

# A Comparison of Soil Physical and Chemical Properties among Three Sites on South Campus

Linhan Xu<sup>1\*</sup>, Heshun Mao<sup>1</sup>

<sup>1</sup> NWAUFU & The University of Arizona, Yangling, China

## Email Address

755400954@qq.com (Linhan Xu)

\*Correspondence: 755400954@qq.com

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## Abstract:

In order to study the effects of different plantations on the physical and chemical properties of soil, we collected soil samples from three representative sites where peony, maple trees and crabapple trees were planted on the South Campus. We determined eight chemical and physical properties. We used statistical methods to determine the differences between the three sites. The results showed that there were significant differences in water content, organic matter and Olson-P among the three plots. In addition, we compared two sites of a time using a t-test, and Site 1 was significantly different than Site 3 for water content, and Organic matter. Through the analysis, the differences and relations between soil characteristics of different sites were revealed, which provided scientific basis for soil management and plant growth of corresponding sites.

## Keywords:

Soil Characteristics, Soil Management, Plant Type, T-Test

## 1. Introduction

Soil refers to a loose layer of material on the Earth's surface, consisting of various granular minerals, organic matter, water, air and microorganisms. Soil is the most important natural resource of a country. It is the material basis of agricultural development. China's land area ranks the third in the world, and the changeable soil formation factors determine the characteristics of abundant soil types and complex distribution [1].

There are 14 different types of soil in China. All kinds of soils are formed under the combined influence of parent material, climate, biology, topography, time and human activities. The distribution of soil types in China is consistent with the bioclimatic zonality, showing the horizontal and vertical distribution laws in a wide area. It is also affected by regional and local terrain, parent material, hydrogeology and other factors, showing regional distribution and micro-distribution.

Shanxi Province is located in the hinterland of China (105°29' -- 111°15' east longitude, 31°42' -- 39°35' north latitude), straddling the Yellow River and Yangtze River [2]. There are 21 soil types in the province. There may be differences in soil types and physical and chemical properties at the same site. For example, soil bulk density, organic matter content, mineral nitrogen content will vary slightly. This is related to the vegetation planted in different areas and different human activities.

Plants grow on soil and play a regulating role in the physical and chemical properties of soil [3]. Plants provide nutrients for soil microorganisms through their litter and secretions, leading to co-evolution between plants and microorganisms and promoting the diversity of soil microorganisms. At the same time, plants can also repair soil pollution [4]. Phytoremediation refers to the technology of using plants to remove heavy metals from contaminated soil and wastewater, including plant extraction, plant volatilization and plant fixation [5]. Plant roots are also important factors influencing soil structure and soil hydraulic parameters [6].

Plants need many nutrients to grow, most of which are absorbed through their roots. Microbial species get nutrients from the soil layer and store or concentrate them around the roots for easy uptake by plants. At the same time, plant root exudates are energy sources for microorganisms, and plant roots play an important role in soil nutrient cycling [7]. On the one hand, it controls the nutrient uptake of plants, which obtain water and nutrients from the soil. In addition, the roots are characterized by rapid renewal and rapid development. Nutrients flow through the roots and carbon and nutrients flow to the soil layer through the roots, so plant roots are important carriers of soil organic matter.

In order to explore the differences of physical and chemical properties of soil in different regions and the effects of planting vegetation on soil, soil samples were collected at three representative sites in the South Campus of Northwest A&F University, Yangling, Shaanxi, China. The bulk density, water content, porosity, mineral nitrogen concentration, pH value, soil organic matter content and available phosphorus concentration of the three soil samples were determined. We used statistics to identify differences among the 3 sites.

## **2. Methods**

### ***2.1. Field sampling***

The first step was to collect soil samples. During the collection, soil samples were required to be representative, so multi-point sampling is required to be fully mixed. Meanwhile, the distribution points should be uniform. The sampling number of mixed samples is usually 5-20 points according to the area of the test area and whether the soil strength is uniform. The sampling depth was usually about 0-20 cm.

### ***2.2. Physical properties***

When collecting soil samples for studying soil physical properties, attention should be paid to keeping them in their original state. When collecting samples for analysis of soil structure, it should also be noted that the soil moisture should not be too dry or too wet. The bulk density cylinder and the aluminium box were first weighed, then samples were taken at three locations using the bulk density cylinder and the soil and the bulk density cylinder, as well as the soil and the aluminium box, were weighed.

