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Correlation Study between Soil Selenium and Selenium Content of Typical Crops in Ankang, Shaanxi

Aorui Li, Jiping Chen, Chi Wang, Hui Wang, Tianyu Sun, Weihua Feng

Shaanxi Hygrogeology Engineering Geology and Environment Geology Survey Center, Xi'an, China

Abstract

Taking rice, corn and root soil in Ankang, Shaanxi as the research object, the characteristics of selenium content in crops and root soil were analyzed, and the relationship between selenium content in crops and total selenium and effective selenium content in root soil was explored. The results showed that the effective selenium content of soil in the study was low, and residual selenium, humic acid-bound selenium and strong organically bound selenium were the main forms of soil selenium in the study area. In this study, the selenium content of rice was slightly higher than that of corn, and the average selenium content of the two crops reached the standard of selenium-rich food. The total selenium and available selenium content of rice and its root soil were extremely significantly positively correlated ($P < 0.001$).

Keywords

Ankang; Shaanxi; Soil; Crops; Selenium Content.

1. Introduction

Selenium is one of the essential trace elements for the human body [1]. It has physiological effects on the human body such as anti-oxidation, promoting growth, delaying aging, protecting the cardiovascular system, anti-toxicity and improving the body's immunity [2]. Research reports show that the lack of selenium in environmental media will not be able to meet the needs of the human body to maintain health [3], leading to the occurrence of diseases such as cancer, liver disease, cardiovascular disease, hypertensive metabolic syndrome, Keshan disease, Kashin-Beck disease, etc. [4]. Crops are the main source of selenium in the diet, and its ultimate source is root soil [5], selenium in crops is mainly absorbed by roots [6], and grains are considered to be one of the main sources of selenium in the human body [7]. The distribution characteristics of selenium in environmental media directly affect the selenium content of crops and the daily selenium intake of resident residents, which in turn affects human health [8]. The distribution of selenium in soils worldwide is extremely uneven [9], and the selenium content of crops grown in selenium-rich soils is significantly higher than that in selenium-deficient areas [10]. The accumulation of selenium by crops in the soil is not only related to the total selenium content and the proportion of available selenium in the soil, but also related to the absorption and enrichment capacity of the crop itself. There will be certain differences in the selenium enrichment capacity of different crops [11].

2. Materials and Methods

2.1. Test Materials and Sampling

The test materials in this study were rice, corn and their root soil, taken from Hanyang Town and Xuanwo Town, Ankang, Shaanxi. From October 9th to 11th, 2020, sampling was conducted through the five-point sampling method. When sampling, avoid plants that are too large or too small, suffer from plant diseases and insect pests or mechanical damage, and are easily affected by humans on the roadside. Collect 25 pieces of rice and 20 pieces of corn, and the quality of crop samples is greater than 500 g. And collect root soil samples at the same point, remove litter attached to the soil surface, excavate 0-20 cm soil samples as test materials, and the mass of the sample is greater than 1 kg. After the soil sample is air-dried naturally, the agglomerates are crushed with wooden sticks, and after passing through a 20-mesh nylon sieve, 300 g is taken for inspection and analysis.

2.2. Methods for the Detection of Crops and Root Soil Samples

The selenium content of crops was measured by inductively coupled plasma mass spectrometer (Agilent 7800). Soil water-soluble selenium, ion-exchange selenium, carbonate-bound selenium, humic acid-bound selenium, iron-manganese-bound selenium, strong organically bound selenium, and residual selenium content were determined by plasma emission spectrometry (ICP-AES).) Determination, using atomic fluorescence spectrometry (AFS) to determine the total selenium content. All crops and soil samples are entrusted to the Xi'an Mineral Resources Supervision and Testing Center of the Ministry of Land and Resources for testing.

2.3. Data Analysis and Mapping

Use Excel and R (Version 3.5.1) for data analysis and graphing. Use "boxplot" function to make box plot of total selenium content in root soil and various forms of selenium; use Excel to analyze the correlation between crop selenium content and soil total selenium and effective selenium content.

