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Mango forest Soil Nutritional Components Analysis and Research in Dong District of Panzhihua City

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---***ABSTRACT***---
Purpose: the pH value of soil determines soil properties and determines whether the activities of plants and microbes in the soil are active or not. A large number of elements such as nitrogen, phosphorous and potassium in soil can reflect a basic characteristic of soil and play a guiding role in further fertilization and soil improvement. Organic matter can reflect the amount of humus in the soil, whether the soil is fertile, the fertility of the soil, and the activities of microbes in the soil. So, this study will focus on exploring the soil pH value, N, P, K factors such as organic matter, because the subjects as the mango trees, and Panzhihua is a large amount of planting mango region, therefore, to appeal the influence of factors on the mango is very direct, hope that the result of the experiment can provide some basic data on mango cultivation, to help farmers to further understanding of the nature of soil and fertilization. Methods: chemical measuring methods were applied to determine the soil pH, organic matter and N, P, K values or concentrations. Results: the average available phosphorus in the whole experimental area is only 5.24, which belongs to a slightly lower level. Conclusions: The content of phosphorus in the soil of mango forest is very low, and the phosphorus element is very deficient. It is suggested to apply phosphorus fertilizer, irrigate mango trees and reduce the pH value to improve the situation of low phosphorus.

Key words: *pH, soil N P K, organic matter, soil fertility*

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I. INTRODUCTION

1.1 Overseas and domestic research status

Soil fertility and chemistry, soil physics and soil ecology, soil carbon cycling and global change even include some contents expanded by using soil knowledge, such as remote sensing and information system of soil resources, nutrient cycling and regulation of ecosystem, soil environmental chemistry and remediation technology of polluted environment, etc. are the scope of previous soil science research, but with the number of human population (Xiong, 2016). With the increase of activities, the progress of science and technology, the content of soil science research has changed (Xiong, 2013). The development of soil science has gone through a long process and is developing continuously (Cabrera, 2015). Nowadays, great changes have taken place in the field of soil science. The direction of soil science is also towards deepening, systematization and comprehensiveness. The research center of soil science has also shifted to the study of material and energy cycle, the impact of soil on human environment, etc. (Xiong, 2015).

1.2 Main research contents

(1) Soil pH value: pH value is an important basic property of soil and one of the factors affecting fertility. It directly affects the existing state, transformation and availability of soil nutrients; pH value has a great impact on nitrification of nitrogen and mineralization of organic matter in soil, so it has a direct impact on the growth and development of plants (Madejón, 2014). The determination of pH value can provide a general understanding of soil acidity, alkalinity and salinity as a reference for soil improvement and utilization. In a series of physical and chemical analysis, soil pH is closely related to the analysis methods and results of many other projects, which is also a basis for reviewing the results of other projects (Xiong, 2012).

(2) Soil organic matter: The content of organic matter is an important indicator of soil fertility. Soil organic matter can be divided into fresh organic matter, semi-decomposed organic matter and humus according to its decomposition status. Humus in organic matter has complexation, which helps to eliminate soil pollution. For low-yielding fields, increasing organic matter content can improve soil fertility (Xiong, 2012). For high-

yielding fields, organic matter needs to be continuously supplemented because of the decomposition of organic matter. Humus can form complexes or chelates with phosphorus, iron and aluminium ions to avoid the formation of insoluble phosphate precipitation and increase the amount of available nutrients. Soil organic matter is composed of a series of organic compounds existing in soil, whose composition and structure are not uniform and whose main components are C and N (Zhang, 2012). It is an important part of the soil. Although soil organic matter accounts for only a small part of the total weight of the soil, it directly or indirectly affects many properties of the soil to a certain extent. It is related to the structure, tillage, water holding capacity, fertilizer and fertilizer conservation characteristics and production performance of the soil. It plays an important role in soil fertility, environmental protection, sustainable agricultural development and so on. Soil organic matter has a significant impact on the behavior of heavy metals, pesticides and other organic and inorganic pollutants, and soil organic matter plays an important role in the global carbon cycle. Therefore, it is considered to be the main cause of global warming (Xiong, 2017).

