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Soil Systematic Classification Research in Xi District of Panzhihua City

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ABSTRACT
Aims: In order to complete the task of land resources survey in Panzhihua Xi District, make clear the distribution of soil types in the Xi District, analyze the nutrient components of the soil in the Xi District, and enrich the content of soil science. There is no systematic classification of soils in Panzhihua Xi District, so this study will make up for this gap. Methods: In this research, the soil pH, organic matter, ammonium nitrogen, available phosphorus and effective potassium were determined by TPY-6A soil tester. Using ARCGIS, SPSS and Sigmaplot software, the original data were analyzed, and the soil type distribution sketch map, soil nutrient distribution map and soil nutrient classification data and charts of Panzhihua Xi District were made. Results: The relative figures and graphs were obtained. Conclusions: The soils in the Xi District of Panzhihua City are all weak alkaline soils. The content of organic matter in the soils is relatively rich, and the content of effective potassium in the soils in the Xi District of Panzhihua City varies greatly. The content of available phosphorus in all the Xi districts is relatively high, but the content of ammonium nitrogen in the Xi districts of Panzhihua City is very low.
KEYWORDS: Soil Taxonomy, Soil Nutrients, Organic Matter, Ammonium Nitrogen, Available Phosphorus, Effective Potassium

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I. INTRODUCTION

Classification is a discipline devoted to discovering, characterizing, naming and categorizing objects (objects or organisms), which facilitates understanding of their formation factors and their interrelationships. The main purpose of classification is to identify and recognize, and to build a new rule system for classification objects. Basic classification is the basic requirement of different scientific research, and it is often updated periodically with the increase of knowledge (Xiong, 2016; Xiong et al., 2013; Cabrera et al., 2015). Soil classification summarizes soil-related knowledge, provides a common language for the exchange of scientists, and also provides relevant scientific knowledge for soil workers to improve work efficiency (Xiong et al., 2015; Madejón et al., 2014; Xiong, 2012; Xiong et al., 2012; Zhang et al., 2012).

1.1 Significance of Soil Classification

Soil is an indispensable natural resource in our daily life. To a certain extent, the progress of human history and civilization is the record of how to use land history. Soil classification refers to the systematic classification of soils according to their characteristics and properties (Xiong, 2017). That is to say, a logical classification system is established. Different levels contain different amounts of soil types, which is convenient to find different soil types and classify soils with the same properties or characteristics into the same categories (Sun et al., 2006). Systematic classification of soils is the basis for us to understand all kinds of soils, and is also the basis for conducting soil survey, land evaluation, land use planning and promoting agricultural production technology according to local conditions. Because of the different factors of soil formation and the formation process of soil, the types of soil on the earth are various, and they have different soil configuration, intrinsic properties and fertility levels (Chen et al., 2010). The purpose of soil classification is to incorporate the same or similar external form and intrinsic properties of soil into a certain classification system according to the analysis and comparison of a large number of specific materials, so as to show the law of occurrence and development of soil under the influence of natural and human factors. Correctly reflect the relationship between the soil and the environment, reflect their fertility level and utilization value, and provide relevant scientific and theoretical support for rational use of soil, transformation of soil, improvement of soil fertility and improvement of production level (Weng et al., 2013; Ehleringer et al., 2000; Connin et al., 2001; Felipe et al., 2003).

1.2 The main purpose of the project

(1) To complete the task of land resources survey in the Xi District.

(2) To clarify the types and distribution of soils in the Xi District and enrich the contents of soil science.

(3) Laboratory analysis of the physical and chemical properties of various soils to provide a scientific basis for soil classification.

(4) Drawing out the sketch map of soil nutrient content distribution in the Xi District.

II. MATERIALS AND METHODS

2.1 Basic Situation of Xi District

2.1.1 Geographical Location

The Xi District, which belongs to Panzhihua City, is one of the main urban areas of Panzhihua City. The Xi District is located in the western part of Panzhihua City and lies between 101°26'43″ to 101°40'08″ east longitude and 26°22'45″ to 26°40'43″ North latitude. It covers an area of 125.45 square kilometers, 21.3 kilometers in east and west, 5.2 kilometers in north and south. The north is Laogong Mountain with rich natural resources, which is connected with Tongde Town and Bude Town. The south is Jinsha River running through Panzhihua City, and the west is Jiguanshishan Mountain, which is also connected with Huaping County, the east is connected with Yinjiang Town. The map of Panzhihua City is shown in Figure 2-1 below.

Figure 2-1 Map of Panzhihua City

2.1.2 Administrative Division of Xi District

Table 2-1 Scope of Xi District

2.2 Research scheme

Firstly, the distribution of soil in Panzhihua Xi District was investigated by searching for data. Soil samples were collected on the spot. The contents of organic matter, ammonium nitrogen and available potassium in the soil were determined by soil nutrient analyzer. The measured data were plotted by SPSS, Sigmaplot and ARCGIS software. Soil classification charts and soil nutrient composition classification charts were drawn. The technical route is shown in Figure 2-2 below.

Figure 2-2Technology Roadmap

2.3 Sampling method

Influenced by human production activities, soil composition often varies greatly, and the difference has a certain direction. Therefore, when collecting soil samples, it is usually necessary to follow a direction and follow the principles of "random", "equal quantity" and "multi-point mixing". "Random" refers to the random selection of sampling points. Equivalent refers to the same amount of soil excavated at each point and the same sampling depth. Multipoint mixing refers to the uniform mixing of multiple sampling points of the same sampling unit after sampling, as the sample of the sampling unit. Soil sample collection points are shown in Figure 2-3 below.

Figure 2-3 Soil Sample Collection Figure

In this experiment, eight different regions were selected to collect soil samples. The corresponding soil types in different regions are shown in Table 2-1.

Table 2-1 Soil types in different regions

2.3 Names of main instruments for experiments

Instrument Name: Soil nutrient fast measuring instrument

Instrument Model: TPY-6A

2.4 scientificity of soil nutrient fast measuring instrument

Since modern times, the determination of soil hydrolytic nitrogen, available phosphorus, available potassium and other nutrient indicators generally adopts a relatively complete and mature conventional method. However, the operation steps of this method are complicated, the determination time is long (from air drying to the end of the determination needs (3-5 days)), the determination cost is relatively high, the analysis efficiency is low, and the operation and maintenance of the laboratory by professionals are insufficient, thus restricting the promotion of side soil formula fertilization. In the practice of soil quality analysis and evaluation, soil testing and fertilization, and field experiments, it is often necessary to carry out continuous batch analysis of soil nutrient indicators, so conventional methods are difficult to meet the needs of research and application. In view of the shortcomings of conventional methods, people have developed a soil nutrient rapid measuring instrument for rapid determination of soil nutrient indicators. With the development of rapid instrument analysis technology, the method of soil nutrient index determination has been greatly improved in analysis efficiency and rate. The development and application of the soil nutrient rapid measuring instrument have realized the large-scale and rapid determination of soil nutrients, greatly improved the efficiency of soil determination, and promoted the development of soil testing and formula fertilization.

2.5 Measurement Items

1. Water content

Determination of Soil Samples by TPY-6A Soil nutrient fast measuring instrument

2、pH

3. Organic Matter

4. Ammonium nitrogen

5. Available Phosphorus

6. Available potassium

III. RESULTS AND DISCUSSIONS

RESULTS

3.1 Result

The original data are collated and calculated by Excel software, and the average value and standard deviation are calculated. The sorted data are analyzed by one-way ANOVA in SPSS software, and the same subset is obtained by calculating the average and standard deviation. Then the same subset is labeled and table 3-1 is obtained.

Table 3-1 Nutritional Composition Table of Soil in Xi District of Panzhihua City

3.2 Analysis of Soil Nutrition Components in Xi District

3.2.1 Distribution of Soil Types

According to the classification of soil types in the Xi district, corresponding to the streets in the Xi district, eight soil samples were collected in this experiment. The distribution map of soil types in the Xi District of Panzhihua City was drawn by using ArcGIS software. See Figure 3-1 below. Soil types in the Xi District of Panzhihua City were systematically classified and studied.

Figure 3-1 Schematic Map of Soil System Classification in Xi District of Panzhihua City

3.2.2 Analysis of Soil Water Content in Xi District

Soil water content is the quantity of water content in soil. Soil water content is an important index of soil water status. It is very important for crop growth. The amount of water content directly affects the growth of crop roots. Next, we use ArcGIS software to draw the water content distribution sketches of different soil types in the Xi District. The water content distribution sketches in the Xi District are shown in Figure 3-2 below.

Figure 3-2 Schematic Map of Soil Water Content Distribution in Xi District of Panzhihua City

We make a one-way ANOVA of different types of soil moisture in the Xi District by SPSS and Sigma plot software. Through the one-way ANOVA table, we can see the difference of water content among different types of soil in the Xi District. The results of one-way ANOVA are shown in Figure 3-3 below.

Figure 3-3 Soil water content one way ANOVA analysis graph

The water content classification table in China is shown in Table 3-2 below.

Table 3-2 Soil water content (%) classification

From Figure 3-2, we can see that most of the soil moisture in the Xi District is not high, because the annual rainfall in the Xi District is 776.3 mm-990 mm, concentrated in June-August. The water content of different soil types is quite different. The lowest water content is 0.02%, the highest water content is 14.59%, and the maximum difference is 14.57%. From the one-way ANOVA chart of water content in Figure 3-3, we can see that the difference between ore-sand soil and black humus soil is the most significant, and the water content difference between them is the greatest. Black sandy soil and gravel soil are the same type, and loess and mineral sandy soil are the same type. There is no significant difference among black sandy soil, gravel soil, loess and mineral sandy soil. The difference between yellow soil and black humus soil is the smallest. If the soil water content is too low, which is not conducive to crop growth, crops will die because of water shortage.

3.2.3 Analysis of Soil Acidity and Alkalinity in Xi District

Soil acidity and alkalinity, also known as "soil pH", is used to measure the strength of soil acidity and alkali reaction, which is mainly determined by the concentration of hydrogen ion and hydroxide ion in soil solution. Most crops are difficult to grow at pH > 9 or pH < 2.5. Each crop has its own suitable pH. Now we can draw a map of the distribution of soil acidity and alkalinity in the Xi District by ArcGIS software. See Figure 3-4 below.

Figure 3-4 Schematic Map of Soil Acidity and Alkalinity Distribution in Xi District of Panzhihua City

We made a one-way ANOVA map of the pH of different types of soils in the Xi District by SPSS and Sigma plot software, labeled the same subset of different types of soils on the one-way ANOVA map, and then analyzed the differences among different types of soils in the Xi District by one-way ANOVA map, one-way ANOVA map. As shown in Figure 3-5 below.

Figure 3-5 Soil pH one way ANOVA analysis graph

The acid-alkalinity grading table in China is shown in Table 3-3 below.