3. Results and Analysis

3.1. Characteristics of Total Selenium and Various Forms of Selenium in Rice and Corn Root Soil

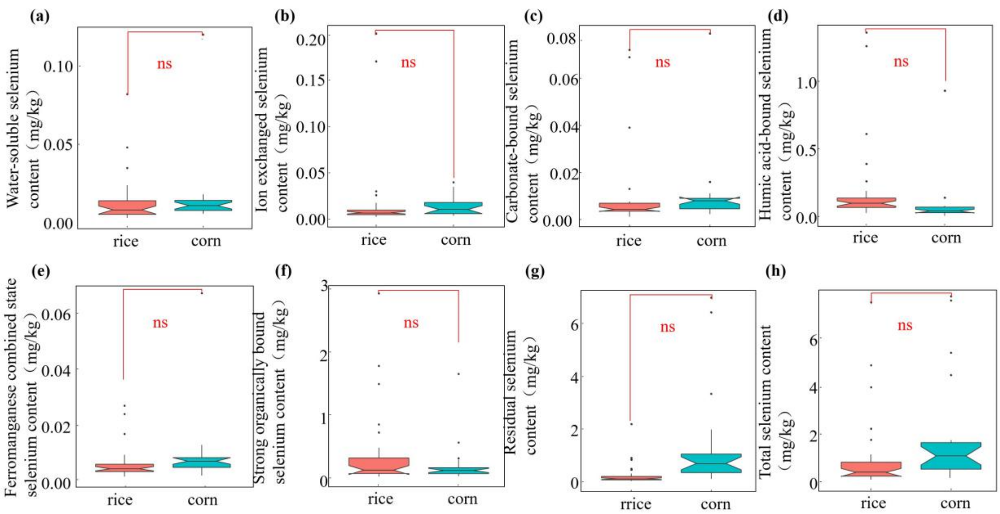

Fig 1. Box plot of total selenium and various forms of selenium in rice and corn root soil

Note: The asterisk indicates the level of significance, *P* value (0: "***", 0.001: "**", 0.01: "*", 0.05: "ns"). The same below.

Analysing the test data of rice and corn root soil, and the results were shown in Fig.1. The samples tested in this study are highly representative, with a wide distribution of soil factor values, good continuity, and overall numerical concentration is good, mostly in a normal distribution. Residual selenium, humic acid-bound selenium and strong organically bound selenium are the main forms of soil selenium in the study area. There was no difference in the total selenium and selenium content of different forms in the root soil of rice and maize (as shown in Fig.1(a)-(h)) (all $P > 0.05$).

The content of water-soluble selenium, ion-exchanged selenium and residual selenium in the soil are distributed symmetrically. The content of humic acid-bound selenium and strong organic-bound selenium in rice root soil is higher than that of corn, and the selenium content of other forms is lower than that of corn. The total selenium content of rice and corn root soils have abnormal detection values. The selenium content of individual samples is higher than 7 mg/kg, which may be related to the uneven distribution of selenium and sampling accident. The total selenium content of rice root soil is left-skewed distribution, the content is 0.01−7.50 mg/kg, and the average is 0.94 mg/kg. The total selenium content of corn root soil is distributed symmetrically, and the content is 0.17−7.74 mg/kg. The average value is 1.96 mg/kg, which is slightly higher than that of rice, but the difference between the two is not significant ($P = 0.364$). The total selenium content of rice and maize root soil is 3.25 and 6.78 times of the national average soil selenium content [12], which is much higher than the national selenium soil background value, reflecting the superior foundation and conditions for the distribution of selenium-rich soils in the study area. However, the study area also has low soil selenium bioavailability, and the results of this study are similar to those in Enshi, Hubei. [13].

3.2. Characteristics of Selenium Content in Rice and Corn

The statistical results of selenium content in rice and corn are shown in Table 1. The average selenium content in rice is 0.070 mg/kg, and the average selenium content in corn is 0.069 mg/kg. Rice is slightly higher than corn. According to the "Selenium Content Standard for Selenium-enriched Food and Related Products" (DB 61T 556-2018), both rice and corn meet the selenium-enriched food standard (≥ 0.05 mg/kg). The coefficient of variation of selenium in the edible part of maize is significantly higher than that of rice, which belongs to strong spatial variability. This result may be due to the different growth environments of the two crops. Rice is a flooded environment and the growth conditions are relatively stable, while corn is a dry land. There is a certain variability in the growth conditions, resulting in a large difference in the selenium content of corn.

Table 1. Formatting sections, subsections and subsubsections.