(3) Nitrogen: Nitrogen is also an important component of the vitamin and energy system in plants. Nitrogen has a great influence on plant growth and development. Plants need a lot of nitrogen because nitrogen is a component of protein, nucleic acid and chlorophyll in plants (Sun, 2006). Green plants use chlorophyll to convert light energy into chemical energy and inorganic matter into organic matter and oxygen through photosynthesis. Nitrogen is also a component of the vitamin and energy system in plants (Chen, 2010). When nitrogen is sufficient, plants can synthesize more proteins to promote cell division and growth. Therefore, plant leaf area increases rapidly and more leaf area can be used for photosynthesis (Weng, 2013).

(4) Phosphorus: Phosphorus plays an important role in plant nutrition. Most of the organic compounds in plants are composed of phosphorus. Phosphorus is also a component element of many important compounds such as nucleic acids, proteins and enzymes in plants (Ehleringer, 2000). Almost many important organic compounds in plants contain phosphorus. Phosphorus participates in the processes of photosynthesis, respiration, energy storage and transmission, cell division and cell enlargement in plants. Phosphorus can not only improve the quality of fruits, vegetables and grains, but also enhance the disease resistance, drought resistance and cold resistance of plants. Organophosphorus is a component of many important organic compounds, which can promote the production and movement of nitrogen-containing substances and carbohydrates in crops, such as starch, protein, oil and sugar, and other life activities.

(5) Potassium: Potassium is highly distributed in organs and tissues with active metabolism. It has the functions of ensuring the smooth progress of various metabolic processes, promoting plant growth, enhancing resistance to diseases and insect pests and lodging. Potassium can promote photosynthesis, and potassium deficiency can weaken photosynthesis (Connin, 2001). Potassium also promotes economic water use for plants. Because potassium ions accumulate more in crop cells, osmotic pressure increases and water diffuses freely. When potassium content is abundant, crops can effectively utilize water and keep it in the body to reduce water transpiration (Felipe, 2003). Potassium can enhance plant tolerance, such as drought, low temperature, salt content, pest and disease damage. The most common symptoms of potassium deficiency in plants are burns along the leaf margin, starting with the old leaves at the lower part of the plant, then slowly expanding to the upper leaves, accompanied by spots. If plants are deficient in potassium, they will grow slowly and their roots will develop poorly; their stems are fragile and often lodging; their seeds and fruits are small and wrinkled.

1.3 Research meaning

To determine the pH, organic matter, nitrogen, phosphorus and potassium content is to understand the soil nutrition component. Hope the data can help farmers and people to better understand the soil nutritional status and then help them to apply fertilizer rationally.

II. MATERIALS AND METHODS

2.1 Overview of the research area

Panzhihua City is a prefecture-level city in Sichuan Province, China. It is located in the south of Sichuan Province. It is adjacent to Yunnan Province on three sides, east, west and south. It is located in north latitude 26°05'- 27°21', east longitude 101°08'- 102°15'. Jinsha River and Yalong River meet here. The northern and eastern boundaries are Yanyuan, Huili and Dechang counties in Liangshan Yi Autonomous Prefecture, Sichuan Province, and the western and southern boundaries are Ninglang, Huaping and Yongren counties in Yunnan Province. Panzhihua City is a three-dimensional climate Island based on the subtropical zone of South Asia, which has four distinct seasons. Panzhihua has sufficient sunshine time, annual sunshine hours up to 2700 hours, strong ultraviolet radiation, large evaporation, and significant vertical climate differences.