Table 3-3 Soil pH grade

From Figure 3-4, we can see that the main soils in the Xi District are weak alkaline soils. This is because the water quality in the Xi District belongs to calcium magnesium bicarbonate type, alkaline, low salinity, so the soils in the Xi District tend to alkaline soils.

From Figure 3-5, we can see that gravel soil and yellow soil, brown soil, red soil are the same type, there is no obvious difference, black sand soil and loess are the same type, there is no significant difference.

3.2.4 Analysis of Soil Organic Matter Content in Xi District

Soil organic matter is an important criterion of soil fertility and the main source of soil nutrients. It contains all kinds of nutrients needed for crop growth. It can promote crop growth and development, promote the formation of soil structure, improve soil physical properties, improve soil structure, improve soil fertility conservation capacity and buffer capacity. Performance, promote soil microbial activity, improve soil nutrient. The sketch map of soil organic matter content distribution in the Xi District is shown in Figure 3-6 below.

Figure 3-6 Schematic Map of Soil Organic Matter Distribution in Xi District of Panzhihua City

A one-way ANOVA was used to analyze the difference between different types of soils in the Xi District. The same subset of different types of soils was marked on the one-way ANOVA map. The one-way ANOVA chart was shown in Figure 3-7 below.

Figure 3-7 Soil organic matter one way ANOVA analysis graph

The classification table of organic matter content in China is shown in Table 3-4 below:

Table 3-4 Soil organic matter (%) grade

From Figure 3-6, we can see that the organic matter content of soils in the Xi District is significantly different. The organic matter content of soils in the Xi District is generally higher than that in the eastern region. The organic matter content of brown soils is the highest, up to 26.47%, and that of loess soils is the lowest, which is 3.57%. Soil organic matter is one of the soil fertility levels. Important indicators: within a certain range of organic matter content, soil fertility increases with the increase of organic matter content, and crop yield increases with the increase of organic matter content, but the more organic matter in soil, the better. When exceeding a certain range, the correlation is not obvious, and too high organic matter content is not. The economy is also not conducive to improving soil fertility.

3.2.5 Analysis of Soil Ammonium Nitrogen Content in Xi District

Soil ammonium nitrogen exists in the form of ammonium ion ($NH4^+$) in soil, which can be dissolved in soil solution, can be directly absorbed and utilized by crops, and can also be adsorbed by soil colloids. It is an exchangeable ammonium nitrogen fertilizer. It is the main component of protein and has a great influence on the growth of plant stems and leaves and fruit development. Important role is the most closely related to the yield of nutrients. ArcGIS software was used to plot the distribution of soil ammonium nitrogen content in the Xi District, as shown in Figure 3-8 below.

Figure 3-8 Schematic Map of Soil Ammonium Nitrogen Distribution in Xi District of Panzhihua City

We use SPSS and Sigma plot software to make a one-way ANOVA map of different types of soil ammonium nitrogen content in the Xi District, marking the same subset of different types of soil, to analyze the difference of different types of soil ammonium nitrogen content in the Xi District. The ANOVA map of ammonium nitrogen is shown in Figure 3-9 below.

Figure 3-9 Soil Ammonium Nitrogen one way ANOVA analysis graph

The ammonium nitrogen content classification table in China is shown in Table 3-5 below:

Table 3-5 Soil Ammonium Nitrogen (mg/Kg) grade

From the single factor analysis chart of available nitrogen in Figure 3-9, it can be seen that there is no significant difference in the content of ammonium nitrogen in the soils of the Xi District. From Figure 3-10, it can be seen that the content of available nitrogen in the soils of the Xi District is relatively low, which is less than 30 (Mg/kg), so the content of available nitrogen in the soils of the Xi District is very low.

3.2.6 Analysis of Soil Available Phosphorus Content in Xi District

Quick-acting phosphorus refers to phosphorus that is easily absorbed and utilized by crops in soil. Apart from phosphate ions in soil solution, some soluble inorganic phosphorus compounds and adsorbed phosphorus in soil belong to available phosphorus. Available phosphorus is one of the essential nutrients for crop growth and development. The distribution of available phosphorus in soils in the Xi District was plotted by ArcGIS software as shown in Figure 3-10 below.

Figure 3-10 Schematic Map of Soil Available Phosphorus Distribution in Xi District of Panzhihua City

Through SPSS and Sigmaplot software, we will make a one-way ANOVA map of available phosphorus content of different soil types in the Xi District, mark the same subset of different types of soils on the one-way ANOVA map, and use this one-way ANOVA map to analyze the difference and one-way variance of available phosphorus content of different soil types in the Xi District. The analysis diagram is shown in Figure 3-11 below.

Figure 3-11 Soil Available Phosphorus one way ANOVA analysis graph

The classification table of available phosphorus content in China is shown in Table 3-6 below:

Table 3-6 Soil Available Phosphorus (mg/Kg) grade

From Figure 3-11, we can see that the content of available phosphorus in soils in the Xi District can be roughly divided into three different types of soils. Among them, the same type exists between loess and mineral sandy soil, brown soil and red soil. There is no significant difference between them, nor between black soil and gravel soil, nor between black humus soil and loess soil. There was no significant difference between them. From Figure 3-10, it can be seen that the content of available phosphorus in the eastern part of the Xi District is higher than that in the Xi District. The highest content of available phosphorus in the gravel soil is 68 (mg/kg), which belongs to a very high level. The lowest content of available phosphorus in the Xi District is 11.07 (mg/kg) in the red soil, which belongs to the upper and middle level. The content of available phosphorus in soils in the Xi District is relatively high as a whole.

3.2.7 Analysis of Soil Effective Potassium Content in Xi District

Figure 3-12 Schematic Map of Soil Effective Potassium Distribution in Xi District of Panzhihua City

Through SPSS and Sigmaplot software, we make a one-way ANOVA figure of effective potassium content of different types of soils in Xi District, mark the same subset of different types of soils in the one-way ANOVA figure, and analyze the difference of effective potassium content of different types of soils in Xi District through this one-way ANOVA figure.

Figure 3-13 Soil Effective Potassium one way ANOVA analysis graph

The classification table of effective potassium content in China is shown in tables 3-7 below:

Table 3-7 Soil Effective Potassium (mg/Kg) grade

According to the single factor analysis chart of available potassium in Figure 3-13, the soils in the Xi District can be roughly divided into three different types according to available potassium. Among them, there is no significant difference between black sandy soil and loess, yellow soil, brown soil, red soil and black humus soil, while there is significant difference between loess, gravel soil and mineral sandy soil. From Figure 3-12, we can see that the highest content of available potassium is 322 (mg/kg) in gravel soil, which belongs to very high level, and the lowest content is 24.67 (mg/kg) in yellow soil, which belongs to very low level. The difference between the two is obvious. The content of available potassium in soil in the Xi District is a reference. The difference is uneven and significant.

3.3 Analysis of Soil Fertility in Different Soil Types

By measuring the water content, organic matter, ammonium nitrogen, available phosphorus and available potassium in different types of soils, the average values of parallel soil samples were calculated, and filling radar maps were drawn by Excel. Because of the different data ranges, in order to make more effective radar maps, some transformations were made to the original data:

Water content (%) ranges from 0 to 15 need not be changed

Organic matter content (%) ranges from 0 to 27, all data divided by 1.5 ranges from 0 to 20

The range of ammonium nitrogen content (mg/kg) is 0-27. All data divide by 1.5 range to 0-20.

The range of available phosphorus content (mg/kg) is 0-70. All data divided by 3.5 ranges change to 0-20.

Effective potassium content (mg/kg) ranged from 0 to 325. All data divided by 17 ranges changed to 0-20.

Radar maps made by Excel software are shown in Figure 3-14 below:

Figure 3-14 Soil Fertility Radar Map

Based on the above principle, the fertility of three parallel samples of different soil types is analyzed by radar plots according to the changed ranges. The fertility radar plots of each soil type are calculated and the area obtained is analyzed by single factor variance using SPSS software. The same subset of the same kind is calculated by means of average value and standard deviation. Annotations, as shown in Table 3-8 below:

Table 3-8 Soil Fertility Data Table

From the radar map of soil fertility in Figure 3-14, we can see the fertility map of black sandy soil in the Xi District. The proportion of water content and available potassium is very low, mainly the content of available phosphorus and organic matter is relatively high, so the fertility of black sandy soil is very good.

IV. DISCUSSIONS

When the pH was over 7.5, the soil nutrients decreased and the availability of phosphoric acid and calcium or iron-aluminum decreased. Destroying the soil structure, it is difficult to form a good soil structure in strong alkali soil, which is not conducive to crop growth. Soil microbial activities are not conducive to soil microbial activities. Soil microorganisms generally have a neutral pH range of 6.5-7.5. Alkaline soils can inhibit soil microbial activities, thus affecting the supply of nutrients, which is not conducive to crop growth.

Adding organic fertilizer is the most fundamental measure to regulate acidity and alkalinity, and it can improve the buffer performance of soil. A small amount of aluminium sulfate (nitrogen fertilizer is needed for application), ferrous sulfate and sulfur powder can be added to adjust the acidity and alkalinity of soils in the Xi District.

According to the one way ANOVA analysis chart of organic matter in Figure 3-7, the soils in the Xi District can be roughly divided into five different types according to organic matter. By comparing the classification table of soil organic matter content, it can be seen that the organic matter content in the soils of the Xi District is very high. Among them, the difference between loess and brown soil is the most significant, while there is no significant difference between black sand soil, gravel soil and yellow soil. There is no significant difference between mineral sandy soil, red soil and black humus soil.

Nitrogen deficiency in soil can result in plant dwarfing, leaf yellowing, delayed flower bud differentiation, small fruit, low yield and other adverse consequences. For the sake of crop growth, ammonium nitrogen fertilizer should be properly added, such as ammonium bicarbonate (NH_4HCO_3), ammonium sulfate, ammonium chloride (NH_4Cl).

The content of available phosphorus in soils in the Xi District is relatively high, which can promote the photosynthesis, respiration and biosynthesis of crops, and promote the growth of young buds and roots.

The content of available potassium in most soils in the Xi District is above or even higher, which can promote better utilization of nitrogen, increase protein content, and promote the production of sugar and starch. It can not only improve crop yield but also improve quality. It is recognized as a "quality element" and can also enhance crop's high and low temperature. Resistance to adverse environments such as drought, waterlogging, diseases and insects makes crops grow healthily. Only yellow soil belongs to very low level, and the available potassium content is higher than (150 mg/kg) without or without potassium fertilizer. If crops lack potassium, they will suffer from cartilage disease, lodging easily, being attacked by pathogens and pests, and the quality of fruits will decline. Potassium fertilizer, such as potassium chloride and potassium sulfate, should be properly applied to soils with low available potassium content in order to increase the content of soil available potassium and promote the growth of crops.

