Status and Evaluation of the Soil Nutrients in Tea Plantation

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Abstract

The objective of this study was to analyze the abundance and deficiency status of soil nutrient in tea plantations. By the methods of matter-element model, the plentiful-lack condition of soil nutrients were evaluated from single indicators and integrated indicators on the basis of the analysis in a small-scale soil nutrient status in tea plantation soils of Mengding Mountain. The results showed that (1) Soil nutrient levels were low in tea plantation, and the distribution of total nitrogen, total phosphorus, total potassium concentration was obviously concentrated. The distribution of alkali-hydrolysable nitrogen, available phosphorus and potassium dispersed highly and alkali-hydrolysable nitrogen was most obvious. (2) Soil nutrient levels of single indicator mainly concentrated in low and marginal, and nearly 90% of the integrated indicator of soil nutrient factors were in a state of the middle and low level.

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Keywords: tea plantation; soil nutrient; single index evaluation; synthetical evaluation; status

1. Introduction

Tea is important economic crops in subtropical area china. Planting area has reached 1.1 million hm\textsuperscript{2}. The main reason why variation of soil properties is difference of soil parent material, climate, irrigation and biological activity (including humans). Relative shortage of soil nutrient content, fertilization extensive management soil acidification problems are more prominent\cite{1,2}, which Seriously restricted the sustainable development of the tea production and the sustainable utilization of the tea plantation soil, and soil nutrient status is the decisive factor of whether tea grown vigorous and the tea quality\cite{3}.

The soil nutrient is a multiple index system. In terms of different types of soil nutrient evaluation speaking, there is no unified evaluation system and method yet. Previous studies mainly choose soil
nitrogen, phosphorus and potassium as index to evaluate, but because of different standers of rank index
and the coefficient of relative weight in created subjectively soil fertility level index, promotion
application is poorer. With the permeability and the widespread application of the modern research
methods, such as numerical value evaluation and black-box method, fuzzy mathematics method and
multivariate statistical analysis methods, soil nutrient evaluation gradually emphasizes on the quantitative
evaluation and multi-factor comprehensive evaluation. But during the process of evaluation, man-made
factors interferences the assessment results. In the early 1980s, the matter element analysis was put
forward [4], which might eliminate the influence of the artificial factor and improve evaluation precision
in the process of evaluation. At present, this theoretical model widely in comprehensive evaluation of
environmental quality assessment, grading product quality and some aspects of agricultural resources
evaluation [5-8], but is seldom applied in the soil nutrient evaluation. Mengding Mountamin tea garden is
located in Mingshan county, Sichuan province, is of typical low mountains physiognomy, directs the
northeast to southwest, belongs to subtropical monsoon climate, and is one of the cradles in the Chinese
tea culture. Therefore, this paper applies the matter element model analysis method to evaluate the soil
nutrients of Mengding Mountamin tea garden, in order to provide scientific guiding to balance
fertilization, which has important practical significance on soil sustainable utilization of regional garden.

2. Materials and methods

2.1. Description of the study Area

Mengding Mountain, located in Ya’an, Sichuan Province, China, has a subtropical monsoon climate and
a precipitation of more than 1 800 mm, with ridges tending from northeast to southwest. It is the original
site of Chinese tea culture and a historical base for tribute tea production. The tea garden where this study
has been conducted is a typically hilly site. It is built on the hillside and mostly spread on the solar-aspect
side with an area of 51.80 ha, a slope of 15-35°, an aspect of 105-160°, an altitude of 900-1450m, and
atopographic orientation of northwest to southeast. Equal cultivation and management of the garden have
been performed, and soil types are yellow earth and purple earth (acid), developed from sandy parent
materials.

2.2. Soil sampling on a small scale

Within the circumference of the whole garden, a total of 106 soil samples were stochastically collected
by means of gridding (grid size, 80 m × 120 m) alongside the tea rows (more samples were taken from the
rugged terrain) (Meng et al. 2003) (Figure 1). Each sample was gathered by mixing five presamples taken at
a radius of 10 m from the presumed node, and the geographic location of each sampling site was recorded
by GPS (GARMIN 72). Soil samplings were performed after tea picking and before fertilization, and top soil
(0-20 cm) was dug under the canopies of tea bushes.
2.3. Items and methods of determination

Soil total nitrogen, total phosphorus, total potassium, alkali-hydro nitrogen, available phosphorus and available potassium is determined by adopting conventional methods [9].

2.4. Data processing

Soil nutrient is evaluated by using matter-element model analysis. First use sorting degree judgment matrix indirect method to construct tectonic judgment matrix, and then using AHP decision analysis method determines the index weight, thus soil nutrient value of the weight of evaluation factors in Mengding Mountain garden are obtained (Table 1). According to the soil nutrient’s classification standards of the second national investigation, the matter-element model analysis method is applied to evaluate the situation of each sample point single index. On this basis, grade comprehensive index of soil nutrient in each sample point to differentiate grades.

