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Study on Soil Erodibility and Related Factors of Different Land Use Types in the Black Soil Area of Northeast China

Tingting Xue, Chen Zhang, Youyou He, Xiangwei Chen, Yu Fu*

Northeast Forestry University Harbin, 150000, China

Abstract

The northeast black soil area is one of the main areas of soil erosion source management in Northeast China. Because of the special weather environment and people's unreasonable use of land and other reasons, the soil wind erosion and sanding problem in this area is very serious. It has been shown by many researchers that different land use practices have a greater relationship with the physicochemical properties of their soils. Land areas with better surface vegetation cover have better fertility properties and have a less fine particulate matter within them. All these studies have been considered from the perspective of soil fertility properties, rather than having a more targeted soil erodibility research result. For the black soil area in northeast China, there is still a gap in the study of soil erodibility for different use methods and types. Therefore, it is of obvious theoretical and practical significance for the authors to study the erodibility of soils and related factors in the black soil area of northeast China.

Keywords

Northeastern Black Soil Region; Soil Erodibility K Value; Factor Study; Land Use Type; Water Content; Capacitance; Porosity.

1. Materials and Methods

People's activities have a significant impact on soil erodibility. The unreasonable use of land in the black soil areas of the northeast of China and the arbitrary change in the nature of its land use, which leaves the original land without any improvement, have led to such serious consequences. Changes in land use can significantly alter the physical and chemical properties of the soil. Many researchers have shown that different land use practices have a strong relationship with the physicochemical properties of the soil. Areas of land with better surface vegetation cover have better fertility properties and have a less fine particulate matter within them. These studies are considered from the point of view of soil fertility, but not from the point of view of a more specific soil erodibility study. For the black soil area in northeast China, there is still a gap in the research on soil erodibility for different use methods and types. Therefore, it is of obvious theoretical and practical significance for the author to study the erodibility of soils and related factors in the black soil area of northeast China.

1.1 Overview of the Study Area

In order to study the soil erodibility of different land use types and their related factors in the northeast black soil area, four farms, namely, Zhaoguang farm, Hongguang farm, Keshan farm, and Heshan farm, which are relatively representative, were selected as the study area, and soil samples of certain use types were selected and analyzed for their composition. The basic information about the four farms is as follows.

Zhaoguang Farm is located at the edge of the southern foothills of the Xiaoxinganling Mountains, and the general topography is high in the southwest and low in the northeast. The altitude is between 240-330 meters. Located in the middle and high latitudes, it is a cold-temperature monsoon climate,

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and the average annual temperature is generally 0.5 ℃, frost-free period of about 120 days. The annual rainfall is 570 mm, and the annual average sunshine is over 2,700 hours. The general climate is characterized by dry and windy spring, high temperature and rain in summer, early frost and fast cooling in autumn, and cold and long winter. The soil types are mainly brown loam, black soil, meadow soil, and swampy soil, and the area of black soil accounts for 57.4% of the total cultivated land area.

Hongguang Farm is located 25 kilometers northeast of Hailun City, across Hailun, Suiling two cities and counties. It is located at the southwest foot of the Xiaoxinganling Mountains, the Songnun Plain Hulan River upstream, between the Zayin River and the Shuangji River. The climate is the fourth cumulative temperature zone, with an annual frost-free period of about 118 days, an annual average sunshine hour of 2209 hours, an effective annual temperature of 2150 ~ 2300 ℃, and an annual average precipitation of about 587 mm. The arable black soil reaches more than 30 cm, the soil is fertile, with an average organic matter content of 5% to 7%, and is resistant to cold and flooding. The good ecological environment and the unique natural resources advantage can develop green and organic agricultural products.

Keshan farm is located on the western foot of the Xiaoxinganling, northeast of the Songnun Plain. Its terrain is hilly diffuse post, fertile soil, black calcium soil accounts for 98% of the land area, suitable for crop growth. The farm is a warm and cool climate zone, characterized by spring drought and wind, high temperatures and rain in summer, rapid cooling in autumn, early frost, longer winters, snow, cold, and dry.