Panzhihua City is located in the valley where the climate is warm. The annual average temperature is between 19 ~21 ℃. There is no severe cold in winter. The monthly average temperature in the coldest month is also above 11 ℃. June is the month with the highest monthly average temperature in the whole year, which is about 26 degrees centigrade. The annual total rainfall is 820-1100 mm, which is divided into dry and rainy seasons. Rainfall in rainy season (June-October) is highly concentrated, accounting for more than 85% of the annual rainfall. In this study, the soil of a mango forest in the Dong District of Panzhihua City was selected as the research object. The general layout of the sampling area is shown in Figure 1. The representative soil sampling points are selected for sampling.

Figure 1 Distribution of sampling points

There are seven sampling points. During the experiment, three parallel experiments are conducted at each sampling point.

Sampling points are shown in Figures 2 and 3.

Figure 2 Status of Mango Forest at Sampling Points

Figure 3 Soil condition at sampling point

2.2 Sample preparation

(1) Sample air-drying: In the air-drying room, wet soil samples are poured into white enamel discs or plastic film, spread into thin layers about 2 cm thick, and are crushed intermittently with glass rods, turned over to make them even air-drying. During the drying process, impurities such as gravel, gravel and plant residues are picked up.

(2) Grinding and sieving: After the soil sample is air-dried, it is ground in a grinding bowl and passed through 20 mesh and 100 mesh nylon sieves. The bag is sealed for reserve.

2.3 Measuring items and methods

pH: Electrode Method

Organic Matter: Burning Method

Alkaline hydrolyzed nitrogen: Alkali-hydrolyzed Diffusion Method

Available phosphorus: Sodium Bicarbonate Method

Available potassium: Ammonium Acetate-flame Photometer Method

III. RESULTS

3.1 Analysis of pH Data

Table 2 shows that the pH values of samples 2 and 4 are between 6.5 and 7.5, and the soil is neutral, accounting for 28.57% of the total soil samples. The pH values of samples 1, 3, 5, 6 and 7 are between 7.5 and 8.5, belonging to alkaline soil, accounting for 71.43% of the total soil samples. So in general, the soil is weak alkaline, so it is not so suitable for mango tree planting. Because the most suitable pH value of mango tree is 5.0-7.0, and most of the samples in the whole experiment are more than 7.0.

3.2 Data Analysis of Organic Matter

From Table 6, it can be seen that sample 1 belongs to grade 3, accounting for 14.29% of the total samples. Samples 2, 3, 4 belong to grade 2, accounting for 42.86% of the total samples. Samples 5, 6, 7 belong to grade 1, accounting for 42.86% of the total samples. Grade 1 and grade 2 account for 85.71% of the total samples. From Table 5, the average organic matter in the experimental area is as high as 3.77%. Therefore, this mango forest is extremely rich in organic matter. Mango tree is a kind of mycorrhizal plant, so the content of organic matter in soil has higher requirements, so the rich organic matter in the experimental area is extremely suitable for the growth of mango tree.

3.3 Analysis of alkali-hydrolyzed nitrogen data

Table 8 shows that 1, 3, 5, 6 and 7 of the seven samples are at a slightly higher level, accounting for 71.43% of the total number of samples; 2 samples are at a general level, accounting for 14.29% of the total number of samples; 4 samples are at a high level, accounting for 14.29% of the total number of samples. Because the total alkali-hydrolyzed nitrogen content is between 80-100 mg/kg, which belongs to a slightly higher level, it shows that alkali-hydrolyzed nitrogen is very rich. However, because of the different demand for nitrogen in different periods of the same plant, the demand for nitrogen in spring is the highest, up to 52%, while the demand for nitrogen in fruit expanding period decreases. Therefore, nitrogen fertilizer should be applied earlier, and it should be avoided during fruit ripening to prevent greening and late ripening.

3.4 Analysis of available phosphorus data

Table 11 shows that the content of 2,5,7 available phosphorus is lower than 5 mg/kg, belonging to low level, accounting for 42.86% of the total samples, while 1,3,4,6 available phosphorus are in 5-10 mg/kg, belonging to a slightly lower level, accounting for 42.86% of the total samples. Table 11 shows that the average available phosphorus in the whole experimental area is only 5.24, which belongs to a slightly lower level.