3. Results and discussion

3.1. Status analysis of soil nutrient

From the Table 2, the levels of soil total nitrogen are between 0.65-2.10 g/kg, the standard deviation is 0.027, Nutrient content range is smaller, and these show that garden soil total nitrogen content distribution was uniformity. The levels of Soil total phosphorus are between 0.27-1.69 g/kg, the standard deviation is 0.031, these show that variety point total phosphorus distribution is also relatively uniform. The grades of soil total potassium are between 9.82-16.39 g/kg, the average is slightly lower than the median, the standard deviation is 0.102, every point of soil total potassium content distribution is also more concentrated. The levels of Soil alkali-hydrolysable nitrogen are between 24.12-143.84 mg/kg, its standard deviation is 22.488, the discrete degree is higher. These show that the difference of distribution in variety point soil alkali-hydro nitrogen is the largest. The levels of Soil available phosphorus are between 0.56-34.89 mg/kg, the average is slightly higher than the median, the standard deviation is 8.003, its content distribution has a wider range, These show that the soil sample point of rapidly-available phosphorus are more decentralized. The levels of Soil available potassium are between 24.48-100.84 mg/kg, the average is higher than the median, These show the fluctuation of available potassium content is bigger, and every point of available potassium content differences are significant.
3.2. Evaluation of soil nutrient situation in single index

Related calculation results of soil nutrient levels in single index of each sample point are obtained by matter-element analysis on soil sampling study area (Table 3). Through all the sampling soil nutrient levels of related calculation results statistical, grade distribution of soil nutrient in single index is draw (Table 4).

About 20% of the soil total nitrogen content is at a high or higher level, and 85% of the total nitrogen content in soil is at a lower level. From above, it is visible that soil nitrogen in Mengding Mountain garden shows loss in some degree, and overall level of nitrogen is relatively low. Above 70% of soil total phosphorus is at a deficient nutrient level, with the rest of the soil total phosphorus concentrates at a medium-low level. Because phosphorus moves difficultly in soil, fertilizer could markedly improve phosphorus content of surface soil, in order to meet the demand of tea growing. Therefore, attention shall be paid to increase phosphate appropriately in view of soil in Mengding Mountain garden. Grade distribution of total potassium is relatively concentrative, and 91.51% of soil total potassium content is at a very low level. Therefore, we need to adopt some certain measures to add potassium fertilizer and maintain the sustainable utilization of the garden soil. 50.94% soil alkali-hydrolysable nitrogen content in IV level in tea plantation, 31.13% soil alkali-hydrolysable nitrogen content belongs to the V grade, the soil at a range of alkali-hydro nitrogen level of suitable tea plantation high yield only occupied around 15%, that accounts for soil alkali-hydrolysable nitrogen overall level of study area is lower. Proper amount of nitrogen has very good promoting effect to improve the tea yield and quality, but excessive nitrogen not only will make tea quality reduced, but also still can bring about tea plantation soil acidification, cause environmental pollution and harm to human health. Therefore, in the tea plantation soil nitrogen management, on the one hand, we should consider the demand of nitrogen for high quality and high yield tea, and must to avoid excessive amounts nitrogen. Available phosphorus status grade distribution is more decentralized, grade IV , V and VI account for 25.47%, 13.21% and 32.07%respectively, more than 70% of the total, however, available phosphorus of the whole tea plantation soil is still in the lower level, that has become a important factor to restrict tea on the health growth. After application phosphorus , It is easy to form hard-soluble phosphate and be adsorbed and fixed by soil minerals or microorganism rapidly, and its utilization ratio hold only 10% ~ 25% in seasonal crop[9], therefore need to application phosphorus and organic fertilizer pertinently that improve the soil phosphorus supply capacity on the whole, and adopt various measures to adjust factors of effect soil phosphorus availability, increasing phosphorus effective degree. And soil available potassium grade IV and V account for 49.06% and 47.17% respectively, It shows tea plantation soil available potassium content is also lower barren level overall. In order to meet the needs of tea grown that should prevent fixation and erosion of potassium, and accelerate the release of available potassium, we should adjust soil potassium content by various measures to ensure soil has plenty of available potassium during the crop growth.

The above analyses knowable, the soil nutrient single indicators of Mengding mountain tea plantation focus mainly on level IV and V level, but a small regional single indicators nutrient in I grade, II grade, a few distribute in III grade, VI grade, It shows study area soil nutrient content is also lower barren level overall. In practical, we should be scientifically application and management fertilizer to improve yield and quality of the tea, for the actual production and management to provide scientific basis.

3.3. Evaluation of soil nutrients synthetically index

Based on single soil nutrients index, it assesses integrated soil nutrients with matter element model of project by the correlation degree function. The result of tea garden soil nutrients distribute condition could be got by analyzing sample soil nutrient statistics (Figure 5).

As Figure 6 shows, 78.30% of soil nutrients index ranks the IV grade, and 11.32% of the soil belongs to the III grade, only few of them are V and VI grade. In general, 90% of the soil is deficiency of nutrients,
which basically limits sustainable utilization of garden ground. In this situation, rational manuring and management, as well as new production and operation mode of "low input, high production and high quality" would be help to sustainable develop the garden.

