Research on the soil nutrient characteristics of tea plantation

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Abstract. This paper based on the sampling and analyzed the soil nutrient status in the tea plantation of Qishan Mountain, western Chongqing. The results show that soil pH value of the tea plantation was found to be acidic, and the available Phosphorus, available Manganese, available Zinc, available Copper and available Iron were abundant. While Organic matter, total Nitrogen, available Potassium, and effective Magnesium content were relatively lacking. There were significant differences in total Nitrogen, Organic matter, available Phosphorus, available Zinc, and available Iron between different tea planting years. Fertilization should be based on the soil nutrient status in the management of tea gardens, in order to increase the income of the plantation.

1. Introduction
Camellia sinensis is an important leaf economic crop in China. The tea leaves processed from tea buds and leaves are rich in essential functional ingredients such as essential oils, caffeine, alkaloids and polyphenols, which have a variety of health effects such as anti-cancer, anti-oxidation, anti-bacterial, and reduce the risk of cardiovascular disease. Tea trees growing in the open system of nature is affected by many environmental factors during the growth and development process, such as the heterogeneity of light, temperature, water and soil nutrients in time and space, and the influence of various diseases and pests. In recent years, with the growth of tea economic benefits, the relationship between the growth conditions of tea trees and product quality has received increasing attention. Liu Yan-li et al described the process of tea tree absorption, transport, accumulation and detoxification of aluminum and fluorine through a research system. Zhao Feng investigated the content of rare earth in commercially available tea and found that the rare earth content of tea difference with different producing areas. Liu Haiyan et al found that the content of zinc and selenium in soil is derived from the parent rock and directly affects the quality of tea [1]. Wang Yan dan et al found that the TN migration flux increased with the increase of tea planting years in tea plantation soils with 0-20 cm and 0-40 cm soil layers, while DON migration flux in 0-20 cm soil layer was significantly positively correlated with tea planting age, the migration of NH4+-N did not change with the age of tea planting, the pH value of tea garden soil had no significant effect on the change of nitrogen migration. The content of phosphorus in soil plays a vital role in soil fertility and tea quality, the higher average level of available phosphorus, the more conducive to tea growth [2].

Yongchuan District, located in the western part of Chongqing, is rich in tea, which is a needle-shaped tea belonging to green tea. The production areas mainly include the five mountain ranges of Yunwu...
Mountain, Yinshan Mountain, Bayue Mountain, Qishan Mountain and Cucumber Mountain in Yongchuan District. It was developed and produced by the Tea Research Institute of Chongqing Academy of Agricultural Sciences in 1959. In 1964, it was officially named as Yongchuan Xiuya by the famous tea expert Professor Chen Wei. The tea is rich in 15 kinds of minerals such as potassium, calcium, magnesium and manganese. This study analyzed the soil nutrient status of Qishan Tea Garden in the main producing area of Yongchuan, in order to better understand the soil environment of Yongchuan tea, which could provide a useful reference for improving the management level of tea garden and improving tea quality.

2. Research methods
Yongchuan District is located in the west of Chongqing and the upper reaches of the Yangtze River. It is located between E105°38’~106°05’and N28°56’~29°34’. Which belongs to the subtropical monsoon humid climate, with an annual average temperature of 17.7 °C. The annual average rainfall is 1015.0 mm, the average sunshine is 1218.7 hours, and the annual average frost-free period is 317 days. The geological structure is part of the slanting platform of the Yangtze River. There are many mountains in the territory, including Yunwu Mountain, Yinshan Mountain, Bayue Mountain, Qishan Mountain and Cucumber Mountain. The five mountain ranges are northeast-southwest trending. The soil types are mainly purple soil and purple mud fields. Yongchuan District is rich in tea, the main producing area is mainly the Qishan Mountain in the north of Yongchuan City. The highest point of Qishan Mountain is more than 1,200 meters above sea level, with an area of 117 square kilometers and a total length of 33 kilometers. The forest coverage rate is 97% and there are 1333 hectare tea garden, which is Asia's largest contiguous and 3333 hectare of Bashu's largest bamboo sea, the average temperature was 14 °C, per cubic centimeter of negative oxygen ion content of up to 30,000, which is the first natural oxygen bar in western Yunnan [3]. The foothills of Qishan Mountain are mainly crops, supplemented by economic crops and gardens, and grasslands are scattered in some areas. A large number of stepped tea gardens are distributed in the northern and southern parts of the lower elevation of Qishan Mount.