From the radar map of loess soil fertility, it can be seen that the content of ammonium nitrogen in loess soil is very high, but the moisture content is very low, the content of organic matter is not high, and the content of available phosphorus is relatively good, so the fertility of loess soil is not much different from that of black sand soil. From the fertility radar map of gravel soil, we can see that the content of available phosphorus and potassium in gravel soil is very high, and the content of water content and ammonium nitrogen is low, so the fertility value of gravel soil is not low, but also higher than that of most other soils. From the fertility radar map of yellow soil, it can be seen that the water content of yellow soil is relatively high, but the contents of available potassium, available phosphorus and ammonium nitrogen are relatively low, so the overall fertility is relatively low. Yellow soil is the lowest fertility area of the eight soil types. From the radar map of mineral sandy soil fertility, it can be seen that the water content and available phosphorus content of mineral sandy soil are very low, but the content of available potassium, ammonium nitrogen and organic matter is good, so the fertility value of mineral sandy soil is in the middle level for the other seven soil types. From the radar map of brown soil fertility, we can see that the content of available potassium and organic matter in brown soil is relatively high, and the content of available phosphorus and ammonium nitrogen are relatively low, so the fertility value of brown soil belongs to the medium level in the eight soil types. From the fertility radar map of red soil, we can see that the organic matter and ammonium nitrogen content of red soil are relatively high, and the water content and available phosphorus content are relatively low. From the fertility radar map of black humus soil, we can see that the moisture content, available phosphorus, ammonium nitrogen and organic matter content of black humus soil are relatively high, so the fertility value of black humus soil is the highest. The order of fertility values of eight different soil types from low to high is yellow soil, mineral sand soil, loess sand soil, red soil, brown soil, black sand soil, gravel soil and black yarn humus soil.

Pearson's correlation

Table 4-1Pearson's correlation coefficients for relationships among soil water content, organic matter, pH, ammonium nitrogen, available phosphorus, and available potassium content in Xi District.

As the table 4-1 shown, significant negative correlations of water with pH -0.477 ($P<0.05$), organic matter with pH -0.597 ($P<0.01$) were observed. This means when the pH value is in alkalinity, higher water and organic matter content can decrease pH value to neutral, to adapt to plant growth.

Principal component analysis

Table 4-2Variable loadings on the first two principal components (PC1 and PC2) for soil water content, organic matter, pH, ammonium nitrogen, available phosphorus, and available potassium content in Xi District.

Figure 4-1Principal component analysis of soil water content, organic matter, pH, ammonium nitrogen, available phosphorus, and available potassium content in Xi District, based on ordination of the plots of the different soil types by the first two principal components (PC). 1=Black Sandy Soil in Xinzhuang; 2=Yellow Sandy Soil in Qingxiangping; 3=Gravel Soil in Yuquan; 4=Yellow Soil in Hemenkou; 5=Mineral Sandy Soil in Taojiadu; 6=Brown Soil in Geliping; 7=Red Soil in Jinshatan; 8=Black humus soil in Mosuohe. The number 1, 2, 3 for example 7-1, 7-2, 7-3, are three sample reduplicate for each soil type.

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 Xi District soil Table 4-2 showed that the first two components accounted for 64.1% of the total variance. The first component (PC1, 36.1%) was mainly positively associated with the parameters organic matter (variable loadings: -0.822), pH (variable loadings: 0.876) and P (variable loadings: 0.616). The second component (PC2, 28.0%) was mainly negatively associated with water (variable loadings: -0.590), N (variable loadings: -0.491) and K (variable loadings: 0.913).Figure 4-1 shows the soil types distribution map: soil types 4, 5, 6, 7, 8, are poor soil fertility types associated together; soil types 1, 2, 3, are greater soil fertility types. Which has a clear demarcation of soil fertility.

V. CONCLUSIONS

The following conclusions can be drawn from the previous data analysis:

(1) The soils in the Xi District of Panzhihua City are weak alkaline soils, which are suitable for planting saline-alkaline plants: Tamarix chinensis, Elaeagnus angustifolia, Lycium barbarum, etc. Nitrogen is highly effective at pH 6-8, while nitrification is inhibited when it is greater than 8. Phosphorus is highly effective at pH 6.5-7.5 and easily forms calcium dihydrogen phosphate when it is higher than 7.5. Therefore, the application of acid and physiological acid fertilizers such as calcium superphosphate, ammonium sulfate and ammonium chloride on the soils of the Xi District is better, which can reduce and reduce the harm of soil alkalinity. Do not apply alkaline fertilizer.

(2) Most of the soil water content in the Xi District of Panzhihua City is not high, and the water content of different soil types is quite different, so it is suitable for planting drought-tolerant crops.

(3) The content of soil organic matter in the Xi District of Panzhihua City is relatively abundant, with the highest content reaching 26.47%. The role of organic matter in improving soil physical properties is multifaceted. Soil organic matter is the main source of nutrients and energy needed by soil microorganisms for life. Therefore, the soil of the Xi District rich in organic matter has stable and stable fertility. It is not easy to cause the phenomenon of plant elongation and fertilization for a long time.

(4) The content of available nitrogen in the soils of the Xi District of Panzhihua City is very low, which makes the soils more suitable for the growth of crops and needs to be supplemented with nitrogen fertilizer.

(5) The content of available phosphorus in the Xi District of Panzhihua City varies greatly from the east to the west. The highest content of available phosphorus in gravel soil is 68 (mg/kg), which belongs to a very high level. The lowest content is 11.07 (mg/kg) in red soil, which belongs to the upper and middle level. Therefore, the content of available phosphorus in the Xi district is relatively high.

(6) The highest content of available potassium in the Xi District of Panzhihua City is 322 (mg/kg) of gravel soil, which belongs to very high level, and the lowest content is 24.67 (mg/kg) of yellow soil, which belongs to very low level. The difference between the two is obvious. The content of available potassium in the Xi District is uneven and significant. Potassium fertilizer should be properly applied to soils with low available potassium content.

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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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Data Availability Statement

Data available on request from the authors

The data that support the findings of this study are available from the corresponding author upon reasonable request.

Xiong Jian

Figure 2-1 Map of Panzhihua City

Table 2-1 Scope of Xi District

Street/Town	Community under its jurisdiction
Qingxiangping	Dashuijin、Lunan、Lubei、Yangjiaping、Tangjiaping、Lishuping
Yuquan	Baguanhe、Xicaoping、Heshiba、Donglizhan、Ganshidianchang
Hemenkou	Nanjie、Beijie、Gaojiaping
Taojiadu	Huashanzhongxin、Goubei、Taohuajie、301、Baodingzhonglu、Xueyuan、Kuangjian
Mosuohe	Taiping、Panhai、Shanshijiu、Mosuohe
Dabaoding	Yanjiang、Lanniqing、Ganbatang、Xiaobaoding
Geliping	Ten villages

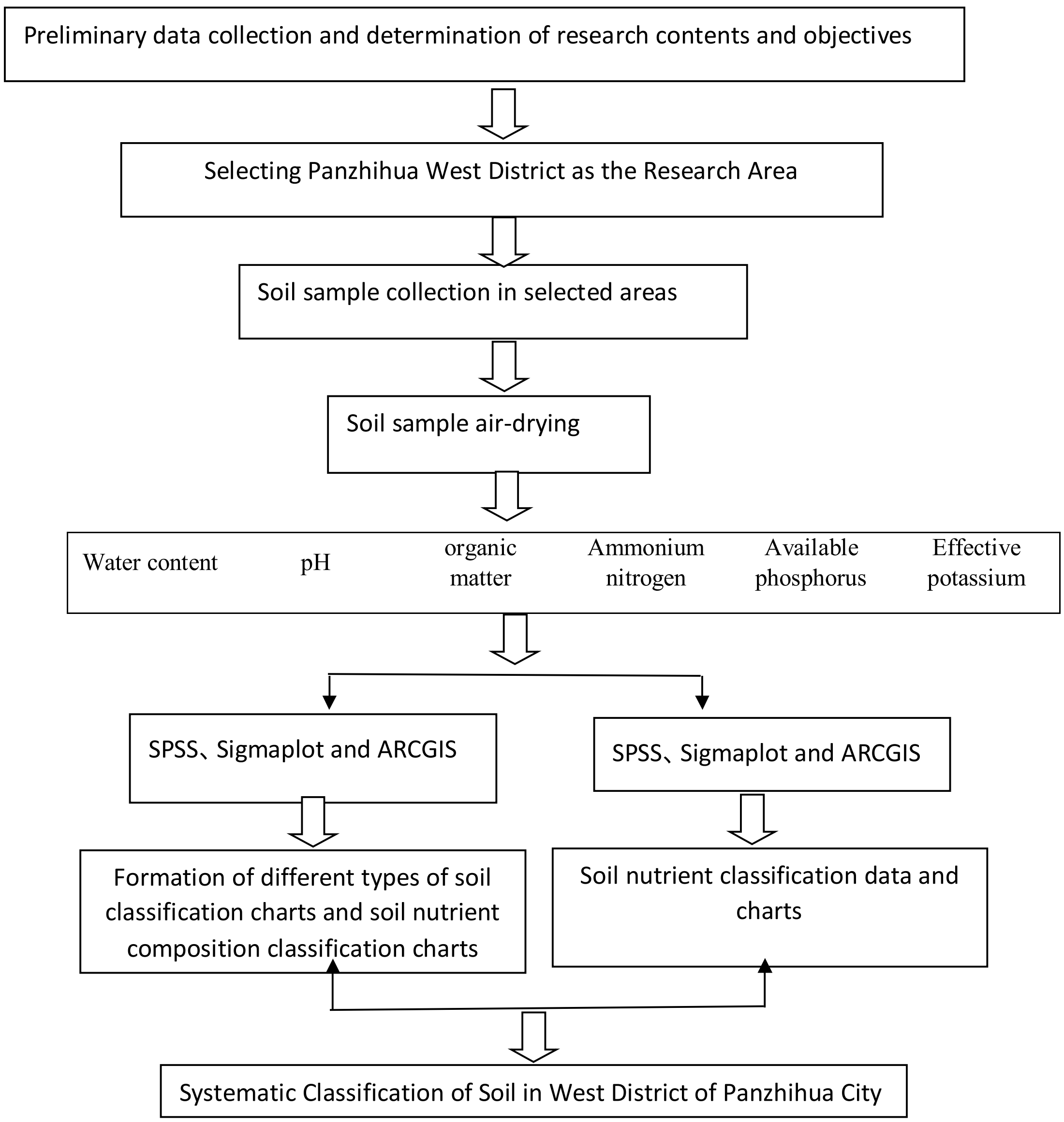

Figure 2-2Technology Roadmap


Black Sandy Soil Yellow Sandy Soil


Gravel Soil Yellow Soil


Mineral Sandy Soil Brown Soil


Red Soil Black humus soil

Figure 2-3 Soil Sample Collection Figure

Table 2-1 Soil types in different regions

Sampling sites	Soil type
Xinzhuang	Black Sandy Soil
Qingxiangping	Yellow Sandy Soil
Yuquan	Gravel Soil
Hemenkou	Yellow Soil
Taojiadu	Mineral Sandy Soil
Geliping	Brown Soil
Jinshatan	Red Soil
Mosuohe	Black humus soil