Crop name	scientific name	Average selenium content (mg/kg)	standard deviation	Coefficient of Variation%
rice	*Oryza sativa L.*	0.070	0.067	95
corn	*Zea mays L.*	0.069	0.150	112

3.3. Correlation Analysis of Crop Selenium Content and Root Soil Total Selenium and Available Selenium Content

Soil is the basic source of human selenium, and crops are important absorbers and transferers of soil selenium [14]. Soil selenium content affects the quality of the surrounding environment, and soil selenium availability affects the selenium content of crops, and also affects the human body's intake of selenium through the food chain [15-16]. Studying the selenium form and availability characteristics in the soil can contribute to improving the productivity of selenium-enriched agricultural products. Theoretical basis. The selenium content of rice and corn was analysed by linear fitting with the total selenium and effective selenium content of the soil, and the fitting results are shown in Fig.2. The results showed that the selenium content of rice was significantly positively correlated with the total selenium and available selenium content of the root soil ($P < 0.001$, as shown in Fig.2(a)-(b)), and the correlation coefficients r were 0.87 and 0.89, respectively. The selenium content of corn and the total selenium and available selenium content of the root soil have a positive correlation trend (as shown in Fig.2(c)-(d)), which did not reach a significant level.

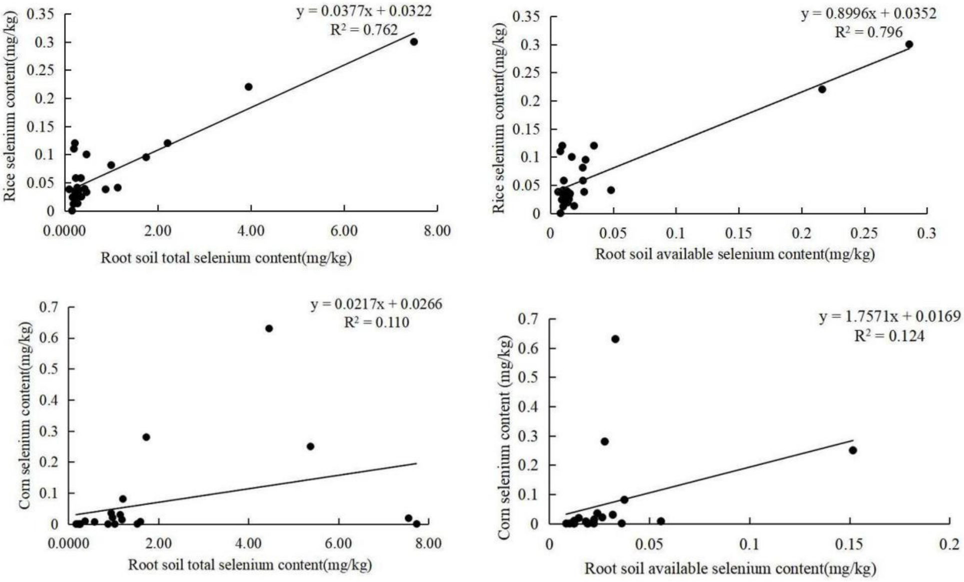

Fig 2. Correlation between selenium content of crops and total selenium and available selenium content in root soil

Water-soluble selenium and ion-exchange selenium are the main selenium forms absorbed and utilized by crops, and the sum of the two content represents the effective selenium content of the soil. The fitting R^2 between the available selenium content in the root soil of rice and corn and the edible selenium content of the crop is greater than the fitting R^2 between the total selenium content of the root soil and the edible selenium content of the crop. This indicates that the study is compared with the total selenium in the soil The effective selenium content of the soil in the district is a key factor that determines the selenium content of local crops. The results of correlation analysis of selenium content between crops and root soil in this study may be affected by the small sample size and the difference in sample size, but the comprehensive data distribution of the two crops has good continuity and representativeness, which can reflect the selenium of soil and crops. The content of the relationship. At present, many studies have shown that there is a significant positive correlation between corn and soil total selenium and available selenium content [17-18]. In future studies, the sample size should be increased to make the research results more representative and reference.

4. Conclusion

The total selenium content of rice and maize root soil in the study area was significantly higher than the national background value of selenium soil, reflecting the distribution advantages of the selenium-rich soil in the study area, but the effective selenium content is low, which is not conducive to the absorption and utilization of crops. Residual, humic acid-bound and strong organically bound selenium are the main forms of soil selenium in the study area. The selenium content of maize root soil is slightly higher than that of rice, and the selenium content of rice is higher than that of corn, indicating that the selenium-enrichment capacity of rice is slightly stronger than that of corn. The coefficient of variation of maize is higher than that of rice, indicating that the selenium content of maize collected in this study is more variable than that of rice. In this study, the selenium content of rice was significantly positively correlated with the total selenium and available selenium content of root soil, while the selenium content of maize was not positively correlated with the total selenium and available selenium content of the root soil. The sample size should be increased in the follow-up study.

Acknowledgments

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