3.5 Data analysis of available potassium

Table 14 shows that the effective potassium content of sample 1, 2 and 3 are in the range of 60-100 mg/kg, which is medium level, accounting for 42.86% of the total samples; sample 4 is high level; sample 5, 6 and 7 are very high level, accounting for 42.86% of the total samples. Table 14 shows that the average level of the whole experimental area is 147.21, which belongs to a high level. This shows that the effective potassium content in the experimental area is very rich. Rich potassium can make mango branches strong, disease-resistant and drought-tolerant, while bearing more fruit, fruit sweet, very conducive to the growth of mango trees and fruit breeding, and ensure the yield and quality of mango.

IV. DISCUSSIONS

Agricultural pH improvement method: mainly salt washing improvement, because water is not only the factor of soil salt accumulation, but also the power of desalination. Perfect all kinds of related water conservancy facilities, implement the combination of rivers, ditches, canals, wells, and irrigation, and match the storage, drainage and irrigation. Reasonable irrigation can promote the water circulation in nature, and can also wash out part of the salt in the soil, so as to achieve the purpose of reducing the pH value.

Chemical improvement: (1) Applying phosphogypsum. Phosphogypsum can increase the content of active calcium cations in soil, reduce the harm of sodium carbonate and sodium bicarbonate to crops, and reduce the pH value. (2) Skillful application of chemical fertilizers. Calcium fertilizer (such as superphosphate, calcium nitrate, etc.) and acidic fertilizer (such as ammonium nitrate, etc.) are often applied in saline-alkali soil. Through these fertilization measures, the content of calcium in soil can be increased and the calcium in soil can be activated. (3) Application of humic acid amendments: These amendments have the ability of substitution and adsorption of harmful ions such as sodium and chlorine through ion exchange, and can regulate the pH value of soil. (4) Application of salt inhibitors: salt inhibitors dilute with water, spraying on the ground will form a continuous film. This film has a good effect on crop seedling protection and yield increase. It can not only prevent water molecules from passing through, but also inhibit water evaporation and increase ground temperature, thus reducing salt accumulation and achieving the effect of reducing pH value.

Improvement measures to reduce pH: (1) Appropriate application of organic fertilizer. Organic fertilizer can not only increase the content of soil organic matter, but also improve the physical and chemical properties of the soil, and enhance the soil to achieve water conservation effect. (2) Planting green manure. Green manure can increase coverage, reduce water evaporation and inhibit salt. At the same time, green manure is also an important source of organic fertilizer. (3) Reasonable cultivation. Reasonable tillage and timely loosening of soil can improve soil aeration, change the state of soil compaction, reduce evaporation and inhibit salt return.

There are four main agricultural measures for soil organic matter conservation: (1) Increasing total biological yield. On the premise of increasing yield, the content of soil organic matter will be increased, because the yield of aboveground part will increase, and the root system of underground part will also increase accordingly, which will lead to more active and flourishing underground organisms, and finally the increase of animal and plant residues. (2) To ensure that straw can be returned to the field as far as possible. Because the easiest way to increase organic matter in soil is to return straw to the field. We should change the bad habit of burning straw, because burning straw in situ not only wastes a lot of organic matter, but also pollutes the environment. (3) Increase the amount of organic fertilizer. Rational fertilization and the combination of organic and inorganic fertilizers will be adopted to increase the amount of organic residues in the soil.

Some methods to maintain nitrogen content: (1) Applying ammonium nitrogen fertilizer and deep application in 8-15 cm soil are most suitable, covering the soil, increasing the adsorption of ammonium ions in the soil, reducing the volatilization of nitrogen nutrients, and improving the utilization rate of nitrogen fertilizer; (2) mixing with other fertilizers, the release of nitrogen fertilizer is slower, and creating suitable nutrient supply conditions is to improve nitrogen fertilizer. An important measure to increase production.