Table 3-1 Nutritional Composition Table of Soil in Xi District of Panzhihua City

Street Name	Soil type	Water content（%）	pH	Organic matter (%)
Xinzhuang	Black Sandy Soil	1.03±0.07ab	8.70±0.01d	12.87±2.75bcd
Qingxiangping	Yellow Sandy Soil	0.67±0.04a	8.77±0.03d	3.56±0.38a
Yuquan	Gravel Soil	1.68±0.07bab	8.38±0.04bc	11.03±1.75ab
Hemenkou	Yellow Soil	9.51±0.32d	8.47±0.01c	9.17±2.91abc
Taojiadu	Mineral Sandy Soil	0.02±0.01a	8.29±0.03ab	17.98±1.42de
Geliping	Brown Soil	5.33±0.22c	8.39±0.03c	26.47±1.47e
Jinshatan	Red Soil	3.12±1.59bc	8.38±0.02bc	17.06±0.51cd
Mosuohe	Black humus soil	14.59±0.86e	8.23±0.03a	17.27±0.88cd
Street Name	Soil type	Ammonium nitrogen（mg/kg）	Available phosphorus（mg/kg）	Effective potassium（mg/kg）
Xinzhuang	Black Sandy Soil	11.67±9.43a	64.00±3.27c	116.00±17.28ab
Qingxiangping	Yellow Sandy Soil	26.67±12.47a	31.80±3.48b	97.00±39.82ab
Yuquan	Gravel Soil	6.53±4.71a	68.00±3.27c	322.00±37.66c
Hemenkou	Yellow Soil	11.67±6.24a	18.80±0.98a	24.67±9.10a
Taojiadu	Mineral Sandy Soil	20.00±11.31a	12.33±1.75a	247.00±30.69c
Geliping	Brown Soil	6.67±1.89a	11.47±0.9a	258.00±6.53c
Jinshatan	Red Soil	21.60±9.34a	11.07±0.47a	130.33±20.5b
Mosuohe	Black humus soil	19.93±10.15a	31.00±2.08b	59.00±31.95ab

Note: Average ± standard deviation (n=3). Different letters in the same column showed significant difference at the level of $p<0.05$.

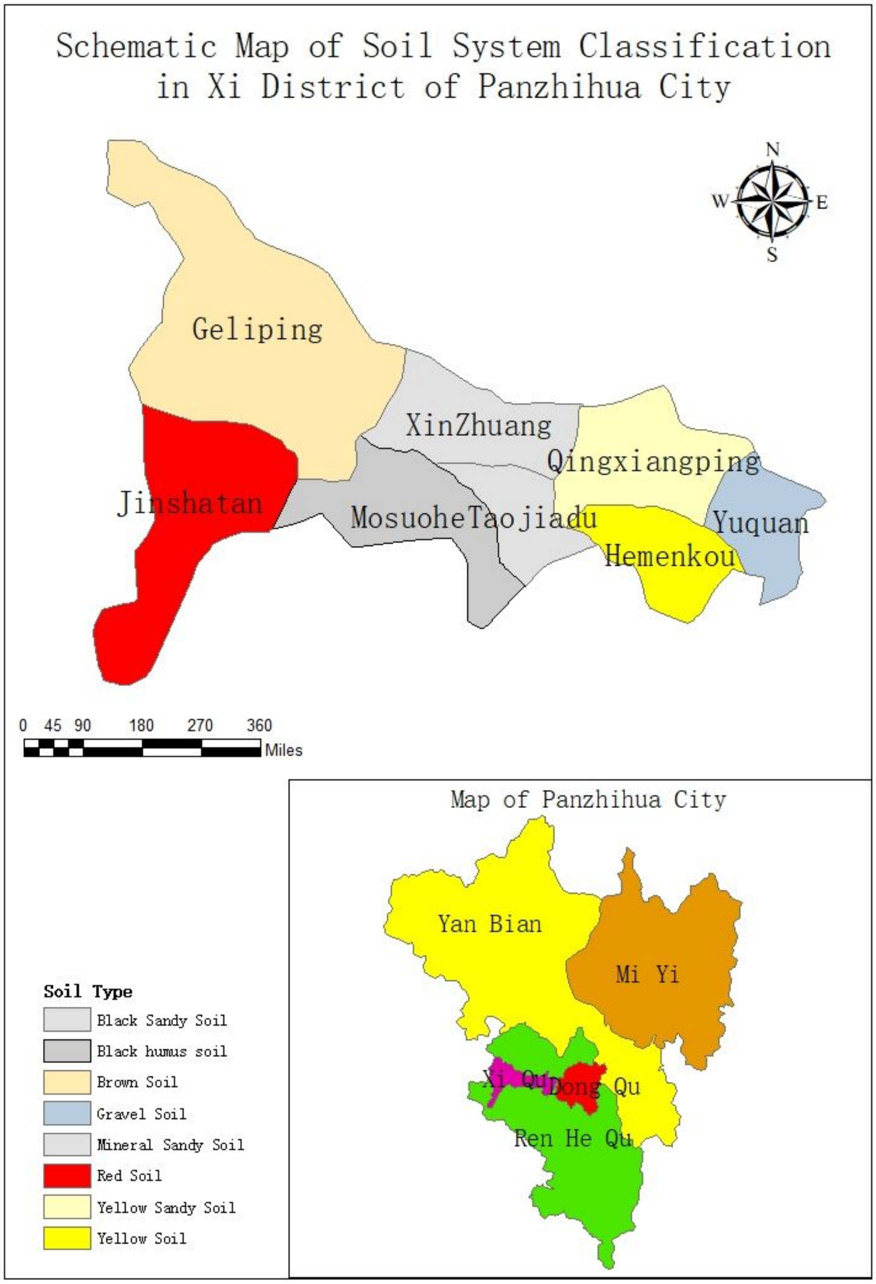

Figure 3-1 Schematic Map of Soil System Classification in Xi District of Panzhihua City

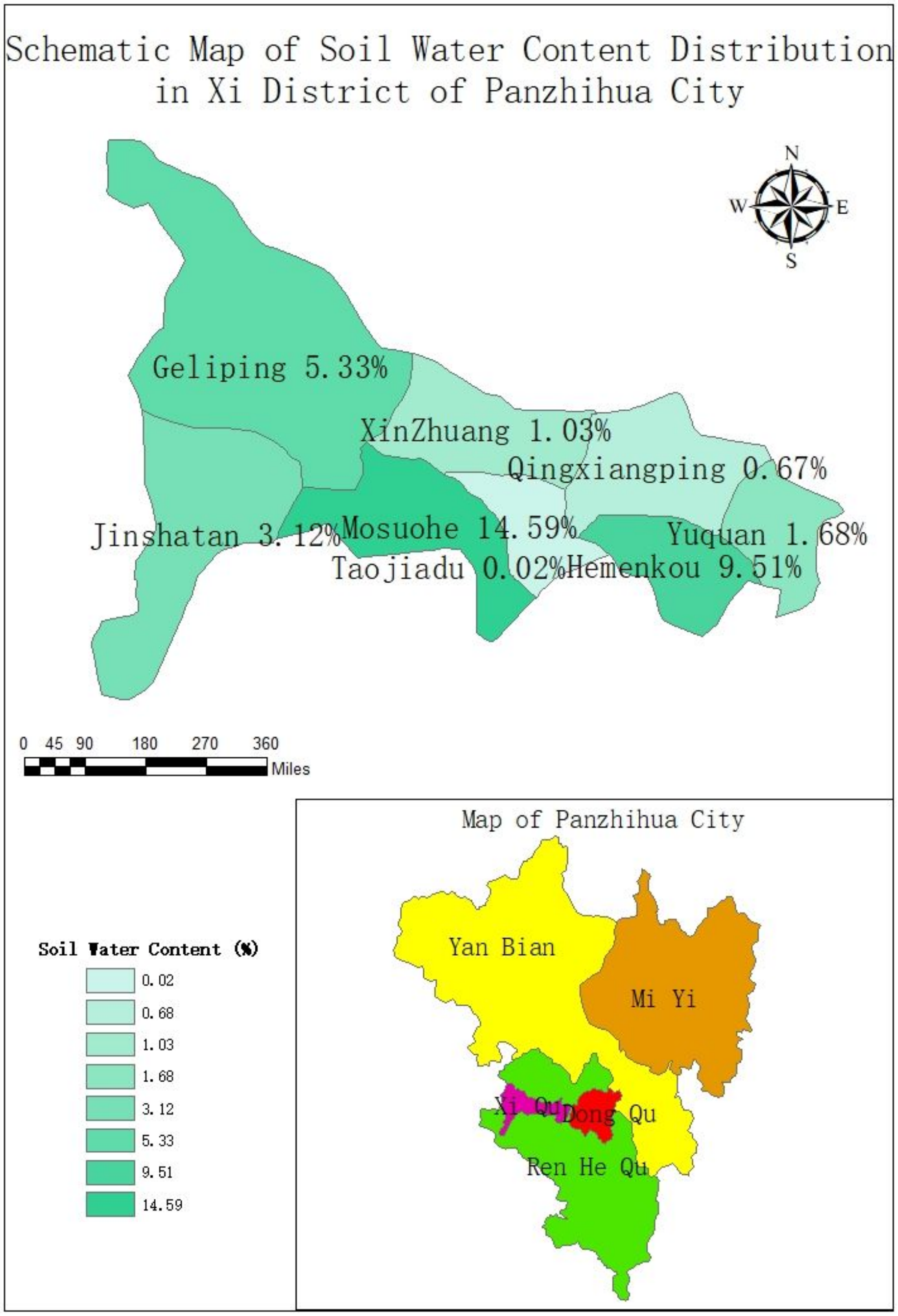

Figure 3-2 Schematic Map of Soil Water Content Distribution in Xi District of Panzhihua City

