Influence of Topographical Factors on Spatial Distribution Characteristics of Soil Nutrients in Qinba Mountain Area

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Abstract. To study the spatial distribution characteristics of soil nutrients in different micro-topography and their correlation with topographic factors, to provide reference basis for soil resource nutrient management and ecological environment construction in other areas with the same topography. This paper is based on 150 soil samples from 3 main tea-producing areas in Shangnan County, and analysis methods such as sampling analysis of variance and correlation analysis are applied to soil organic matter, total nitrogen, available potassium, and available phosphorus under different micro-topography (slope, aspect, and slope position). The spatial distribution characteristics of phosphorus were analyzed and the correlation between soil nutrients and topographic factors was explored. The results showed that the contents of soil organic matter, total nitrogen, available potassium, and available phosphorus in the surface layer (0-10cm) of the study area were significantly higher than those in the middle and lower layers of soil, all of which were of moderate intensity variation. Soil total nitrogen, available potassium, and available phosphorus were affected to some extent by slope, aspect, and slope position. In general, soil total nitrogen, organic matter content, and slope position are significantly negatively correlated (P <0.05), and the slope direction showed a very significant positive correlation (P <0.01), while the soil available potassium and available phosphorus had a negative correlation with the slope position and slope (P <0.05).

1. Introduction

Soil nutrients contain the nutrients necessary for the growth and development of tea plants, and are the material basis of soil fertility, which largely determines the yield and quality of tea [1]. Soil water and heat distribution conditions and material movement and accumulation characteristics are significantly different under different altitudes, slopes, and slope topography conditions, especially in mountainous areas. Under similar conditions of soil formation in the same area, soil nutrients are often caused by...
different terrains. The spatial differentiation of the land, therefore, the topography and landform characteristics affect the surface soil nutrient content and spatial distribution characteristics [2-4]. For a long time, domestic and foreign scholars have done a lot of research on the correlation between soil nutrients and topographic factors. Deng Ouping [5] used geostatistical methods to study the correlation between the four topographic factors of slope position, slope, aspect and shape in the purple hilly area of central Sichuan and their different combinations and the spatial distribution of soil nutrients. Slope and aspect have a strong influence on the distribution of soil nutrients; Zhao Yue [6] et al. Took Xiajiang County, Jiangxi Province as an example, and discussed the relationship between soil nutrients and elevation, slope, and aspect using geostatistics and GIS technology. Correlation; Yang Jianhu [7] analyzed the spatial characteristics of soil nutrient content and its correlation with topographic factors using the Hongyanhe small watershed in Bin County, Shaanxi as an example. Shangnan County is the northernmost emerging tea area in western China, with special geographical conditions, tea industry has become the number one leading industry and dominant industry in Shangnan County. At present, there are few studies on the influence of topographic factors on soil nutrients in tea gardens [8-9]. To this end, this paper mainly studies the spatial distribution characteristics and correlations of soil nutrients under different micro-topography, in order to provide a certain reference for soil nutrient management and ecological environment construction in other regions of the same terrain.

2. Materials and methods

2.1. Study area overview

The study area is located in Shangnan County, Shangluo City, Shaanxi Province, with geographic coordinates between 110°24'22"-110°01'43" east longitude and 33°05'53"-33°44'37" north latitude. The landform type is dominated by low mountains and hills, higher in the southwest and north, lower in the southeast and middle, sloping from northwest to southeast, crisscrossing the mountain, infiltrating rivers, forming palm-shaped veins of mountains, rivers, pings, and beaches Complex and diverse landforms. The climate belongs to the warm and semi-humid monsoon climate zone in the southern warm temperate zone. The annual average temperature is between 10.7-15.0 °C, and the annual average temperature is> 10 °C. The soil type is mainly yellow brown soil, with obvious vertical zonality and horizontal zonality. Shangnan County is the newest tea area in the northwest of China. The tea garden area of the county exceeds 240,000 acres, of which 155,000 acres have been exploited, and the total annual tea output reaches 2,800 tons.