In October 2017, 50 soil samples were collected at the Qishan Tea Plantation in accordance with the tea planting years of 5, 10, 20 and 30 years. 200 soil samples was collected in total, Before collecting the sampling area was divided to several units according to the soil type, the soil properties of each unit were as uniform as possible. According to the principle of random, equal-quantity and multi-point mixing, take “S”-shaped cloth points, take 5 samples for each sample, every sample point is in the middle of the tea line, or outside the tea line edge tea drip line, avoiding fertilization Ditch sampling, sampling depth of 0-30cm. Discard the excess soil with the quadruple method and leave about 1 kg mixed soil sample.

The soil sample was sent to the laboratory to dry, and the pH value and the available phosphorus and available potassium content were measured by air-dried soil passing through a 1 mm aperture sieve; the contents of organic matter, total nitrogen and medium and trace elements were measured by a 0.25 mm aperture sieve sample. The pH value was measured by a pH meter. The soil organic matter was determined by potassium dichromate method. The total nitrogen (TN) was decomposed with concentrated sulfuric acid by a catalyst, and the Kelvin nitrogen analyzer was used. The effective phosphorus was extracted with sodium bicarbonate Method, trace elements in samples were determined by inductively coupled plasma mass spectrometry [4].

3. Result analysed

3.1. Analysis of soil nutrient status in tea plantations in Qishan
The sample data were analyzed and processed by Excel 2013 and SPSS19.0 software. The soil nutrient analysis results of the Laoshan tea plantation in western Yunnan are shown in Table 1.
Table 1. Soil nutrient analysis results of Qishan tea garden

| Category                | Maximum value | Minimum value | Average value | Standard deviation | Evaluation |
|-------------------------|---------------|---------------|---------------|--------------------|------------|
| Ph                      | 7.5           | 3.9           | 4.8           | 0.49               | Acidic     |
| Total nitrogen(%)       | 2.41          | 0.10          | 0.16          | 0.22               | Shortage   |
| Organic matter (g/kg)   | 86.8          | 11.3          | 29.6          | 5.44               | Shortage   |
| Effective phosphorus (mg/kg) | 49.7       | 12.0          | 27.8          | 4.64               | Enrichment |
| Quick-acting potassium (mg/kg) | 128.5     | 9.6           | 31.2          | 15.32              | Shortage   |
| Effective magnesium (mg/kg) | 165.3      | 9.1           | 41.7          | 19.86              | Shortage   |
| Effective manganese (mg/kg) | 245.2      | 4.9           | 40.2          | 21.32              | Enrichment |
| Effective zinc (mg/kg)   | 76.8          | 5.1           | 16.4          | 5.32               | Enrichment |
| Effective copper (mg/kg) | 16.6          | 2.8           | 5.1           | 2.78               | Enrichment |
| Effective iron (mg/kg)   | 523.1         | 29.7          | 202.5         | 45.37              | Enrichment |

The highest soil pH value of the tea plantation in Qishan Mountain was 7.5, while the lowest is 3.9, the average is 4.8, and the pH value of the sample which less than 4.8, accounting for 69.2% of the total, and the soil is acidic in total. One aspect was that the rainfall in the research area was weakly acidic, and the long-term rainfall infiltration leaded to the soil being weakly acidic. Second, fertilization was another factor that causes soil acidity, especially excessive nitrogen fertilizer. Third, the root metabolism of the tea tree itself was also Causes acidification of tea garden soil. Acidic soil with pH value less than 4.8 is not conducive to the healthy growth of tea trees. Acidic fertilizer should be used less. At the same time, soil improvement measures should be taken to adjust. Organic fertilizer can be applied to increase the stress resistance of the soil. Magnesium fertilizers increase the exchangeable Ca2+ and other based ions could regulate soil pH in a reasonable range.

The soil total nitrogen content was usually used to reflect the fertility and nitrogen supply, and the soil total nitrogen content was positively correlated with the tea yield. The total nitrogen content of the tea plantation in Qishan Mountain with the highest value at 2.41%, and the lowest at 0.10%, the average value was 0.16%. The total nitrogen content of high-quality tea garden soils is usually required to be higher than 0.1%. The soil nitrogen content of the tea plantation in Qishan Mountain was generally higher, mainly because the plantation applied a certain amount of nitrogen fertilizer every year. In the future management process, the plantation can reduce the amount of nitrogen fertilizer, which could not only reduce the planting cost, reduce the agricultural non-point source pollution caused by excessive nitrogen fertilizer, but also prevent the nitrate content in the tea from exceeding the standard, thus improving the tea quality.

The soil organic matter content of the tea plantation in Qishan Mountain, ranged from 11.3 to 86.8 g/kg, with an average of 29.6 g/kg, the content lower than 29.6 g/kg, accounting for 65.8%. Previous studies have shown that soil organic matter content in high-quality, high-yield and high-efficiency tea gardens was usually required to be higher than 30g/kg. The soil organic matter content in the tea plantation in Qishan Mountain was generally shortage. This may be due to the low use of organic fertilizer in the plantation and the deterioration of soil ripening. In the future management of the area, organic fertilizer should be applied to increase soil organic matter content.