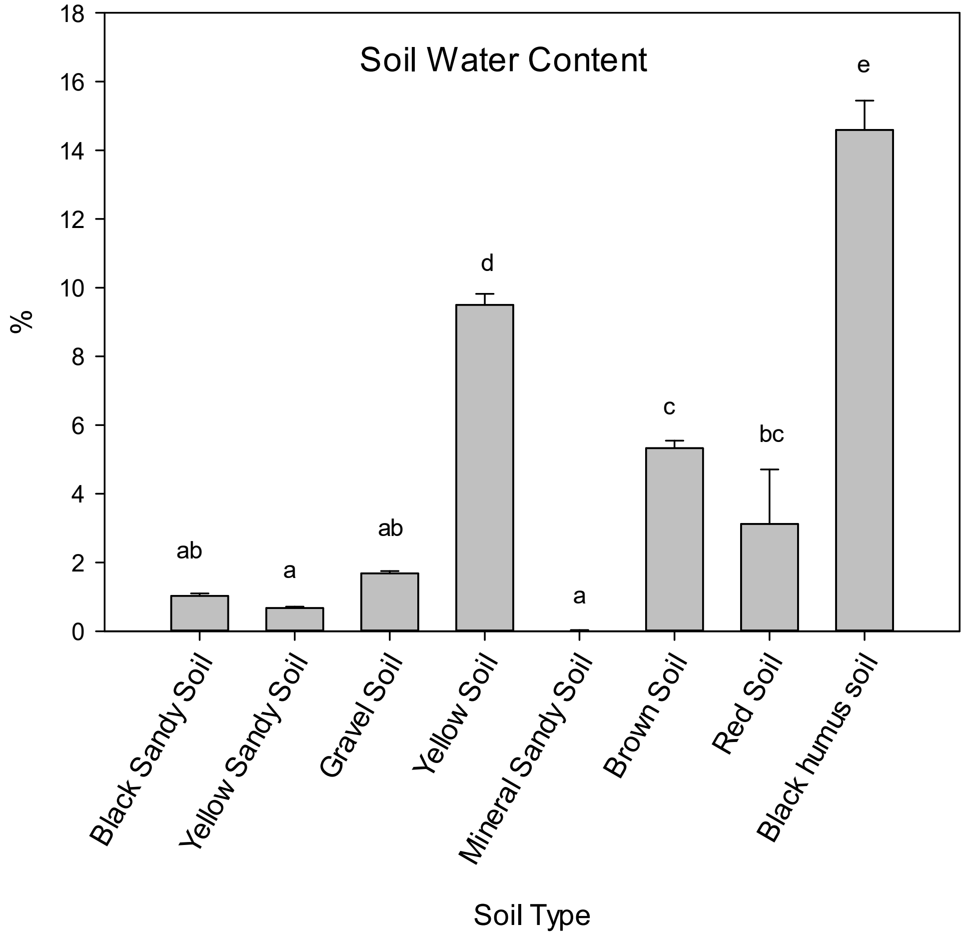

Figure 3-3 Soil water content one way ANOVA analysis graph

Table 3-2 Soil water content (%) classification

Water content (%)	<1	1-5	5-10	10-15	>15
Grade	Extremely low	Low	Normal	High	Higher

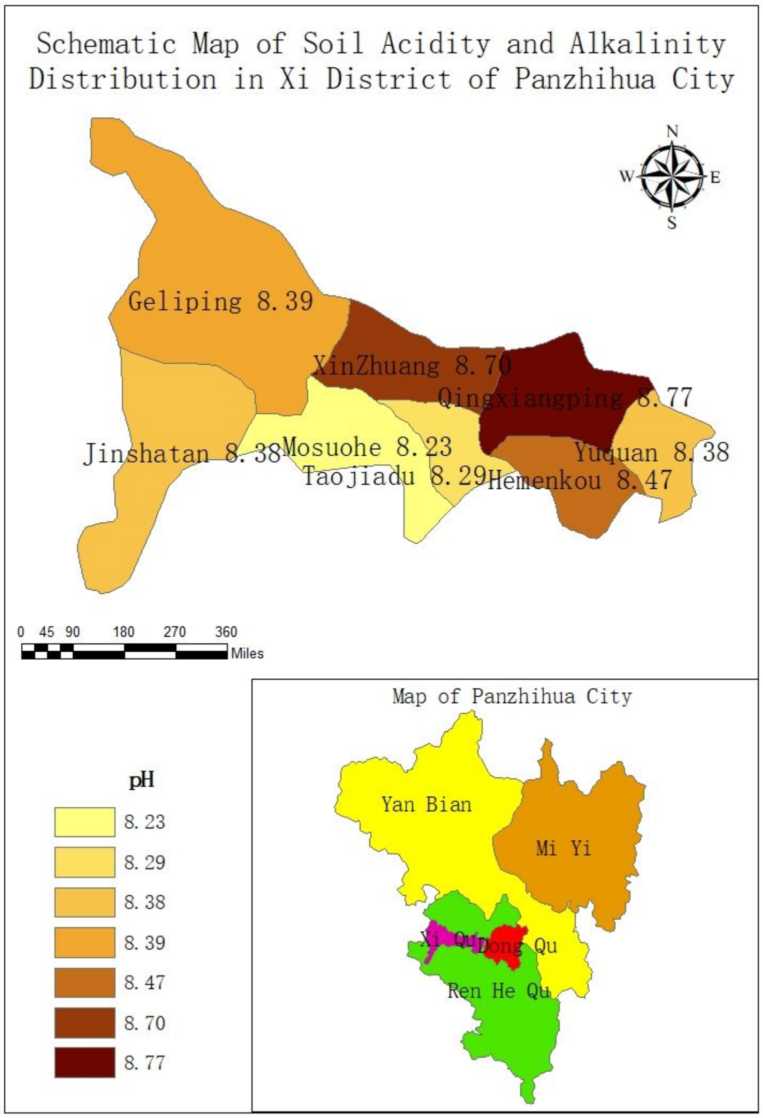

Figure 3-4 Schematic Map of Soil Acidity and Alkalinity Distribution in Xi District of Panzhihua City

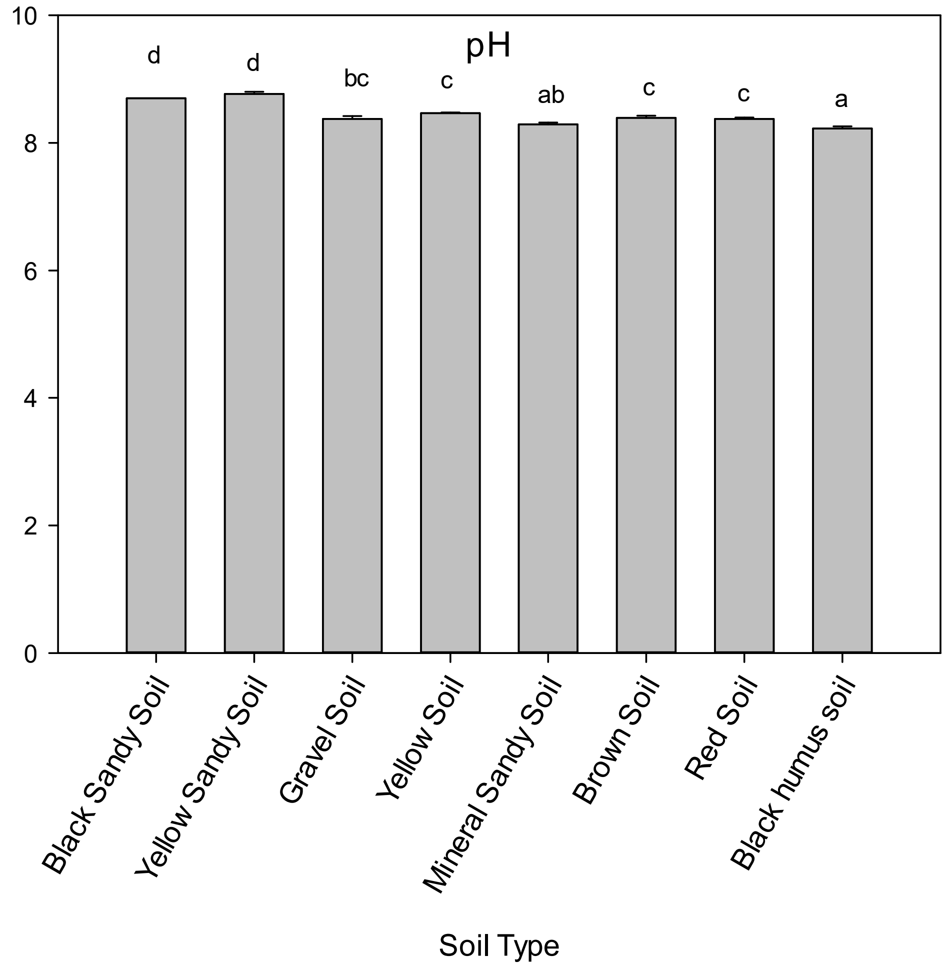

Figure 3-5 Soil pH one way ANOVA analysis graph

Table 3-3 Soil pH grade

Grade	strong acid	acid	weak acid	neutral	Weak alkali	alkali	Strong alkali
pH value	＜4.5	4.5~5.5	5.5~6.5	6.5~7.5	7.5~8.5	8.5~9.0	＞9.0

