hani terraced field also increased obviously. The SOM content in tea garden, which is almost at high elevation, was the highest in all six land use types, and the SOM content decreased in a following sequence: tea garden > paddy field > corn field > banana garden > cassava field > sugarcane field. In addition, at the same elevation, the paddy field had the highest SOM content compared with other land use types. All these results demonstrate that paddy field is the most efficient and suitable land use type for SOM conservation at high, middle or low elevations in the fragile Hani terraced field. In order to protect soil quality and maintain the sustainable agricultural development, it is necessary to maintain or even to enlarge the area of paddy field in Yuanyang county, Yunnan Province, China.

**Key words:** Hani terraced field; elevation; land use type; geostatistics; soil organic matter content

As the product of on-site biological decomposition, soil organic matter (SOM) affects the chemical and physical properties of soil and its overall health. Also, the composition and breakdown rate of SOM affect structure and porosity, water infiltration rate and moisture holding capacity, diversity and biological activity, and plant nutrient availability of soil (Bot and Benites, 2005). Accurate information of the spatial variation of SOM content is extremely critical for sustainable soil utilization and management (Zhang et al, 2012). Therefore, the spatial variation of SOM content and its influence factors are becoming hot spots in studying of soil science, ecology and geochemistry.

Scholars have performed numerous studies on the

spatial distribution of SOM content in various countries, regionals and ecosystem scales, such as China (Li Q Q et al, 2012), Taiyuan (Zhang et al, 2009), urban-rural transition zone of Beijing (Hu et al, 2007), eastern Canada (Mabit and Bernard, 2010), small watershed of the Loess Plateau (Fang et al, 2012), river marginal wetlands (Bai et al, 2005), Qinghai Lake (Cao et al, 2011) and different agricultural ecosystems (Yang et al, 2008). These studies had a high consistence with spatial heterogeneity in SOM content, and revealed its influence factors including climate, topography, natural vegetation, texture, drainage, soil erosion, cropping and tillage, crop rotations, nutrients and others. Of all these factors, land use type is the most sensitive to

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human disturbance (Fang et al, 2012). Therefore, monitoring SOM contents in different land use types is essential for estimating SOM distribution.

Terraced field is one of the most important land types for agricultural products in hilly and mountainous areas of China. According to statistics, the cultivated area with a slope greater than  $8^\circ$  is  $3.334 \times 10^7$   $\text{hm}^2$ , accounting for 35.11% of the cultivated area in China. In China, the hilly and mountainous areas are widely distributed in northeast, southeast, south, southwest, Loess Plateau and Qinba Mountain area. The area of slope farmland in hilly and mountainous areas of Southeast, South and Southwest China is  $1.669 \times 10^7$   $\text{hm}^2$ , which occupies 43.1% of total hilly area and 17.5% of total cultivated area of China (Zhang and Huang, 1999). Hence, revealing the spatial variability of SOM and analyzing its influence factors in terraced fields are important to improve sustainable land use. Hani terraced paddy fields are the predominant mode of agriculture in tropical mountain areas, they are developed by ethnic groups such as Hani and Yi along the slopes of the Ailao Mountains in Yunnan Province of Southwest China (Adachi, 2007). Hani terraced paddy fields have been selected into the list of the world cultural relics by UNESCO (United Nations Educational, Scientific, and Cultural Organization). To sustain the cultures of Hani ethnic minorities, it is important to preserve the farmland and maintain the terraced rice cultivation. In recent years, several studies have been carried out to reveal spatial distribution patterns of soil nutrients in Hani terraced paddy fields. Wang et al (2011) found spatial distribution patterns of soil nutrients along the increasing elevations are different in Mengpin and Quanfuzhang transects. Cui et al (2010) found the distribution of soil nutrients of Hani terraced paddy fields is affected by geographical environmental conditions and agricultural technology. Although SOM contents in part of Hani terraced paddy fields have been studied, relatively few studies have been conducted to determine the effects of land elevation and use type on the SOM content in a whole county scale. With the acceleration of agricultural restructuring, the area of dry land is keeping increase, and that of paddy fields is decreasing sharply. Thus, in order to protect soil quality and maintain sustainable agricultural development in Yuanyang county, Yunnan Province, China, it is meaningful to study the effects of land elevation and use type on spatial distribution of SOM content.

The objectives of this study were to (1) estimate the spatial distribution of SOM content in the whole Yuanyang county; (2) analyze the effects of land elevation on the SOM content; (3) analyze the effects of land use types on the SOM content; and (4) discuss the most suitable land use type for SOM sequestration and sustainable agriculture development in Hani terraced fields of Yuanyang county.

## MATERIALS AND METHODS

### Study area

The studied area is Yuanyang county in Yunnan Province of China, which located at  $102^\circ 27'$  to  $103^\circ 13'$  E and  $22^\circ 49'$  to  $23^\circ 19'$  N, with an altitude of 156 m to 2 944 m above sea level. It is one of the most typical terraced field areas in Yun-Gui Plateau. This area has a subtropical monsoon climate with a mean annual temperature of  $16.4^\circ\text{C}$ , a mean annual precipitation of 665.7–1 189.1 mm, a mean annual sunshine time of 1 770.2 h, and frost proof date of 363 d. The seasonal rainfall pattern shows the existence of two contrasting seasons: rainy season with moist monsoon from the south and dry season with dry monsoon from the north.

### Field sampling and analysis

The soil samples were collected from areas with different land use types and environmental factors such as altitude, gradient, and orientation of slope. Soil was collected during the fallow period. Five soil cores were randomly sampled from 0 to 20 cm depth in each sampling plot and mixed into a composite sample. A portable global positioning system (GPS) was used to locate the sampling sites and 437 sampling sites were selected in the Hani terraced fields of Yuanyang county in December 2010. After three weeks of air dry, all soil samples were crushed and sieved through a 0.18 mm sieve, and then used to determine SOM content according to the method of Walkley and Black (SSSSC, 1998).

### Statistical analysis and geostatistics

Basic statistical parameters such as mean, extreme value, standard deviation (SD), skewness, kurtosis and coefficient of variation (CV) were analyzed. One sample Kolmogorov-Smirnov (K-S) test was used to examine the normality of the data. One-way analysis of variance (ANOVA) and Duncan's test (Duncan,

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