Heshan farm is located in the southern foothills of the Daxinganling hills and manga. Its overall shape is narrow from north to south and narrow from east to west, basically in the shape of a strip. The terrain is high, with an average elevation between 267-300 meters. The surface of the land is complexly undulating. The plain area is relatively small, mainly dominated by the slope of the hill, and the general topography is high in the northeast and low in the northwest. It has a cold-temperate continental climate and is a typical dryland crop production area. The climate is characterized by windy spring, temporary hot summer, fast cooling in autumn, and long cold winter. The soil type is mainly black soil, accounting for 65.2% of the total area. The cultivated land is weakly acidic, with a PH value between 6.5 and 7.0, an organic matter between 4 and 6%, fertile soil, and balanced ground strength. It is suitable for the growth of high-quality barley, wheat, soybeans, and other crops.

1.2 Sample Site Selection and Sample Collection

By investigating the vegetation and topographic conditions of the study area, four types of land use, namely, five-flower grass ponds, natural forests, sphagnum pine, and cultivated land in four farms, were selected for the study, and the soils were sampled in the corresponding areas at depths of 0-10, 10-20 and 20-40 cm, respectively, in an "S" shaped route. The samples of in situ soils were contained in aluminum boxes [1]. To avoid excessive random errors, the measurements were repeated three times for each land type and each depth [2]. After the determination of physical properties, the samples were air-dried and sieved and then the mechanical composition and organic matter content of the soil were determined by laser particle size meter and potassium dichromate method, respectively. The data obtained are presented in the Appendix [3].

1.3 Determination of Physical and Chemical Properties of Soils

1. Determination of soil water content [4]:

Soil moisture content is the proportion of water contained in the soil to the total weight of the soil and is generally expressed as a percentage.

A large aluminum box containing a fresh soil sample is weighed on an analytical balance to the nearest 0.0001g. Remove the lid of the box, place it under the bottle, and bake it in an oven that has been preheated to 105±2°C for 12h. Remove, cover, transfer to a desiccator and cool to room temperature (about 30min), weigh immediately. The determination of moisture in fresh soil samples was done in three parallel determinations.

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Result calculation:

Calculation formula:

Moisture (analytical basis), %=(m1-m2)/(m1-m0)×100

Moisture content (dry basis), %=(m1-m2)/(m2-m0)×100

where m0-drying empty aluminum box mass

m1-mass of the aluminum box and soil sample before drying

m2-quality of the aluminum box and soil samples after drying

The results of the parallel measurement are expressed as the arithmetic mean, retaining one decimal point after.

2. Determination of soil capacitance

The mass or weight of a unit volume of soil (including soil grains and pores) in the natural basal state of the field is called the soil capacity.

Place the ring knife rest on the known weight of the ring knife, rub the inner wall of the ring knife slightly with petroleum jelly, and press the edge of the ring knife vertically downward into the soil until the ring knife cylinder is filled with soil samples. Cut the soil sample around the ring with a soil trimmer, remove the ring knife that has been filled with soil, and carefully trim and wipe the excess soil at both ends of the ring knife and outside. At the same time, sample the soil at the same layer with an aluminum box to determine the soil water content. Cover both ends of the ring knife with soil samples immediately to avoid evaporation of water. Immediately afterwards, weigh the sample (to the nearest 0.01g) and record it.

Results are calculated:

where XX-soil volume weight;

m-weight of the wet sample inside the ring knife;

V-ring knife volume;

XX-sample moisture content.

3. Determination of soil porosity

The percentage of pore space per unit volume of soil is called soil porosity. Determination of porosity provides insight into the soil structure, aeration, permeability, thermal properties, and effects on crop root growth and root respiration. Soil porosity is determined by soil texture, degree of agglomeration, organic matter content, type of soil cement and soil tillage and irrigation conditions. Soil porosity can be determined by a variety of methods, which can be broadly divided into two categories: instrumental and computational methods. Total porosity is generally not directly measured, but is calculated by the two values of soil density and relative density through the formula:

Porosity, % = (1 - soil bulk / soil specific gravity) × 100

4. Determination of agglomerates

Soil agglomerates are good soil structuring bodies. It is characterized by porosity and water stability. This is reflected in the moderate size of soil porosity, the coexistence of water-holding pores and aerated pores, and the appropriate number and proportion. As a result, the solid, liquid, and gas phases of the soil are in a coordinated state with each other. Therefore, it is generally accepted that a high number of agglomerates is one of the signs of fertile soil. Agglomerates are measured in order to measure the number of agglomerates in each diameter range and to estimate qualitatively the fertility of the soil at once. The measurement procedure is as follows.