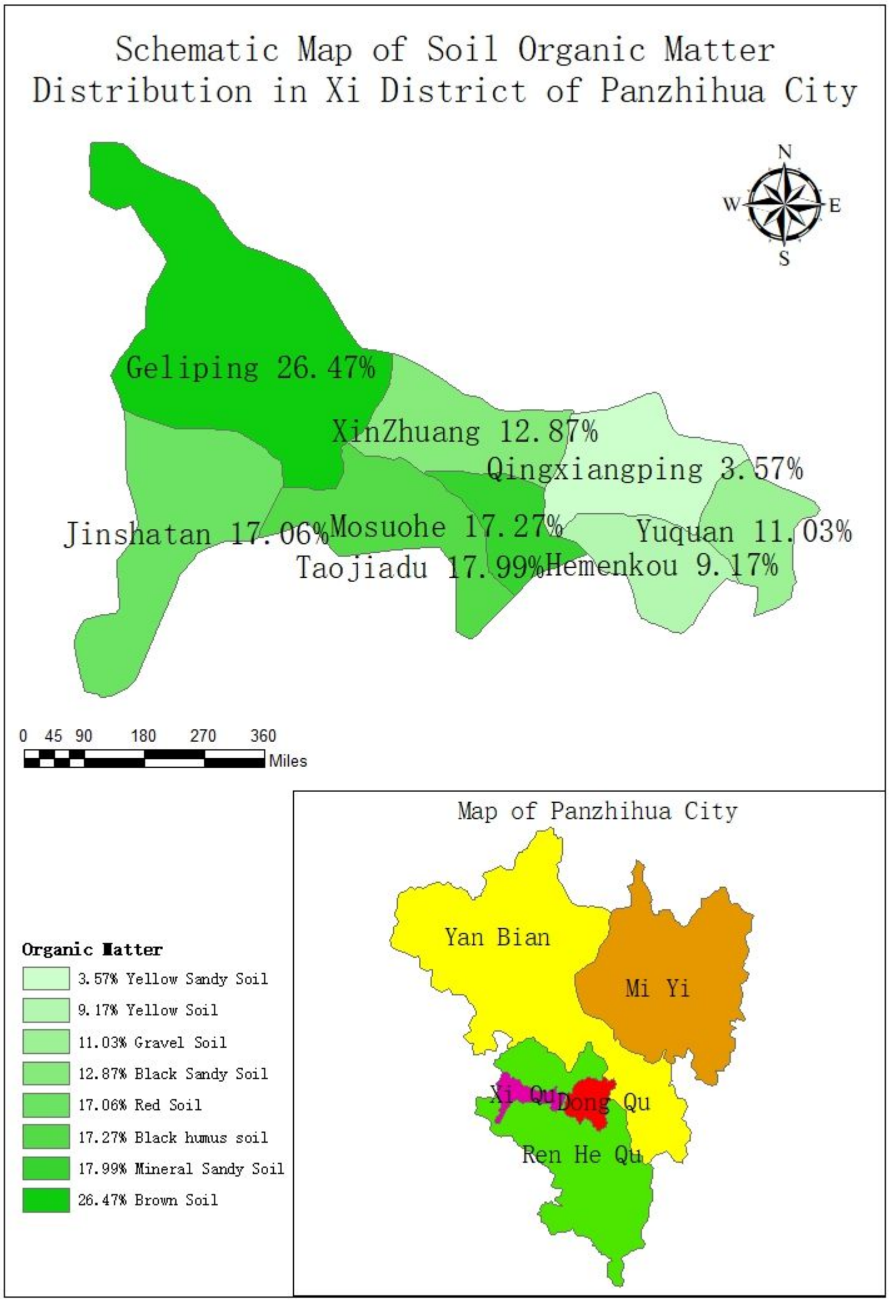

Figure 3-6 Schematic Map of Soil Organic Matter Distribution in Xi District of Panzhihua City

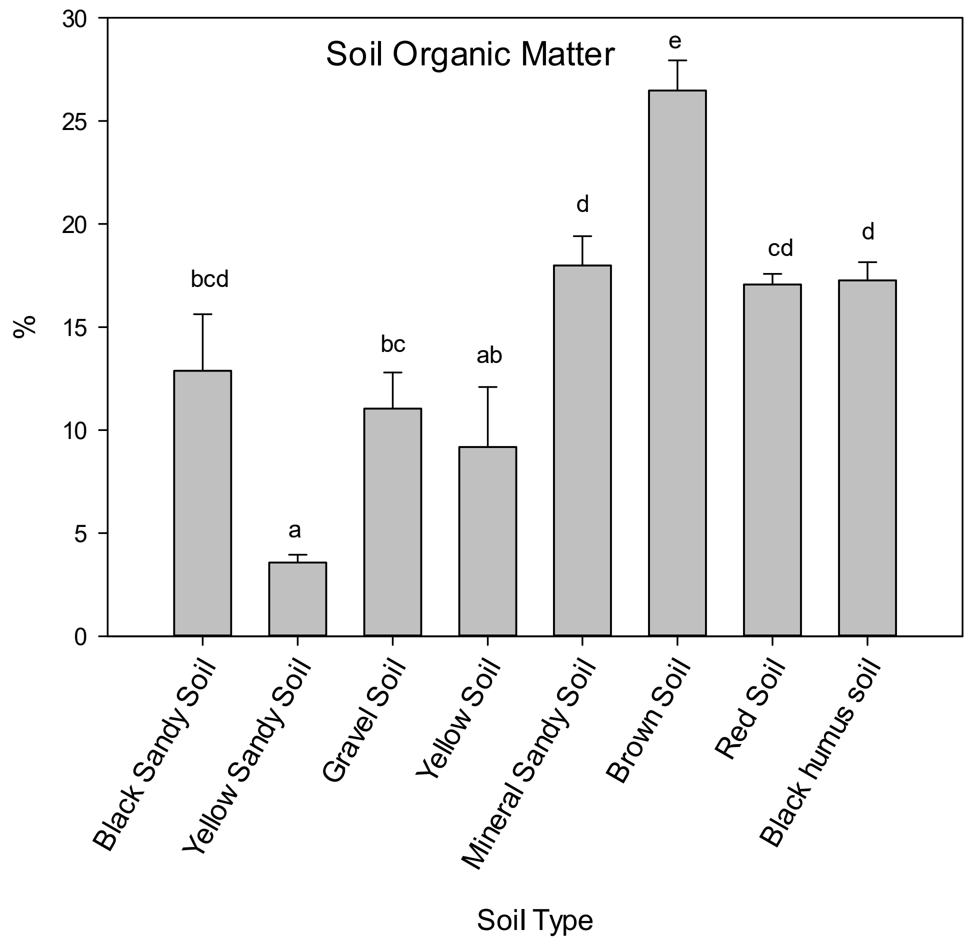

Figure 3-7 Soil organic matter one way ANOVA analysis graph

Table 3-4 Soil organic matter (%) grade

Grade	1（Extremely abundant）	2（Rich）	3（Middle-higher）	4（Middle-lower）	5（Lack）	6（Extremely deficient）
Soil organic matter	＞4	3~4	2~3	1~2	0.6~1	＜0.6

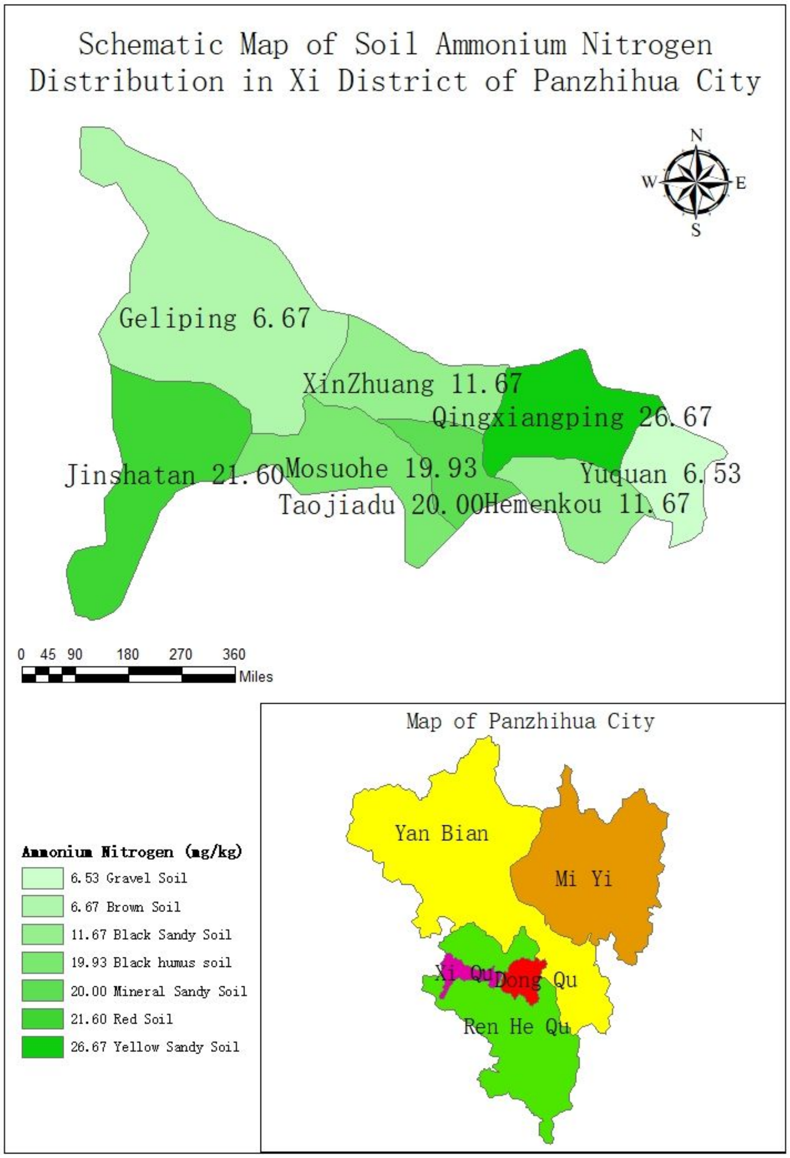

Figure 3-8 Schematic Map of Soil Ammonium Nitrogen Distribution in Xi District of Panzhihua City

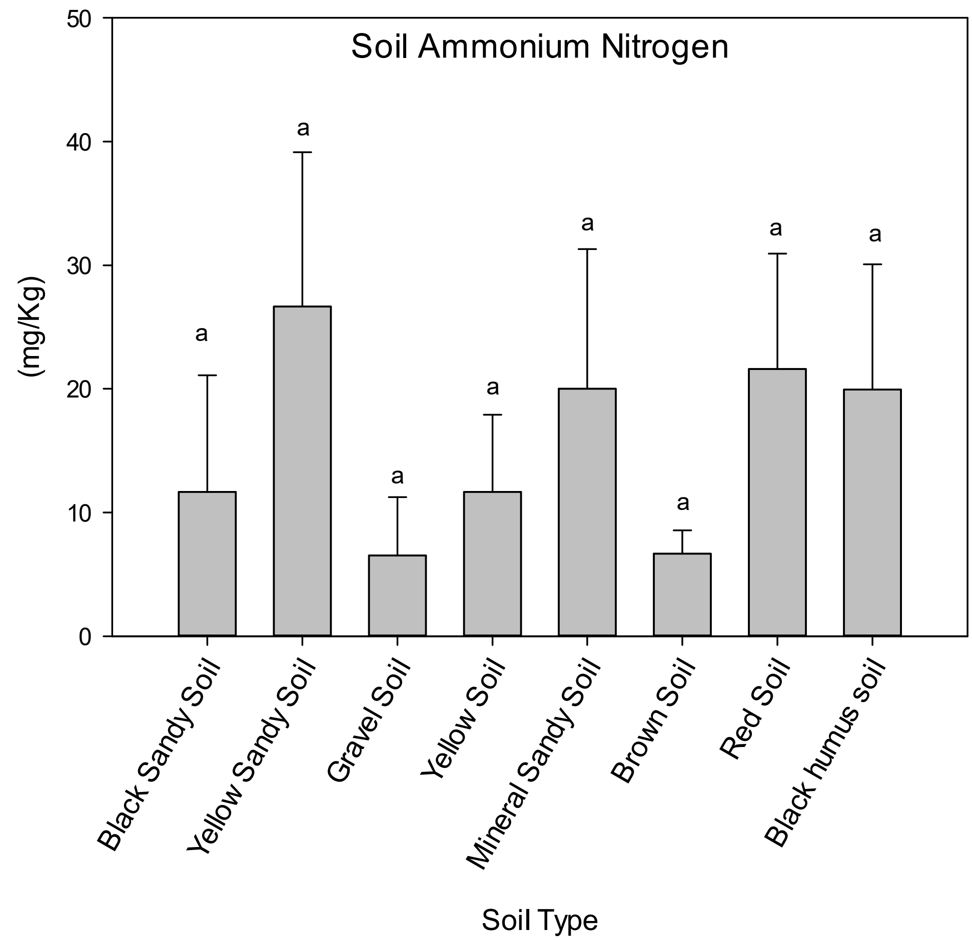

Figure 3-9 Soil Ammonium Nitrogen one way ANOVA analysis graph

Table 3-5 Soil Ammonium Nitrogen (mg/Kg) grade

Grade	1（Extremely abundant）	2（Rich）	3（Middle-higher）	4（Middle-lower）	5（Lack）	6（Extremely deficient）
Concentration	＞150	120~150	90~119	60~89	30~59	＜30