The soil available phosphorus content in the tea plantation of Qishan Mountain was 12.0 mg/kg, the highest value was 49.7 mg/kg, and the average value was 29.6 mg/kg. The effective phosphorus content of high-quality and high-yield tea garden soil was usually higher than 25 mg/kg. The effective phosphorus in tea garden soil less than 25mg/kg, accounting for 8.6%, which was basically no shortage. The main reason was that tea farmers usually apply compound fertilizer in recent years. The effective phosphorus in compound fertilizer was accumulated in soil by a certain part, resulted in soil phosphorus rich. As a result, the excess of phosphate fertilizer in the soil may lead to the reproductive growth of tea trees. Therefore, the amount of phosphate fertilizer should be controlled and reduced in the future management.

The soil available potassium content in the tea plantation of Qishan Mountain was between 9.6 and 128.5 mg/kg, with an average value of 31.2 mg/kg. The soil available potassium content in high-
quality, high-yield and high-efficiency tea gardens was usually higher than 25.0 mg/kg, while the soil available potassium content in Qishan tea plantation lower than 25.0 mg/kg, accounting for 40.5%. Although the average content of available potassium in the tea plantation in Qishan Mountain of has reached the level of potassium in high quality tea gardens, but the soil available potassium content in different places within the tea garden varies greatly, and nearly half of the areas was lower than the soil requirements for high quality and high yielding high quality tea gardens. Potash should be added to planting areas where the available potassium content was less than 25.0 mg/kg.

The soil available magnesium content in the tea plantation of Qishan Mountain was between 9.1 and 165.3 mg/kg, with an average content of 41.7 mg/kg. The effective manganese content ranges from 4.9 to 245.2 mg/kg, and the effective zinc content ranges from 5.1 to 76.8 mg/kg. The effective copper content ranges from 2.8 to 16.6 mg/kg, the effective iron content ranges from 29.7 to 523.1 mg/kg. High-quality, high-yield and high-efficiency tea gardens usually require an effective magnesium content of more than 50.0 mg/kg, an effective zinc content of more than 2.0 mg/kg, an effective copper content of more than 1.0 mg/kg, and an effective iron content of more than 10 mg/kg. It was found that the content of available zinc, available copper and available iron in the tea plantation of Qishan Mountain were higher than that of high-quality and high-yield high-efficiency tea gardens, and the effective magnesium content was low. For tea plantation area with effective magnesium content less than 50.0 mg/kg, should pay more attention to the application of magnesium fertilizer.

Table 2. Soil nutrient analysis results with different planting years

| Category              | 5 years     | 10 years    | 20 years    | 30 years    |
|-----------------------|-------------|-------------|-------------|-------------|
| Ph                    | 5.40±1.11a  | 4.90±1.24a  | 4.60±0.92a  | 4.70±0.84a  |
| Total nitrogen (%)    | 0.21±0.08a  | 0.19±0.06a  | 0.14±0.04ab | 0.12±0.05b  |
| Organic matter (g/kg) | 22.3±3.54a  | 25.7±4.32ab | 29.8±3.88ab | 31.2±4.21b  |
| Effective phosphorus (mg/kg) | 33.2±4.21a   | 29.1±3.98ab | 27.2±2.56ab | 24.3±3.12b  |
| Quick-acting potassium (mg/kg) | 36.7±4.25a | 33.2±5.22a | 36.5±4.78a | 27.4±4.18a |
| Effective magnesium (mg/kg) | 39.6±5.11a | 41.9±4.87a | 42.6±4.85a | 40.2±4.23a |
| Effective manganese (mg/kg) | 41.3±5.68a | 36.7±4.76a | 43.1±3.21a | 36.2±4.19a |
| Effective zinc (mg/kg)  | 28.4±3.87a  | 22.1±4.13ab | 13.1±2.25b | 10.6±2.74b |
| Effective copper (mg/kg) | 4.10±0.98a  | 5.60±1.11a  | 3.90±0.91a | 6.00±1.42a  |
| Effective iron (mg/kg) | 245.20±15.28a | 276.40±16.75a | 199.50±10.82b | 169.90±14.75b |

Note: Different lowercase letters in the same column indicate significant differences in values (P<0.05).