4. Conclusions

The nitrogen, phosphorus and potassium contents of tea plantation were low. The distribution trends of total nitrogen, total phosphorus, total potassium is concentrated obviously but the distribution of alkali-hydrolysable nitrogen, available phosphorus and available potassium content are highly dispersive, the most obvious of which is the distribution of alkali-hydrolysable. Single index of tea plantation soil nutrients status levels is mainly Concentrated in the IV and V levels. Soil nutrients shows a low overall and a poor level; in addition to the distribution of total potassium status is scattered, the remaining distribution of soil nutrients are concentrated, which show a normal distribution characteristics. In the mass nearly 90% of tea plantation soil nutrients are in the medium-low level.

5. Acknowledgment

The research was supported by the National Natural Science Foundation of China (Grant No.40901138), supported by Foundation of Si’chuan Science and Technology Department (Grant No. 2010JY0083) and also supported by National Key Technology R&D Program in the 11th Five year Plan of china (Grant No. 2008BAD98B03).

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| Soil nutrient | Total nitrogen | Total phosphorus | Total potassium | Alkali-hydrolysable nitrogen | Available phosphorus | Available potassium |
|---------------|----------------|-----------------|----------------|-----------------------------|---------------------|-------------------|
| Weight        | 0.266          | 0.226           | 0.187          | 0.147                       | 0.107               | 0.067             |
### TABLE 2 DESCRIPTIVE STATISTICAL CHARACTERISTIC OF SOIL NUTRIENT

| Variate   | Sample number | Average | Minimum | Maximum | Standard deviation |
|-----------|---------------|---------|---------|---------|--------------------|
| TN (g/kg) | 106           | 1.14    | 0.65    | 2.10    | 0.027              |
| TP (g/kg) | 106           | 0.63    | 0.27    | 1.69    | 0.031              |
| TK (g/kg) | 106           | 3.61    | 9.82    | 16.39   | 0.102              |
| AN (mg/kg)| 106           | 70.49   | 24.12   | 143.84  | 8.003              |
| AP (mg/kg)| 106           | 8.74    | 0.56    | 34.89   | 22.488             |
| AK (mg/kg)| 106           | 52.19   | 24.48   | 100.84  | 14.640             |

### TABLE 3 THE RELEVANT STATISTICS OF SOIL NUTRIENTS

| Correlation degree | N01 | N02 | N03 | N04 | N05 | N06 | Grade |
|--------------------|-----|-----|-----|-----|-----|-----|-------|
| Kj (TN)            | -0.272 | 0.405 | -0.202 | -0.468 | -0.557 | -0.601 | II    |
| Kj (TP)            | -0.411 | -0.215 | 0.355 | -0.131 | -0.289 | -0.365 | III   |
| Kj (TK)            | -0.502 | -0.252 | -0.003 | 0.009 | -0.249 | -0.400 | IV    |
| Kj (AN)            | -0.490 | -0.362 | -0.150 | 0.449 | -0.178 | -0.378 | IV    |
| Kj (AP)            | -0.824 | -0.648 | -0.295 | 0.410 | -0.225 | -0.365 | IV    |
| Kj (AK)            | -0.714 | -0.618 | -0.428 | 0.145 | -0.112 | -0.322 | IV    |
| Kj (M1)            | -0.467 | -0.152 | -0.056 | -0.033 | -0.318 | -0.433 | IV    |

### TABLE 4 DISTRIBUTION OF SOIL NUTRIENT GRADE IN SINGLE INDEX

| Index | I Height | II Higher | III Middle | IV Low | V Impoverishment | VI Utmost impoverishment |
|-------|----------|-----------|------------|--------|------------------|--------------------------|
| Sample number | Proportion (%) | Sample number | Proportion (%) | Sample number | Proportion (%) | Sample number | Proportion (%) | Sample number | Proportion (%) | Sample number | Proportion (%) |
| TN    | 1        | 0.943     | 13         | 12.26  | 55               | 51.89                    | 35             | 33.02          | 2               | 1.89            | 0             | 0.00          |
| TP    | 0        | 0.000     | 1          | 0.94   | 15               | 14.15                    | 13             | 12.26          | 25              | 23.59           | 52            | 49.06         |
| TK    | 0        | 0.000     | 0          | 0.00   | 8                | 7.55                     | 97             | 91.51          | 1               | 0.94            | 0             | 0.00          |
| AN    | 0        | 0.000     | 4          | 3.77   | 13               | 12.26                    | 54             | 50.94          | 33              | 31.13           | 2             | 1.89          |
### Table 5: Distribution of Soil Nutrient Grade in Synthetically Index

| Grade            | Sample number | Proportion (%) |
|------------------|---------------|----------------|
| I Height         | 0             | 0              |
| II Higher        | 0             | 0              |
| III Middle       | 12            | 11.32          |
| IV Low           | 83            | 78.30          |
| V Impoverishment | 8             | 7.55           |
| VI Utmost        | 3             | 2.83           |