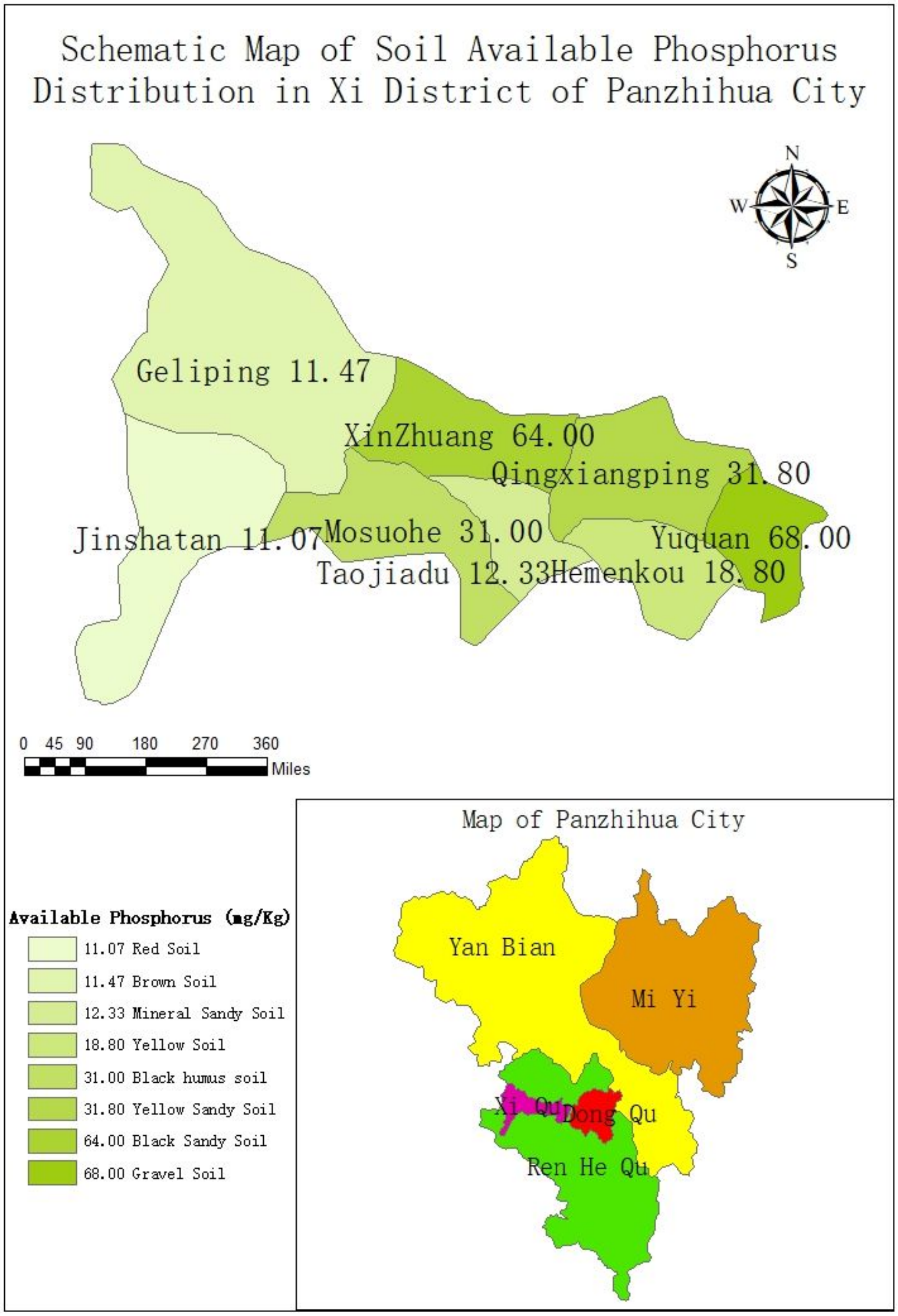

Figure 3-10 Schematic Map of Soil Available Phosphorus Distribution in Xi District of Panzhihua City

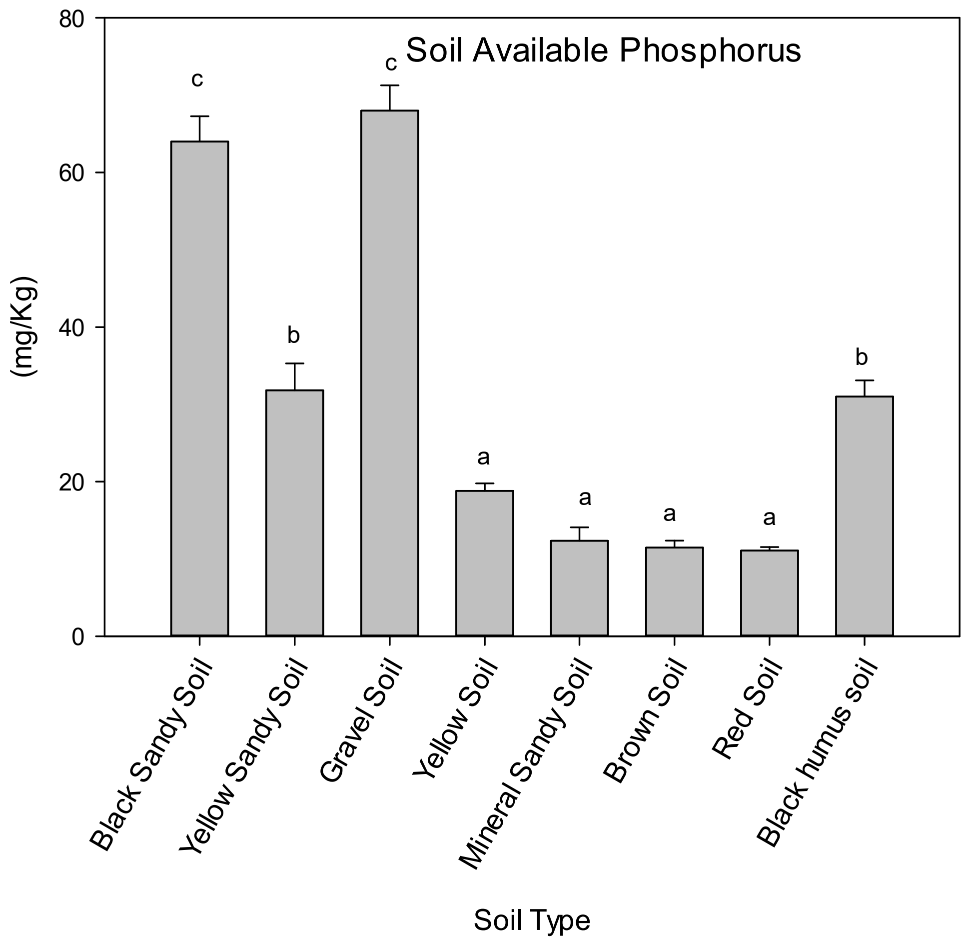

Figure 3-11 Soil Available Phosphorus one way ANOVA analysis graph

Table 3-6 Soil Available Phosphorus (mg/Kg) grade

Grade	1（Extremely abundant）	2（Rich）	3（Middle-higher）	4（Middle-lower）	5（Lack）	6（Extremely deficient）
Concentration	＞40	20~40	10~20	5~10	3~5	＜3

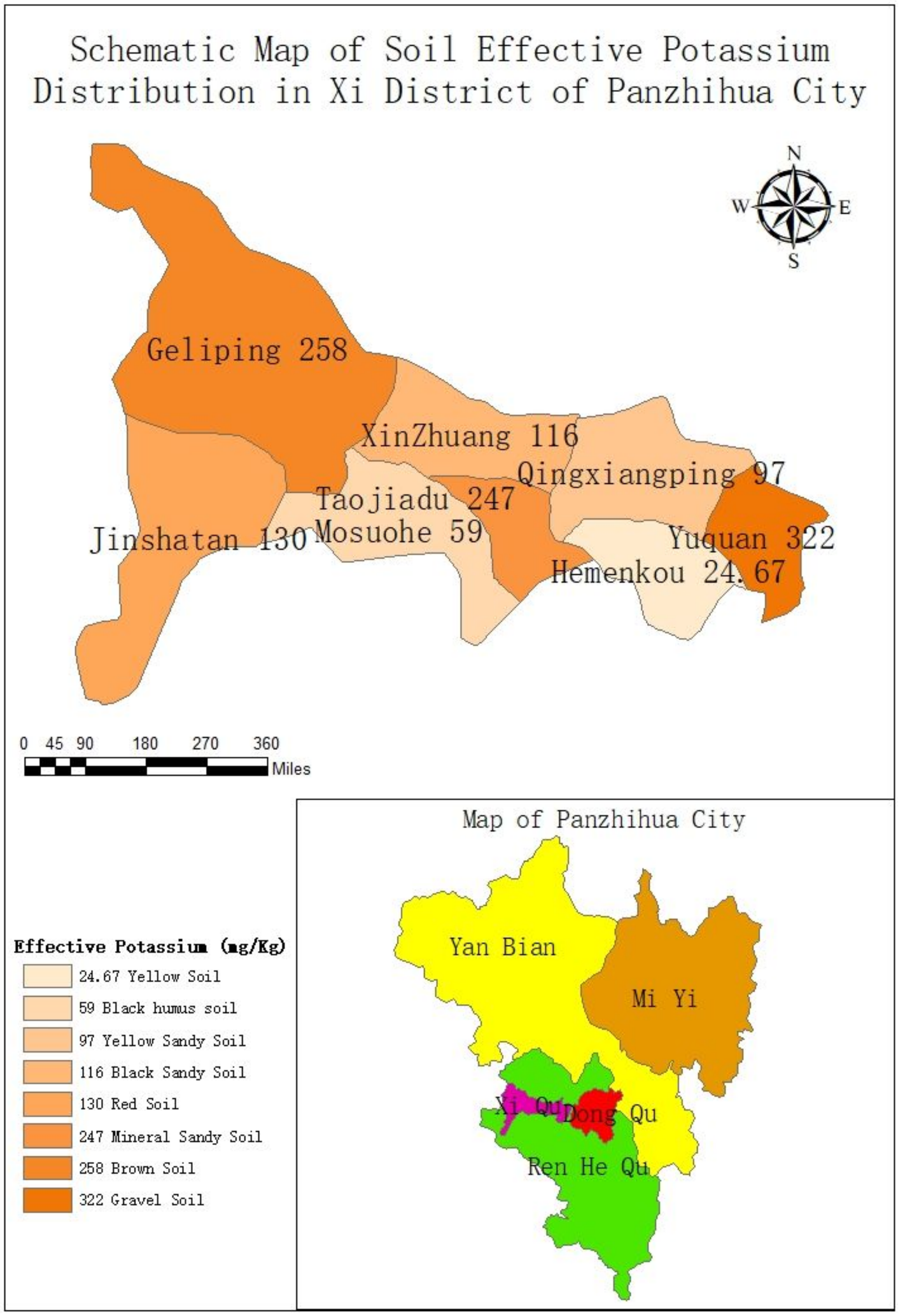

Figure 3-12 Schematic Map of Soil Effective Potassium Distribution in Xi District of Panzhihua City