3.2. Analysis of soil nutrients in different planting years of tea plantation

There was no significant difference in soil pH between different planting years of tea plantation in Qishan Mountain tea plantation, indicating that soil pH was mainly affected by rainfall and fertilization (Table 2). The total nitrogen content of soil showed a decreasing trend with the increase of planting years. The 30-year-old planting area was significantly lower than the 5-year and 10-year areas, mainly caused by the more fertilization of tea trees in the new planting area. The content of organic matter and available phosphorus increased with the increase of tea planting years. The 30-year planting area was significantly higher than the 5-year area, mainly due to the strong growth of young tea trees and high yield, and the consumption of soil organic matter and available phosphorus was more. As the age of the tree grows, the growth and yield gradually decrease, and the organic matter and available phosphorus consumed decrease accordingly. The contents of available potassium, available magnesium, available manganese and available iron in different ages were not significant, and the difference in content was mainly caused by regional heterogeneity. The content of available zinc and available iron decreased with the increase of tree age, and the lowest age was 30. The main reason was that with the increase of tree age, tea trees need to absorb more of these two elements to maintain their survival.

4. Conclusion

The growth status of tea trees and the quality are closely related with soils condition [5]. By sampled and analyzed the soil nutrient status in the tea plantation in Qishan Mountain, found that the soil pH
value of the tea plantation was acidic. There was no significant difference between different tea planting years, mainly due to rainfall and fertilization. For acidic soils with pH below 4.8, acid-based fertilizers should be used less, and soil improvement measures should be used for adjustment. The total nitrogen content of Laoshan tea plantation was 0.16%, which was better overall. It was beneficial to the use of nitrogen fertilizer, and the content showed a decreasing trend with the increase of planting years. The amount of nitrogen fertilizer should be reduced in the process of land management with high local nitrogen content. Which could reduce the planting cost, reduce the agricultural non-point source pollution caused by excessive nitrogen fertilizer, and prevent the nitrate content in the tea from exceeding the standard, thereby improving the quality of the tea. The average organic matter content of plantation soil was 29.6 g/kg, and the level was generally low. Organic fertilizer should be applied to increase soil organic matter content. The average available phosphorus content in soil was 29.6 mg/kg, which was basically non-deficient. Benefit from the use of compound fertilizer, the site with higher local effective phosphorus content should control and reduce the amount of phosphate fertilizer, the content of organic matter and available phosphorus were increase with the tea planting years, mainly due to the difference in the growth and metabolism of tea trees with the change of planting years. The average available potassium content in the plantation soil was 31.2 mg/kg, and the soil available potassium content in different places in the tea garden was different.

In terms of trace elements, the effective magnesium content of Qishan tea plantation was 41.7 mg/kg, the effective manganese content ranged from 4.9 to 245.2 mg/kg, the effective copper content ranged from 5.1 to 76.8 mg/kg, and the effective copper content ranged from 2.8 to 16.6 Mg/kg, effective iron content ranges from 29.7 to 523.1 mg/kg. The effective zinc, available copper and effective iron content were higher than the high-quality, high-yield and high-efficiency tea garden requirements, while the effective magnesium content was lower. For the tea plantation area with effective magnesium content less than 50.0 mg/kg, attention should be paid to the application of magnesium fertilizer. The contents of available magnesium, available manganese and available iron in different ages were not significant, and the difference in content was mainly caused by regional heterogeneity. The content of available zinc and available iron showed a tendency to decrease with increasing age.

Acknowledgments
This work was financially supported by Chongqing municipal education commission science and technology research program “Spatio-temporal differentiation of non-point source pollution load in Linjiang River Basin based on SWAT model”, Chongqing municipal education commission youth key teacher funding scheme “Study on ecological effect of typical vegetation communities in ecological conservation in Northeast Chongqing (2016054)”.

References
[1] H.Y. Liu, C.M.Hang, S.Y. Zhou, et al. Study on the Content Changes of Zinc and Selenium in Tea and Differences in the Planting Soil. Plant Science Journal, Commun.33 (2015) 237-243.
[2] L. K. Dong, B.Fang, L.B.Shi, et al. Comparative analysis of spatial heterogeneity of soil available phosphorus at the township scale. Resources and environment in the Yangzi basin, Commun.25 (2016) 1576-1584.
[3] A.Z. Wang. The research on brand mold of Tea Mountain and Bamboo Sea scenic spot in Chongqing based on visitor perception. Journal of Fujian forestry science and technology, Commun. (2015) 204-209.
[4] S.X. Liu, W.Q.Ji, D.J. Hou, et al. Study on the efficient determination method of 12 trace elements in soil. Anhui agriculture science of bull, Commun. 17(2017)60-62.
[5] X.N.Zhao, Y.H.Li, A.Q.Lu, et al. Effects of organic fertilizer on soil properties and tea quality in tea garden. Jiangsu agricultural sciences, Commun. 46(2018)119-124.