In general, the experimental area is extremely deficient in phosphorus, so phosphorus fertilizer should be applied appropriately. The most easily absorbed is dihydrogen phosphate, followed by hydrogen phosphate, which is hardly absorbed, so the pH value will affect the absorption of phosphorus by plants. Acidic conditions are conducive to the formation of dihydrogen phosphate, alkaline is conducive to phosphate. Therefore, appropriate methods can be used to reduce the soil pH and improve the content of available phosphorus: (1) adjust the pH 6.5-6.8. (2) Increasing organic matter and forming complex with aluminium. (3) Concentrated fertilization was applied in the root concentration area. (4) Phosphorus availability was significantly improved after flooding.

Some methods and measures for maintaining high potassium content are as follows: applying different kinds of potassium fertilizers, potassium chloride and potassium sulfate are commonly used potassium fertilizers. In addition, in recent years, a multi-element potassium fertilizer has been introduced, which contains not only potassium, magnesium and sulfur, but also iron, zinc, calcium, silicon and boron, i.e. magnesium sulfate potassium fertilizer; using organic fertilizers as far as possible. Potassium fertilizer resources in China are scarce, and a large number of potassium fertilizers need to be imported, so local materials should be taken to increase the source of potassium fertilizer, such as straw returning to the field, plant ash returning to the field and so on.

Pearson's correlation

As the table 16 shown, significant positive correlations of organic matter with K 0.718 ($P<0.01$), N with K 0.467 ($P<0.05$) were observed. This means where there is more organic matter concentration, there is more K concentration. This demonstrate the organic matter is the K nutrition fountain. The N and K concentration also have a significant positive correlation.

Principal component analysis

Principal component analysis (PCA) allows simplification of data complexity by reducing the number of variable orthogonal factors, thus facilitating the visualization of meaningful correlations. The PCA results of mango forest soil Table 17 showed that the first two components accounted for 71.7% of the total variance. The first component (PC1, 42.9%) was mainly negatively associated with the parameters pH (variable loadings: -0.517), organic matter (variable loadings: -0.802) and K (variable loadings: -0.913). The second component (PC2, 28.7%) was mainly positively associated with N (variable loadings: 0.768) and P (variable loadings: 0.795). Figure 4 shows the parameters distribution map: K and organic matter associated together, pH and N associated together, demonstrated they have close correlation. Infers that improve organic matter concentration can increase K content in the soil.

V. CONCLUSIONS

In this experiment, soil samples of mango forest were taken as experimental objects, and the pH value, organic matter, alkali-hydrolyzed nitrogen, available phosphorus and available potassium of soil were determined by electrode method, alkali-hydrolyzed diffusion method, sodium bicarbonate method, ammonium acetate-flame photometer method and burning method, respectively. The following conclusions were drawn:

(1) The whole soil is alkaline, and the pH value is not so suitable for the growth of mango trees. Some agricultural means can be used to reduce the pH value slightly, which is more conducive to the growth of mango trees. Through agricultural improvement, water conservancy facilities are improved, fertilizers, phosphogypsum, salt inhibitors and loosening soil are applied to chemical improvement.

(2) The soil organic matter content in the whole mango forest is very rich, indicating that microbial activities are more active, and mango trees are just mycorrhizal plants, which are lazy to microorganisms, so the soil organic matter content is very conducive to the growth and development of mango trees. Maintain organic matter, pay attention to straw returning, mix organic fertilizer and inorganic fertilizer.

(3) The soil of mango forest is rich in alkali-hydrolyzed nitrogen. In order to maintain the high level of nitrogen content, nitrogen fertilizer should be applied appropriately. Keep in mind that according to the season, fertilizer should be applied in spring as far as possible to avoid the application at Mango ripening stage.

(4) The content of phosphorus in the soil of mango forest is very low, and the phosphorus element is very deficient. It is suggested to apply phosphorus fertilizer, irrigate mango trees and reduce the pH value to improve the situation of low phosphorus.