2.2. Sampling method

In May 2019, soil samples of 0-10, 10-20 and 20-40 cm were collected from three major tea-producing areas in Shangnan County, namely, qingyouhe, guofenglou and jinsixia. Three sites were set up in each sample plot using the s-shaped sampling method, and a total of 150 soil samples were collected. During sampling, debris such as litter and weeds should be removed from the surrounding area. Soil samples should be collected at a distance of 30-35cm from the root of the tea tree. About 1 kg of soil samples should be collected at each sample point. After air drying, gravel, plant residue, roots and other debris were removed, ground and sifted (1mm and 0.149mm) for the determination of soil nutrient content.

2.3. Determination of soil nutrients and topographic factors

The content of soil organic matter was determined by potassium dichromate volumetric method and external heating method. The total nitrogen content of soil was determined by sulfuric acid-hydrogen peroxide water elimination distillation and nitrogen determination method. The content of available phosphorus in soil was determined by sodium bicarbonate extraction and molybdenum-antimony colorimetric method. The content of available potassium in soil was determined by ammonia acetate extraction and flame photometer. The longitude, latitude and altitude were measured by hand-held
GPS, and the slope and slope direction were measured by hand-held compass. Various topographic factors were classified as follows: (1) slope position: downhill position (< 500m), middle position (500-550m), and uphill position (> 550m). (2) slope: gentle slope (< 10°), moderate slope (10-15°), medium slope (15-25°), steep slope (> 25°); (3) slope direction: negative slope (0~45°, 315~360°), semi-positive slope (45~135°), positive slope (135~275°), semi-negative slope (275~315°).

2.4. Data processing
SPSS19.0 and Excel software were used for statistical analysis and data processing.

3. Result and analysis

3.1. The vertical distribution of soil nutrients
It can be seen from Table 1 that the soil nutrient content in the study area has a large difference in the vertical distribution between the soil layers, and it shows a decreasing trend as the depth of the soil layer increases, and the difference between the soil layers is similar, that is, 0-10 cm There is a significant difference between the 20-40cm soil layers (p <0.05), while there is no significant difference between the 0-10cm and 10-20cm soil layers, indicating that the phenomenon of soil nutrient accumulation in the study area is more obvious. The average contents of Total N, Available P, Available K and Organic matter in 0-40cm soil in the study area are 0.22g / kg, 9.99 g / kg, 75.62 g / kg and 3.27 g / kg respectively, among which the difference of available potassium The maximum and maximum values are 45 times the minimum value, and the maximum values of total nitrogen, available phosphorus and organic matter content are 16 times, 5 times and 19 times of the respective minimum values. From the point of view of the coefficient of variation, the coefficients of variation of total nitrogen, available potassium, available phosphorus, and organic matter at different soil depths range from 33% to 79%, which is a medium-intensity variation. Among them, the spatial coefficient of variation of total nitrogen is: top soil> intermediate soil> lower layer soil, the spatial coefficient of variation of available phosphorus is: middle layer soil> lower layer soil> surface layer soil; Soil> surface soil. Among the 4 nutrient indicators at 3 different levels, the coefficient of variation is the largest total nitrogen in the 0-10cm soil layer (CV = 0.79), and the smallest is the available potassium in the 20-40cm soil layer (CV = 0.41).

Table 1. Descriptive statistics value of soil nutrients of sampling points in the study area