(1) Slowly pour the weighed sample on the first layer of the sieve; transfer the residual sample in the container to the sieve completely with a small brush and gently shake the sieve to make the sample lay flat on the first layer of the sieve;

(2) Fix the sieve with a triangular holder;

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(3) Place the sieve set in a bucket, hold the sieve set with a rubber tube and slowly add water along the wall of the bucket to allow air to escape from the sieve set; Add water to the water level line drawn in advance (Note: Do not add water to the sample when adding water to the bucket); add water until the sample of the first layer of the sieve is not exposed to the water when the sieve rises to the top; if the sieve does not completely exhaust the air, the bucket can be properly tilted to make the air escape, and pay attention to the speed of adding water, do not make the water overflow into the soil layer from the edge of the first layer of the sieve.

(4) Hang the four prepared sieves on the hook of the agglomerate analyzer after adding water in the bucket, and turn on and off the instrument for half an hour.

(5) Put the special container in the oven to dry at 105C (drying time 8~10h); take out the sample, cool to room temperature, weigh the mass of cyanogen and sample, and calculate.

5. Determination of organic matter content

The determination of soil organic matter is defined as soil organic matter including various plant and animal residues as well as various organic products of microorganisms and their life activities. The determination of soil organic matter is achieved by multiplying the results of the determination of its organic carbon by the conversion factor (1.724).

Soil solution with potassium dichromate oxidizer and sulfuric acid was boiled for 5 min in an oil bath at 170-180°C. Carbon in soil organic matter was oxidized to carbon dioxide by potassium dichromate, while hexavalent chromium in potassium dichromate was reduced to trivalent chromium, and the remaining potassium dichromate was titrated with a standard solution of divalent iron. Based on the amount of ferrous sulfate consumed by the potassium dichromate before and after the organic carbon was oxidized, the amount of organic carbon was calculated, which in turn was converted to the soil organic matter content.

6. Determination of soil PH value

Weigh 10g of an air-dried soil sample through 1 mm sieve in 25 mL beaker, add 10 mL of distilled water and mix well, let it stand for 30min, and measure the pH value of the suspension with a calibrated p-positive meter. When measuring, the sphere (or bottom) of the glass electrode is immersed in the suspension mud layer, and the plug on the side hole of the glymeric acid electrode is removed. The glycerol electrode is immersed in the clear liquid of the upper part of the suspension and the pH value is read.

1.4 K-value Determination of Soil Erodibility

Shiraze and Boersma obtained the average particle size and standard deviation of particle size of soil by analyzing the percentage of clay, silt, and sand in soil samples to provide a uniform benchmark for comparison of soils and their physicochemical properties. Soil texture classification was carried out according to and to analyze the relationship between soil water retention [5] and suggested that, in the case of limited information on soil physicochemical properties, only the geometric mean soil particle size (mm) should be considered to calculate soil erodibility K values.

where XX is the grade mass fraction of the ith grain size class in the original soil, %; XX is the arithmetic mean of the values at both ends of the ith grain size class, mm; the K-value unit in the formula is the American system, and the K-value is multiplied by 0.1317 after calculation and converted to the international system unit (t, h/(MJ mm)). This method considers only the geometric mean particle size of the soil and is based on the information on the mechanical components of the soil, i.e., the soil erodibility K-value estimation. In this paper, this method is used to calculate.

1.5 Data Processing

1. Water content

Based on the collected sample data (see Appendix), the water content data obtained from the three measurements were averaged and made into the form of a bar graph as follows.