Soil bulk density was calculated using the data. Soil porosity is then calculated. The moisture content of soil was obtained by alcohol burning method.

$$\text{Soil bulk density} = \frac{\text{Dry soil weight (g)}}{\text{The volume of bulk density cyclinder( cm3)}} = \frac{\frac{100}{100 + W} \text{ Wet soil weight}}{\text{The volume of bulk density cyclinder( cm3)}}$$

$$\text{Soil porosity} = \left(1 - \frac{\text{Bulk density}}{\text{Soil grain density (2.65g/cm3)}}\right) \times 100$$

$$\text{Soil moisture content} = \frac{\text{Wet soil weight (g)} - \text{Dry soil weight (g)}}{\text{Dry soil weight (g)}} \times 100$$

### 3. Chemical Propertie

#### (1) Inorganic- N

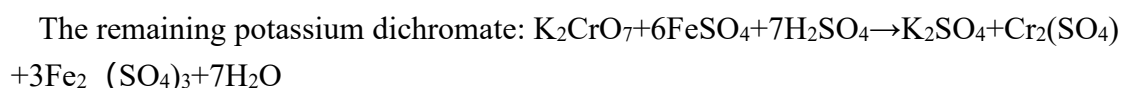
NO<sub>3</sub><sup>-</sup> and NH<sub>4</sub><sup>+</sup> adsorbed by soil particles were extracted by KCl solution. The extracts were determined using a continuous flow analyzer. Firstly, 1mol/L extract was prepared. After crushing the recovered fresh soil samples and sifting them through 3mm, we weighed 5.00g of fresh soil, added 50mL 1mol/L KCl solution, shook for 1h, and took them out for filtration. At the same time we added two blanks for control. After indicating the sequence of samples, the continuous flow analyzer was used to determine nitrate nitrogen and ammonia nitrogen in the extracts. The measurements for each group are subtracted from the blank mean of the same batch.

#### (2) pH

The pH of soil was measured by potentiometric method. The 10g soil sample was air-dried through 1mm sieve and mixed with 10mL distilled water. After standing, the corrected pH meter was used to measure the soil suspension after standing for 30min. The glass electrode ball was immersed in the suspension clay layer to read and record the pH value.

#### (3) Organic matter

A certain amount of standard potassium dichromate ---- sulfuric acid solution was boiled at constant temperature (170-180°C) for 5 minutes to oxidize the carbon in soil humus. The remaining potassium dichromate was titrated with ferrous sulfate. The content of soil organic carbon was calculated from the amount of potassium dichromate consumed, then multiplied by the constant of 1.724, which is the content of soil humus. The equation is as follows:



In the reduction of potassium dichromate by ferrous sulfate, o-phorphine was used as an indicator. At the beginning of titration, due to excessive potassium dichromate, the solution was covered with orange red potassium dichromate. During titration, the green color of Cr<sup>3+</sup> gradually deepened, and the solution turned gray green near the end. If the standard ferrous solution is too much by half a drop. It turns brick red to indicate that the point had arrived.

$$\text{Soil organic matter} = \frac{\frac{c \times 5v}{V_0} \times (V_0 - V) \times 3.0 \times 1.1}{m \times k} \times 1.724$$

#### (4) Olson P

We weighed 2.5g of air-dried soil sample through a 20-mesh sieve, and added 0.5mol/LNaHCO<sub>3</sub> and 1 scoop of phosphorous free activated carbon. At the same time, a blank control test was conducted, that is, no soil samples were added, only extracts and activated carbon were added. After shaking for 30min, filter with phosphorus-free filter paper. We absorbed 10mL filtrate, added 30mL distilled water, added 5mL molybdenum-antimony anti-reagent with pipette, shake well, and held the volume to 50mL. Colorimetry was performed at 700mm wavelength.

## 4. Results

We analyzed the means of the eight soil variables at the three research sites. At our three sites, these were significant difference among the three sites for three of the variables measured (Table 1). These included water content (p=0.000009), organic matter (p=0.0003) and Olson-P (p=0.02). In addition, we compared two sites of a time using a t-test (Table 2), and Site 1 was significantly different than Site 3 for two variables (water content, Organic matter). Meanwhile , we compared site1 and site 2 for Olson-P. Site 1 was significantly different than Site 2 for Olson-P.