| Soil nutrient | Soil depth | Max  | Min  | Mean  | multiple comparison | CV  |
|--------------|-----------|------|------|-------|--------------------|-----|
| Total N (g/kg) | 0-10 cm   | 0.84 | 0.12 | 0.29  | a                  | 0.79|
|              | 10-20 cm  | 0.49 | 0.12 | 0.24  | a                  | 0.54|
|              | 20-40 cm  | 0.19 | 0.05 | 0.13  | b                  | 0.53|
|              | 0-40 cm   | 0.84 | 0.05 | 0.22  | —                  | 0.75|
| Available P (g/kg) | 0-10 cm   | 22.18| 4.71 | 12.04 | a                  | 0.44|
|              | 10-20 cm  | 20.29| 3.12 | 9.85  | ab                 | 0.50|
|              | 20-40 cm  | 15.52| 1.21 | 8.09  | b                  | 0.47|
|              | 0-40 cm   | 22.18| 4.71 | 9.99  | —                  | 0.63|
| Available K(g/kg) | 0-10 cm   | 188.65| 44.18| 88.30 | a                  | 0.42|
|              | 10-20 cm  | 145.63| 33.69| 71.27 | ab                 | 0.42|
|              | 20-40 cm  | 123.94| 33.69| 67.29 | b                  | 0.41|
|              | 0-40 cm   | 188.65| 4.18 | 75.62 | —                  | 0.49|
| Organic matter (g/kg) | 0-10 cm   | 19.14| 6.02 | 12.03 | a                  | 0.39|
|              | 10-20 cm  | 16.37| 2.93 | 7.41  | ab                 | 0.45|
|              | 20-40 cm  | 7.74 | 1.01 | 3.27  | b                  | 0.55|
|              | 0-40 cm   | 19.14| 1.01 | 7.57  | —                  | 0.42|

Note: Different letters in the same column indicate significant differences between treatments (p <0.05)
3.2. Distribution characteristics of soil nutrients under microtopography

It can be seen from Table 2 that the total nitrogen, available potassium, available phosphorus and organic matter content of the soil in the study area under different slope positions all decreased with the increase of the slope position, that is, the upper slope position < middle slope position < lower slope position. This is due to the fact that tea gardens in southern Shaanxi are mostly hills and hills, with poor soil water retention and fertility, steep topography, and strong rainfall leaching. Nutrient elements in the soil at the upper slope are washed down by rainfall and runoff, and are low in the lower slope. Accumulation of parts [10]. From the analysis of the differences between the different nutrients in the slope position, we can see that the content of soil organic matter and available nutrients in the lower slope position is significantly higher than that in the middle and upper slope positions (P < 0.05), but the difference between the middle and upper slope positions is not significant.

On the slope, the content of soil organic matter, total nitrogen and available potassium decreased with the increase of slope, and the highest content was on the gentle slope, which were 10.17 g / kg, 0.28 g / kg and 117.28g / kg, which was 1.6, 1.4 and 2.0 times. However, the differences in soil organic matter and total nitrogen between different slopes were not significant (p> 0.05), while the difference in the available potassium content between gentle and steep slopes reached a significant level (p <0.05). This is because soil available potassium is easily soluble in surface runoff, and slope is an important factor affecting the soil erosion process on slopes. The greater the slope, the greater the amount of soil erosion, and the more potassium will be lost. However, the available phosphorus content in the soil showed a trend of medium slope > steep slope > gentle slope, and the difference between gentle slope and middle slope, steep slope and gentle slope reached a significant level (p <0.05). This is mainly because the available phosphorus in the soil is mainly combined with the fine particles in the soil. There are relatively few human activities on the steep and middle slopes, the vegetation coverage is relatively good, and the amount of sediment carried away by runoff erosion is small [11].

On the slope, the total nitrogen and organic matter content of the shaded and semi-positive slopes were significantly higher than that of the semi-shaded and sunny slopes (p <0.05), while the contents of available potassium and available phosphorus were significantly higher than those of the semi- and sunny slopes. Half shade slope and shade slope (p <0.05). This is because different slopes receive different light and rain conditions. The sunny, semi-sunny, and semi-shade slopes are moderately exposed to sunlight, the temperature is suitable, the microbial activity is high, and the decomposition and oxidation rates of organic matter and nitrogen are accelerated. Not conducive to nutrient accumulation [12].