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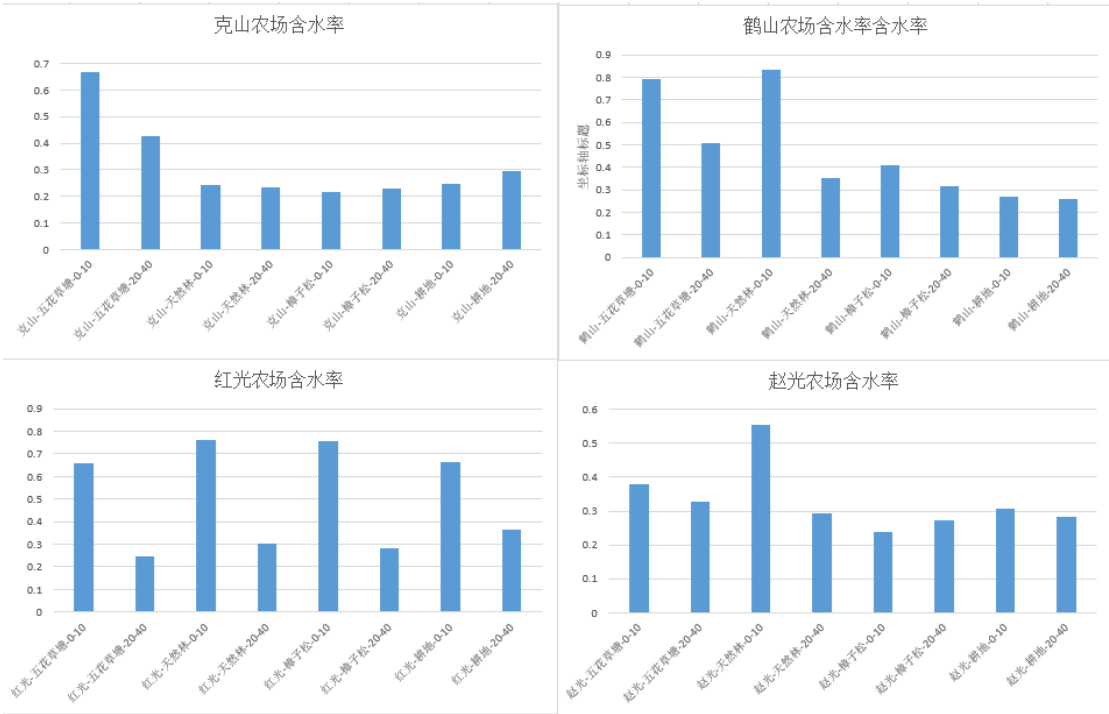

Fig 1. The water content data obtained from the three measurements were averaged and made into the form of a bar graph

Analysis of the data in the figure shows that the moisture content of 0-10 mm in the ponds of the pentosols of all four farms is greater than that of 20-40 mm, indicating that the moisture in the ponds of the pentosols is mainly distributed in the surface layer of the soil. The difference between the moisture in the 0-10 mm layer and the 20-40 mm layer of the soil in the natural forest of Keshan farm is not significant, probably due to topographical factors, while the moisture content of the soil in the 0-10 mm layer of the remaining three farms is higher than that of the soil in the 20-40 mm layer. (b) The water content of the 0-10 mm layer in the camphor pine area of Hongguang farm remains higher than that of the 20-40 mm layer, while the water content of the 0-10 mm and 20-40 mm layers of camphor pine in the other three farms is basically the same. The distribution of water content of cultivated land and camphor pine is basically the same.

Regarding the analysis of each farm, the water content of the five-flower grass ponds in Keshan farm is much higher than the other three types of land; the water content of the five-flower grass ponds and natural forests in Heshan farm is higher than the other two types of land; the water content of several land types in Hongguang farm is basically the same; and the water content of natural forests in Zhaoguang farm is the highest.

The factors that cause differences in soil moisture content between farms, land use types, and depths are probably climatic factors, topographic factors, precipitation, and vegetation types on the farm.

2. Soil capacity

Based on the collected sample data (see Appendix), the soil capacity data obtained from the three determinations were averaged and made into the form of a bar graph as follows.

As can be seen from the figure, the soil capacity of the 20-40 mm layer is greater than that of the 0-10 mm layer, regardless of the farm and land type. This is due to the fact that the soils in the 20-40 mm layer receive more compression.