(5) Potassium is abundant in the soil of mango forest, so the current situation of potassium content should be maintained and potassium should not be lost. The measures of returning plant ash to the field can be implemented, and the mixed application of nitrogen and phosphorus fertilizer should also be paid attention to, because when the nitrogen and phosphorus content is low, the productivity will be low, and the problem of potassium will not be highlighted. Once a large number of nitrogen and phosphorus fertilizers are applied, the productivity will be greatly increased, and a large amount of potassium will be urgently needed. And potassium has many benefits for mango growth.

Additional Information

Competing Interests statement

The author Jian Xiong declare that there is no competing interests.

Conflicts of Interest

The authors declare no confilicts of interest.

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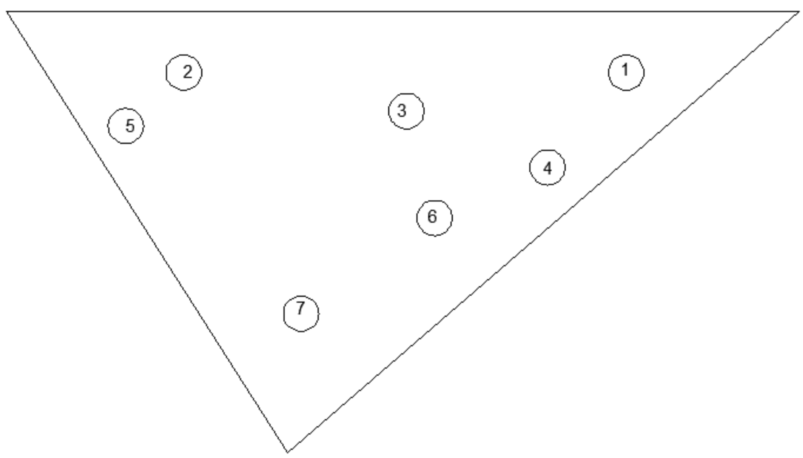

Figure 1 Distribution of sampling points

Figure 2 Status of Mango Forest at Sampling Points

Figure 3 Soil condition at sampling point

Table 1 Soil pH original data

sample	pH value		
1	7.62	7.61	7.60
2	6.78	6.77	6.76
3	7.63	7.61	7.66
4	7.04	7.05	7.06

5	7.56	7.54	7.56
6	7.83	7.78	7.81
7	7.83	7.78	7.79

Table 2 Average pH value

sample	pH mean value
1	7.61±0.01
2	6.77±0.01
3	7.63±0.03
4	7.05±0.01
5	7.55±0.01
6	7.81±0.03
7	7.80±0.03
The whole experimental area	7.46

Table 3 pH Classification Standards

pH	<4.5	4.5-5.5	5.5-6.0	6.0-6.5	6.5-7.0	7.0-7.5	7.5-8.5	8.5-9.5	>9.5
Grade	Very strong acid	Strong acidity	Acidic	Weak acidity	neutral	Weak alkalinity	alkalinity	Strong alkaline	Very strong alkaline

Table 4 Soil organic matter content

sample	Organic matter content		
1	1.98%	2.55%	2.44%
2	3.85%	4.01%	3.32%
3	2.14%	4.04%	3.32%
4	3.71%	2.67%	4.51%
5	4.26%	5.67%	4.37%
6	5.06%	4.43%	4.59%
7	4.62%	4.10%	4.41%

Table 5 Average Soil Organic Matter Content

sample	Average organic matter content
1	2.32%±0.30%
2	3.72%±0.36%
3	3.16%±0.95%
4	3.63%±0.92%
5	4.76%±0.78%
6	4.69%±0.32%
7	4.37%±0.26%
The whole experimental area	3.77%

Table 6 Organic Matter Classification Standards

organic matter （%）	<0.6	0.6-1	1-2	2-3	3-4	>4
Grade	6	5	4	3	2	1

Table 7 Soil Alkali-hydrolyzed Nitrogen Data

sample	Alkaline hydrolysis nitrogen content (mg/kg)		
1	81.94	87.73	82.64
2	60.22	57.83	61.67
3	90.80	88.14	87.27
4	99.67	110.20	108.09
5	101.41	98.16	95.47
6	78.92	86.95	87.06
7	97.68	96.58	92.00