| Aspect of Slope   | Shady slope | Semi-sunny slope | Sunny slope | Semi-shady slope |
|-------------------|-------------|------------------|-------------|------------------|
| Microtopography   | 8.49±0.60a  | 8.26±0.42a       | 5.89±0.58b  | 6.35±0.71b       |
| Available P (g/kg) | 12.10±1.48a | 12.24±0.76a      | 11.45±0.62a | 7.50±1.01b       |
| Available K (g/kg) | 63.80±3.68ab| 75.65±5.33ab     | 60.09±3.28b | 56.57±18.34b     |

Note: arithmetic mean ± standard error; Different letters in the same column indicate significant differences between treatments (p<0.05).
3.3. Correlation analysis of soil factors and topographic factors

According to the correlation analysis in Table 3, in addition to available phosphorus, total nitrogen, organic matter and slope have a negative correlation between the study area, available potassium and slope have a significant negative correlation (p < 0.05), and available potassium and slope have a significant positive correlation (p < 0.05). The soil available nutrients and organic matter content were positively correlated with the slope direction. Among them, the soil total nitrogen and organic matter content were extremely significantly positively correlated with the slope direction (p < 0.01), which indicated that the soil nutrient content was also subject to light to some extent Restrictions directly affect the decomposition rate of organic matter. Both the available soil nutrients and organic matter were significantly negatively correlated with the slope position (p < 0.01), indicating that under the effect of long-term runoff erosion, the nutrient elements on the top of the slope continuously migrated to the bottom of the slope [13].

Table 3. The correlation analysis between soil properties and topography factors

| Index          | Total N | Available K | Available P | Organic matter | slope | Aspect of Slope | Position of Slope |
|----------------|---------|-------------|-------------|----------------|-------|----------------|------------------|
| Total N        | 1.000   | —           | —           | —              | —     | —              | —                |
| Available K    | 0.201** | —           | —           | —              | —     | —              | —                |
| Available P    | 0.123*  | 0.195**     | 1.000       | —              | —     | —              | —                |
| Organic matter| 0.733** | 0.228**     | 0.057       | 1.000          | —     | —              | —                |
| slope          | -0.068  | -0.152*     | 0.148*      | -0.034         | 1.000 | —              | —                |
| Aspect of Slope| 0.157** | 0.080       | 0.100       | 0.200**        | 0.251*| 1.000          | —                |
| Position of Slope | -0.520** | -0.486*    | -0.403*     | -0.432*        | 0.105 | 0.102          | 1.000            |

Note: * and **represent significant correlation (p<0.05) and extremely significant correlation (p<0.01), respectively.

4. Discussion

The content of soil organic matter, total nitrogen, available phosphorus and available potassium in the 0-10cm soil layer in the study area is significantly higher than that in the 20-40cm soil layer by 123.1%, 48.8%, 31.2% and 267.8%. This is related to the decomposition of tea tree litter to the surface soil to provide nutrients. The coefficients of variation of soil nutrients in different soil layers are between 0.1 ≤ CV ≤ 1, which are all medium-intensity variations. Among them, the relatively largest coefficient of variation is total nitrogen in 0-10cm soil layers (CV = 0.79), and the smallest is 20-Available potassium in 40cm soil layer (CV = 0.41).

Comprehensive analysis of the content characteristics of soil available nutrients, total nitrogen and organic matter under different micro-topography shows that slope position, slope and aspect have a strong influence on the distribution of soil nutrients in the study area, especially total nitrogen and organic matter in different slopes There is a significant difference between the location and different slopes, and the slope mainly affects the soil available phosphorus and available potassium. Correlation analysis results show that the study total nitrogen and organic matter content are significantly negatively correlated with slope position (P < 0.05), and extremely significantly positively correlated with slope direction (P < 0.01), while soil available potassium and available phosphorus are related to slope The position and slope were extremely negatively correlated (P < 0.05). Therefore, in this study area, slope direction and slope position are the main micro-topographic factors affecting soil organic matter and total nitrogen content, while slope and slope position are the main micro-topographic factors affecting soil available nutrients.

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