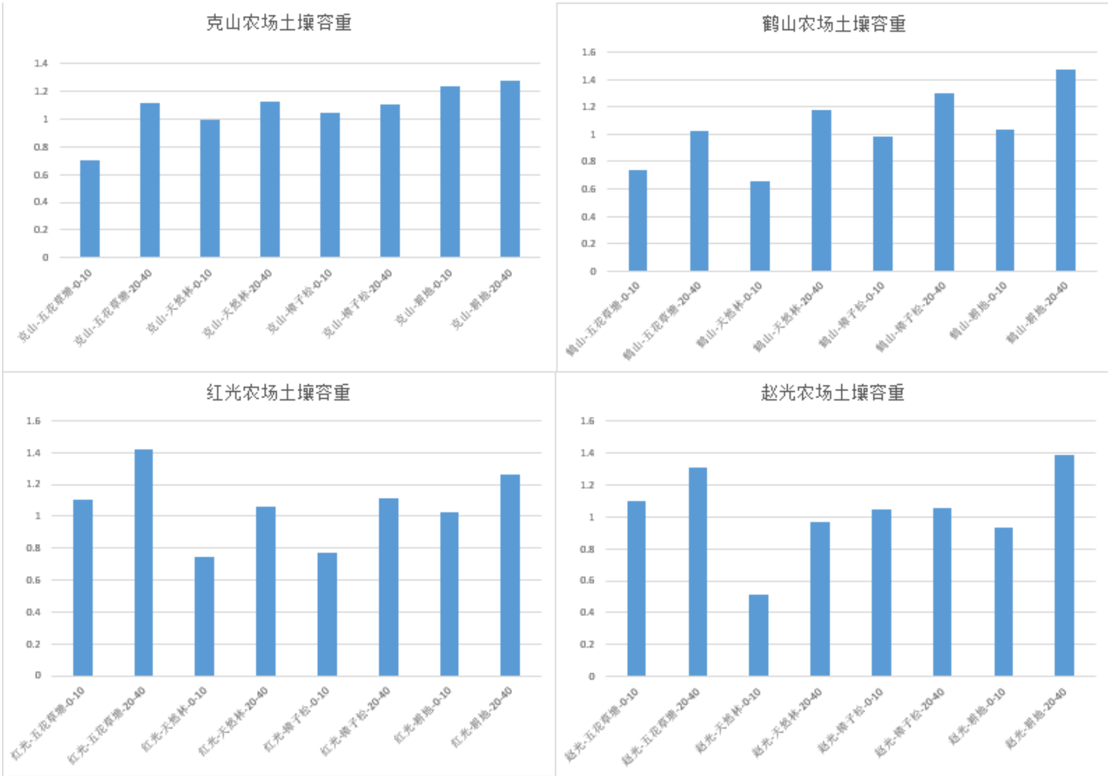

Fig 2. The soil capacity data obtained from the three determinations were averaged and made into the form of a bar graph

3. Total porosity

Based on the collected sample data (see Appendix), the total porosity data obtained from the three determinations were averaged and made into the form of a bar graph as follows.

The figure shows that the total porosity of the 20-40 mm layer is greater than the 0-10 mm layer, regardless of the farm and land type. Again, this is due to the fact that the soil in the 20-40 mm layer receives a stronger squeeze, with the same distribution pattern as the soil capacity.