Table 8 Average Soil Alkali-hydrolyzed Nitrogen

sample	Average Content of Alkali-hydrolyzed Nitrogen (mg/kg)
1	84.10±3.16
2	59.91±1.96
3	88.74±1.84
4	105.99±5.57
5	98.35±2.97
6	84.31±4.67
7	95.42±3.01
The whole experimental area	92.82

Because the alkali-hydrolyzed nitrogen content of sample 2 is obviously low, so sample 2 should belong to the special situation of sampling point, so the total alkali-hydrolyzed nitrogen content of the experimental area does not consider sample 2.

Table 9 Alkali-hydrolyzed Nitrogen Classification Standards

Alkali hydrolyzed nitrogen content	<30mg/kg	30-50mg/kg	50-80mg/kg	80-100mg/kg	>100mg/kg
Grade	low	slightly lower	commonly	slightly higher	high

Table 10 Soil Available Phosphorus Data

sample	Available phosphorus content (mg/kg)		
1	5.61	5.20	5.88
2	4.87	2.03	3.96
3	8.05	6.05	7.51
4	3.48	8.41	10.63
5	3.65	4.29	6.41
6	5.43	1.29	4.74
7	2.55	2.60	3.63

Because the second data 1.29 of sample 6 deviates from the data 5.43 and 4.74 seriously, it should be the wrong data caused by misoperation in the experiment, so it should not be considered, should be discarded, and should not be included in the average calculation of sample 6.

Table 11 Average Available Phosphorus in Soil

sample	Average Available Phosphorus Content（mg/kg）
1	5.56±0.34
2	3.62±1.45
3	7.20±1.03

4	7.51±3.66
5	4.78±1.44
6	5.09±0.35
7	2.93±0.61
The whole experimental area	5.24

Table 12 Available Phosphorus Classification Standards

Available phosphorus content	low	slightly lower	commonly	slightly higher	high
Grade	<5mg/kg	5-10mg/kg	10-15mg/kg	15-30mg/kg	>30mg/kg

Table 13 Soil Available Potassium original Data

sample	Available potassium content（mg/kg）		
1	85.94	81.30	88.69
2	105.56	111.21	102.38
3	71.18	76.53	72.24
4	146.89	150.27	158.77
5	271.56	280.94	275.50
6	167.63	176.39	174.28
7	189.36	199.33	200.56

Table 14 Average Available Potassium in Soil

sample	Average Value of Available Potassium Content（mg/kg）
1	85.31±3.74
2	106.38±4.47
3	73.32±2.83
4	151.98±6.12
5	276.00±4.71
6	172.77±4.57
7	196.42±6.14
The whole experimental area	147.21

Table 15 Available Potassium Classification Standards

Available potassium content	Extremely low	low	middle	high	Extremely high
grade	<30mg/kg	30-60mg/kg	60-100mg/kg	100-160mg/kg	>160mg/kg

Table 16

Pearson's correlation coefficients for relationships among soil pH, organic matter, Alkali-hydrolyzed Nitrogen, Available Phosphorus, and Available Potassium content in the Mango forest Soil

Variable	pH	Organic Matter	N	P	K
pH	1	0.156	0.383	-0.117	0.244
Organic Matter		1	0.130	-0.333	0.718**
N			1	0.344	0.467*
P				1	-0.276
K					1

**Significant at $P<0.01$ (n=21); *Significant at $P<0.05$ (n=21).

Table 17

Variable loadings on the first two principal components (PC1 and PC2) for soil pH, organic matter, N, P and K.