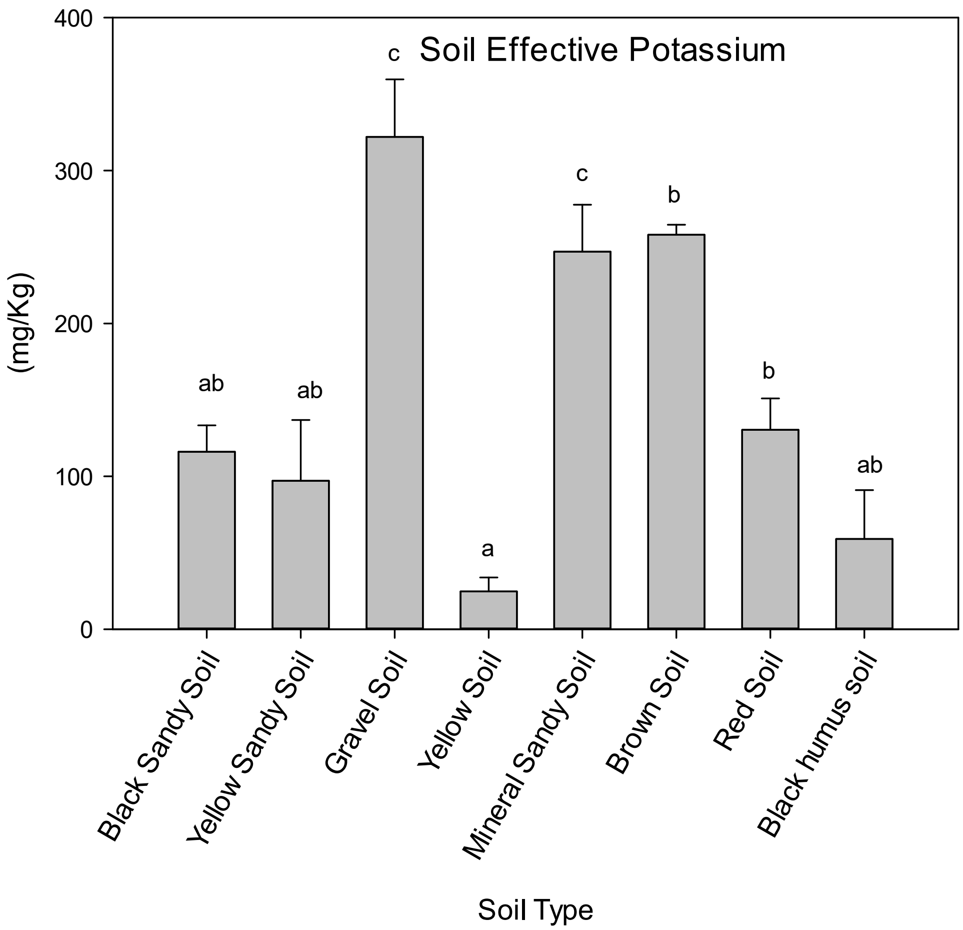

Figure 3-13 Soil Effective Potassium one way ANOVA analysis graph

Table 3-7 Soil Effective Potassium (mg/Kg) grade

Grade	1（Extremely abundant）	2（Rich）	3（Middle-higher）	4（Middle-lower）	5（Lack）	6（Extremely deficient）
Concentration	＞200	150~200	100~150	50~100	30~50	＜30

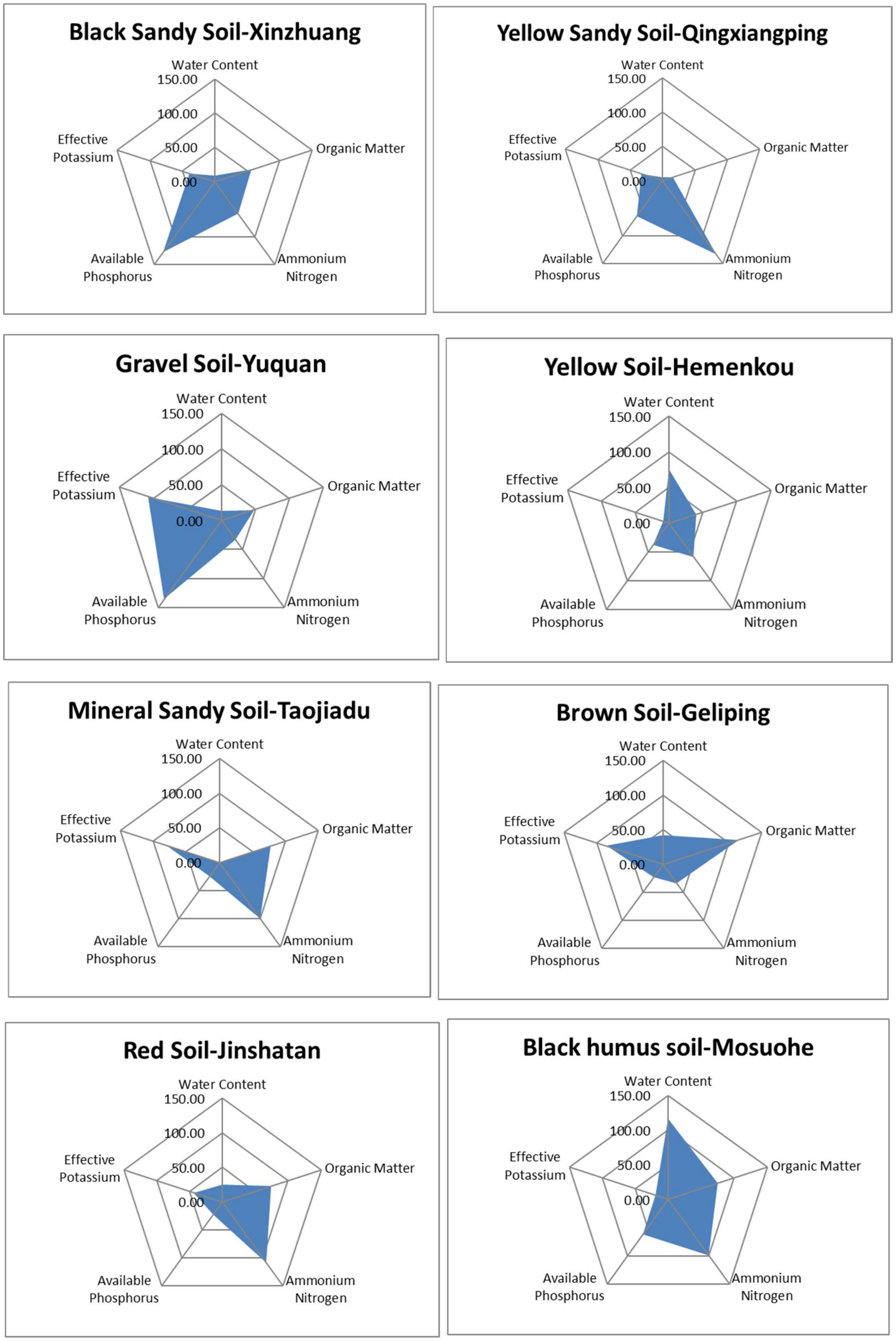

Figure 3-14 Soil Fertility Radar Map

Table 3-8 Soil Fertility Data Table

Soil types in streets	A	B	C	Average
Black Sandy Soil-Xinzhuang	47.23	151.51	43.26	80.67±50.12ab
Yellow Sandy Soil-Qingxiangping	77.45	62.73	39.3	59.83±15.71ab
Gravel Soil-Yuquan	139.35	85.47	94.54	106.45±23.55b
Yellow Soil-Hemenkou	37.31	33.82	45.78	38.97±5.02a
Mineral Sandy Soil-Taojiadu	37.09	98.64	40.06	58.6±28.34ab
Brown Soil-Geliping	81.4	62.61	72.54	72.18±7.68ab
Red Soil-Jinshatan	78.61	78.52	47.49	68.21±14.65ab
Black humus soil-Mosuohe	101.38	91.21	172.55	121.71±36.19b

Table 4-1Pearson's correlation coefficients for relationships among soil water content, organic matter, pH, ammonium nitrogen, available phosphorus, and available potassium content in Xi District.

Variable	Water	Organic Matter	pH	N	P	K
Water	1	0.192	-0.477*	-0.066	-0.224	-0.508*
Organic Matter		1	-0.597**	-0.213	-0.413*	0.355
pH			1	0.072	0.356	-0.270
N				1	-0.258	-0.218
P					1	0.179
K						1

*Significant at P<0.05 (n=24); **Significant at P<0.01 (n=24).

Table 4-2Variable loadings on the first two principal components (PC1 and PC2) for soil water content, organic matter, pH, ammonium nitrogen, available phosphorus, and available potassium content in Xi District.

Variable	PC1	PC2
Water	-0.558	**-0.590**
Organic Matter	**-0.822**	0.334
pH	**0.876**	-0.104
N	0.126	**-0.491**
P	**0.616**	0.365
K	-0.139	**0.913**

Variance explained (%)	36.1	28.0

Figure 4-1Principal component analysis of soil water content, organic matter, pH, ammonium nitrogen, available phosphorus, and available potassium content in Xi District, based on ordination of the plots of the different soil types by the first two principal components (PC). 1=Black Sandy Soil in Xinzhuang; 2=Yellow Sandy Soil in Qingxiangping; 3=Gravel Soil in Yuquan; 4=Yellow Soil in Hemenkou; 5=Mineral Sandy Soil in Taojiadu; 6=Brown Soil in Geliping; 7=Red Soil in Jinshatan; 8=Black humus soil in Mosuohe. The number 1, 2, 3 for example 7-1, 7-2, 7-3, are three sample reduplicate for each soil type.