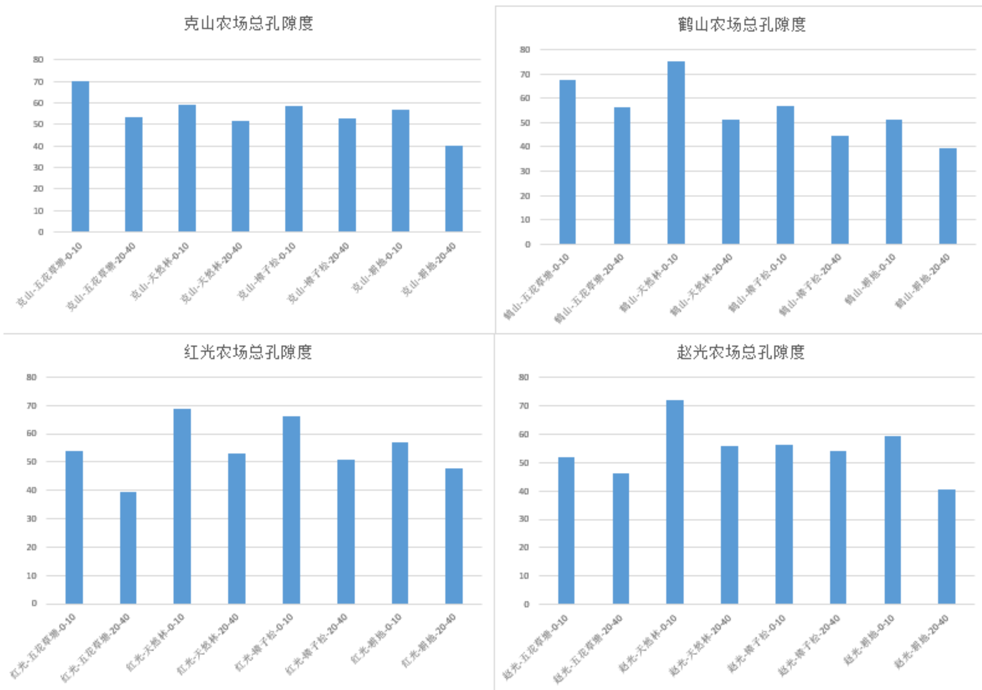

Fig 3. The total porosity data obtained from the three determinations were averaged and made into the form of a bar graph

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4. Organic matter content.

Based on the collected sample data (see Appendix), the organic matter content data obtained from the three measurements were averaged and made into the form of a bar graph as follows.

In general, the organic matter content of the 0-10 mm layer of soil was generally higher than that of the 20-40 mm layer, which was caused by the accumulation of fallen leaves and animal manure in the 0-10 mm layer of soil. In general, the organic matter content of all the five-flower grass ponds was relatively high, and the organic matter content of all the cultivated lands was low. The organic matter content of the remaining two types of land was more related to the farm itself.

The organic matter content of the five-flower grass ponds in Keshan Farm was significantly higher than that of other land types. The organic matter content of both Wuhua grass ponds and natural forests in the Heshan farm was higher. The organic matter content of natural forest and camphor pine land in Hongguang Farm is higher, but the difference between the organic matter content of 0-10 mm layer and 20-40 mm layer in the former is not significant, while the difference between 0-10 mm layer and 20-40 mm layer in the latter is larger. Only the natural forest of Zhao Guang farm has a higher organic matter content and the 0-10 mm layer content is about 216, which is much higher than other farms. In addition, the content of the 0-10 mm layer was much higher than that of 20-40 mm layer.