**Table 1.** Means (+/- Standard deviation) for eight soil variables estimated at three sites on South Campus.

| Variable                            | Site 1      | Site 2      | Site 3      | p-value * |
|-------------------------------------|-------------|-------------|-------------|-----------|
| Bulk density (g/cm <sup>3</sup> )   | 1.26 (0.30) | 1.23 (0.20) | 1.12 (0.30) | 0.67      |
| Porosity (%)                        | 52.3 (12.0) | 53.9 (8.70) | 57.5 (14.1) | 0.70      |
| Water content (%)                   | 17.3 (1.40) | 12.1 (1.90) | 14.2 (1.60) | 0.000009  |
| Organic matter (%)                  | 10.0 (1.70) | 7.2 (1.00)  | 5.7 (1.90)  | 0.0003    |
| NH <sub>4</sub> <sup>+</sup> (mg/L) | 8.3 (2.10)  | 11.7 (9.40) | 12.7 (6.10) | 0.44      |
| NO <sub>3</sub> <sup>-</sup> (mg/L) | 8.7 (3.10)  | 9.0 (4.80)  | 5.6 (1.80)  | 0.16      |
| Olson-P (mg/L)                      | 28.1 (9.50) | 15.6 (10.5) | 17.0 (3.60) | 0.02      |
| pH                                  | 8.5 (0.04)  | 8.4 (0.06)  | 8.5 (0.07)  | 0.81      |

\* one way ANOVA

**Table 2.** Comparison of sites using a t-test.

| Variable                            | Site comparison  | P-value |
|-------------------------------------|------------------|---------|
| Bulk density (g/cm <sup>3</sup> )   | Site 1 VS Site 3 | 0.45    |
| Porosity (%)                        | Site 1 VS Site 3 | 0.47    |
| Water content (%)                   | Site 1 VS Site 3 | 0.0001  |
| Organic matter (%)                  | Site 1 VS Site 3 | 0.0009  |
| NH <sub>4</sub> <sup>+</sup> (mg/L) | Site 1 VS Site 3 | 0.11    |
| NO <sub>3</sub> <sup>-</sup> (mg/L) | Site 2 VS Site 3 | 0.12    |
| Olson-P (mg/L)                      | Site 1 VS Site 2 | 0.05    |
| pH                                  | Site 1 VS Site 2 | 0.51    |

## 5. Discussion

First we need to identify the different plants in the three sites. The first site was planted with peonies, the second with grass and maple trees, and the third with grass and crabapple trees.

The observed differences in water content between sites may be the result of a combination of factors. First, soil moisture content is affected by different plant mulch. The presence of grass in site2 may be one of the main reasons for the higher soil moisture at the site, since grass has a higher water retention and retention capacity than peony or crabapple trees [8]. Furthermore, differences in irrigation sources, amounts of water and times of irrigation may cause soil moisture content [9]. The three sites selected in this experiment are all in the south campus, so the irrigation source is the same, but there are slight differences in irrigation amount and irrigation time. This also affects the water content of the soil in different locations.

The difference in organic matter content can be attributed to different inputs at each site. It was found that site1 had the highest organic matter content, which may be caused by the large amount of organic matter input such as fertilizer and the accumulation of peony biomass [10]. The organic matter content of Site2 is at moderate levels, which may be the result of the accumulation of leaves from maple trees that fall into the soil [11]. The leaf yield of crabapple trees planted by Site3 was lower than that of maple trees, so the accumulation of organic matter was lower than that of site2. These results indicate that the composition and amount of vegetation biomass are the key factors affecting soil organic matter content.

Available phosphorus in soil is one of the main nutrients needed by all plants, but different plants have different requirements and absorption capacity of available phosphorus [12]. Through the experimental study, we also found that the Olson P content of site1 was higher than that of other sites. Peony is one of the flowers with high nutrient requirement, and it requires more available phosphorus in soil. Compared with peony, herbaceous plants generally have shallow root system and short growth cycle, and their demand for available phosphorus is smaller. Therefore, the content of available phosphorus in soil planted with peony is generally higher than that planted with herbaceous plants. Maple trees also have different requirements for available phosphorus than herbs [13]. Because Maple trees are trees with deeper roots and longer growth cycles, they have a relatively large demand for available phosphorus in the soil (but less than peonies), and their absorption rate in the soil may be faster than that of herbaceous plants.

## 6. Conclusions

By conducting soil sample collection, property inspection, and data analysis, we have observed significant impacts of various vegetation types on the physical and chemical properties of soil. Notable differences were found in water content, organic matter content, and Olson-P concentration. These findings highlight the crucial role of human management practices and soil properties. It underscores the need for careful consideration of vegetation selection and management strategies to ensure optimal soil conditions and productivity. Managing soil properties can contribute to sustainable land use and ecosystem health.

## Conflicts of Interest

The authors declare that there is no conflict of interest regarding the publication of this article.

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