Variable	PC1	PC2
pH	-0.517	0.322
Organic Matter	-0.802	-0.329
N	-0.532	0.768
P	0.346	0.795
K	-0.913	-0.040
Variance explained (%)	42.9	28.7

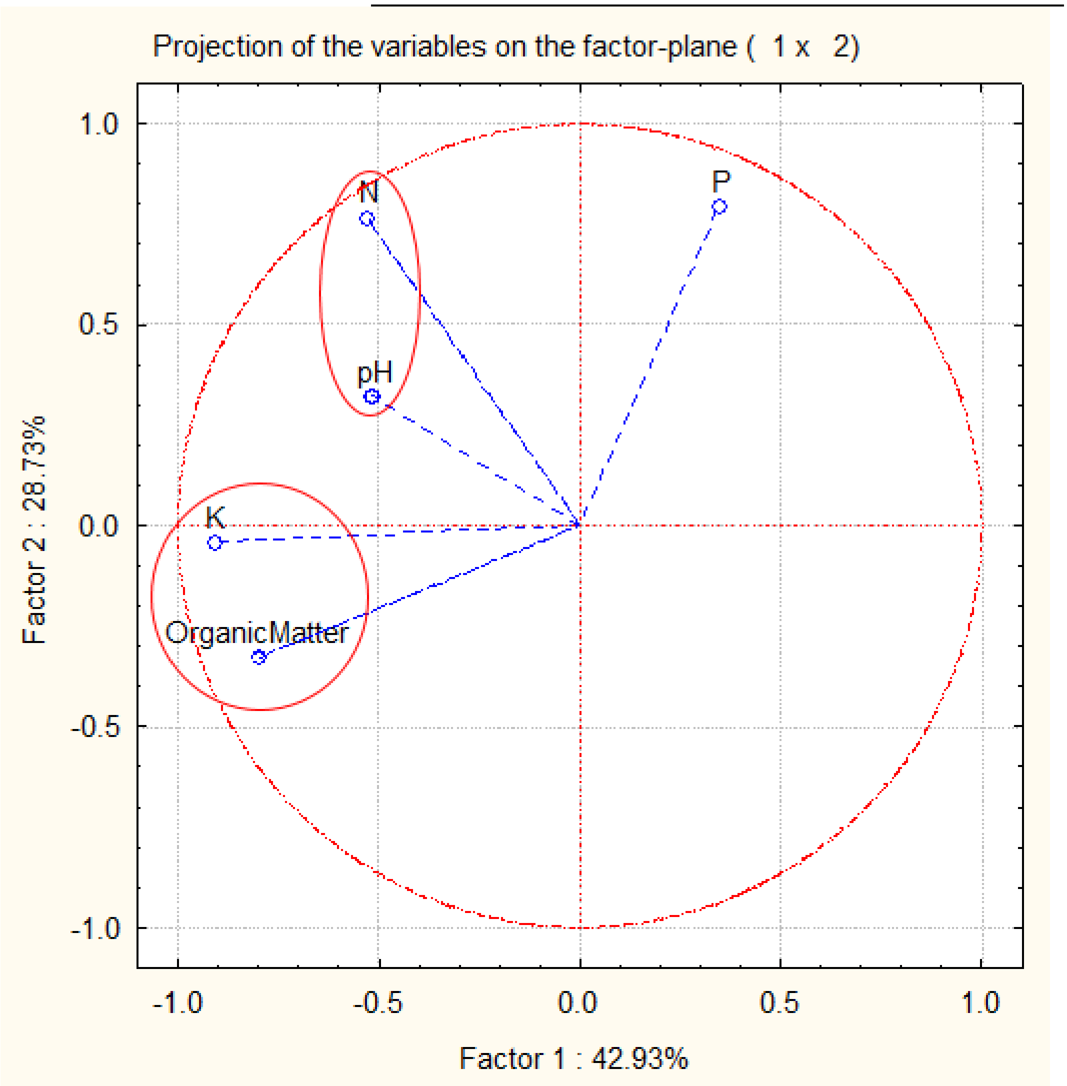

Figure 4 Principal component analysis of soil pH, organic matter, N, P and K.