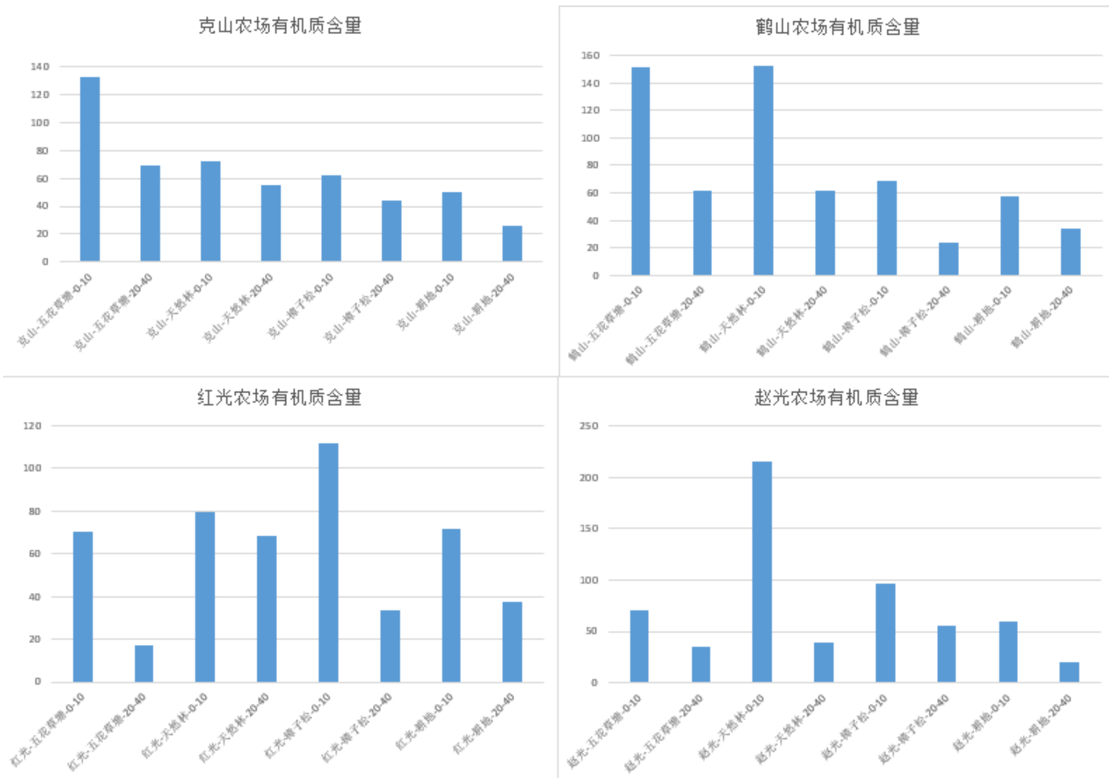

Fig 4. The organic matter content data obtained from the three measurements were averaged and made into the form of a bar graph

5. pH value

Based on the collected sample data (see Appendix), the PH data obtained from the three measurements were averaged and made into the form of a bar graph as follows.

As can be seen from the data in the figure, only the natural forest of Keshan farm and the land PH value of the 0-10 mm layer of five-flower grass pond of Heshan farm are higher than the 20-40 mm layer (deeper layer is more acidic), and the difference between the latter 0-10 mm layer and the 20-40 mm layer is not significant. The PH values of the remaining farms and land types were higher in the 20-40 mm layer than in the 0-10 mm layer (the surface layer was more acidic).

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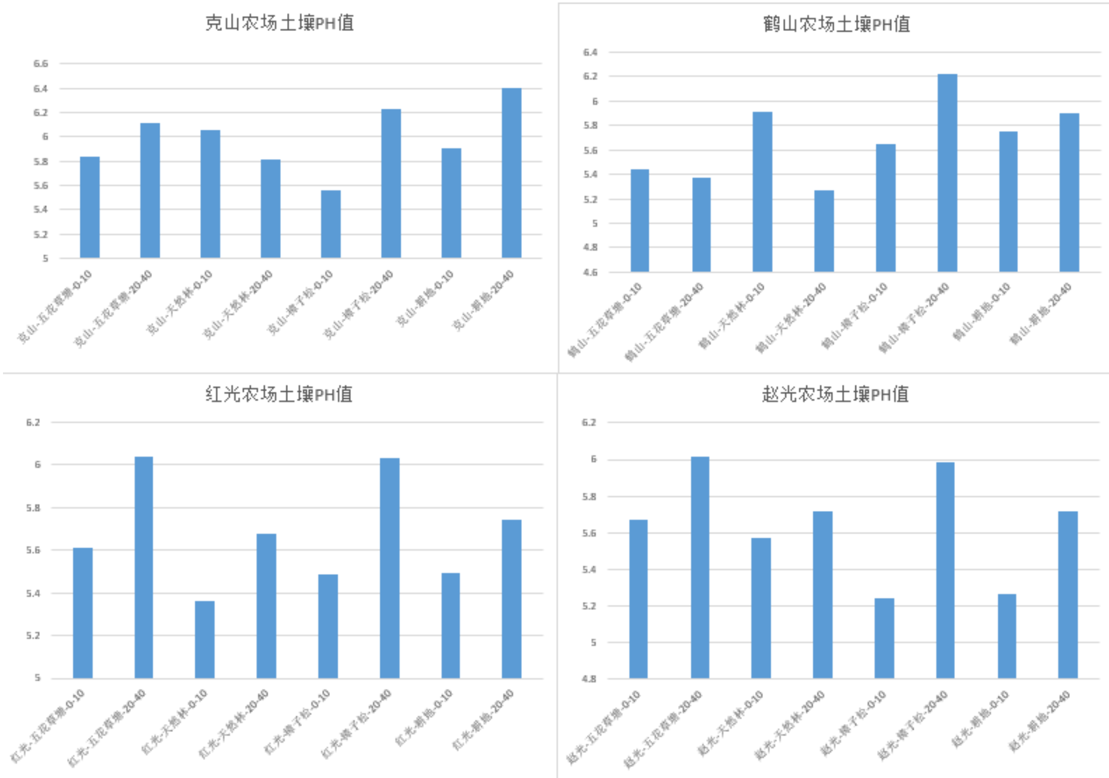

Fig 5. The PH data obtained from the three measurements were averaged and made into the form of a bar graph

6. K value

Based on the collected sample data (see Appendix), the K-value data obtained from three measurements and calculations were averaged and made into the form of a bar graph as follows.

In general, soil K values basically meet the 20-40 mm layer higher than the 0-10 mm layer, except for the type of camphor pine in Keshan farm, which does not meet this condition, which may be related to the chance of taking samples and measurement and calculation errors. In addition, the K values of Hongguang and Zhaoguang farms were generally higher than those of Keshan and Heshan farms, which should have a great relationship with their topographic factors.

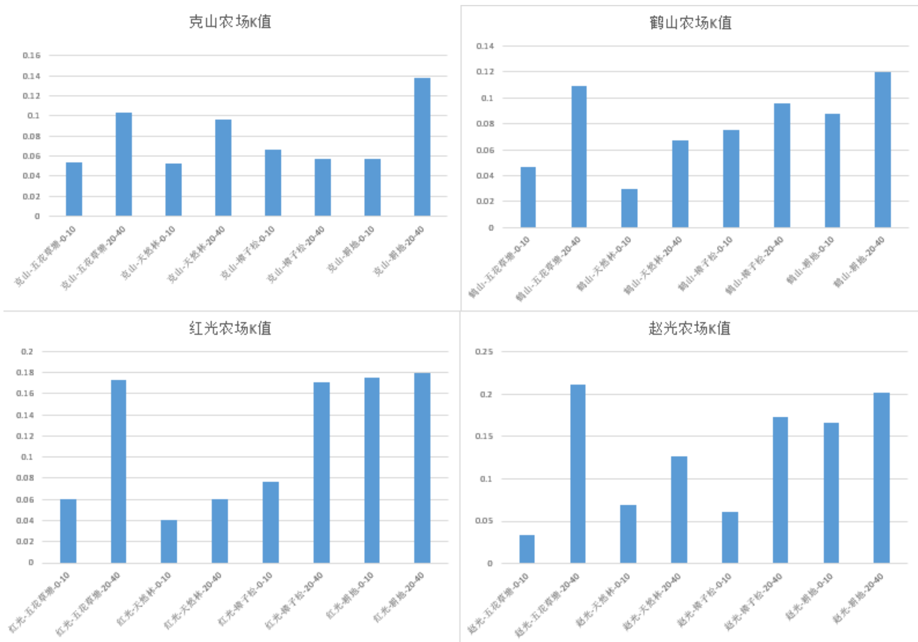

Fig 6. The K-value data obtained from three measurements and calculations were averaged and made into the form of a bar graph

References

[1] Tongwei Kong, Shuai Wang, Binhui Liu. Effects of renewal of farmland protection forest on soil agglomerate characteristics and erodibility [J/OL]. Journal of Central South University of Forestry Science and Technology,2022(11):128-140 [2022-12-25].DOI:1 0.14067/j.cnki.1673-923x.2022.11.014.

[2] Jiayong Gao, Rui Li, Pingping Yang, Lidong Pan, Kai Huang. Spatial distribution characteristics of soil erodibility K values and main influencing factors in Guizhou Province[J]. Soil and water conservation research,2022,29(05):77-84.DOI:10.13869/j. cnki. rswc.2022.05.017.

[3] Hao Zhou. Influence of freeze-thaw action on soil erodibility in open pit mine drainage sites [D]. China University of Mining and Technology, 2022. DOI:10.27623/d.cnki.gzkyu.2022.001494.

[4] Qiulan Feng, Yunchao Zhou. Distribution characteristics of soil particles in karst mountains and their influence on erodibility[J]. Journal of Hunan Agricultural University (Natural Science Edition), 2022, 48(05): 563-571. DOI: 10.13331/j.cnki.jhau.2022.05.009.

[5] Shirazi M A, Boersma L. A unifying quantitative analysis of soil texture[J]. Soil Science Society of America Journal, 1984, 48(1): 142-147.