

Effect of Exogenous Cd Pollution on Red Soil and Wheat

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Abstract. Cadmium is a toxic element and highly mobile in soil. Cadmium can inhibit the growth and development of crops, leading to reduced yield and quality. The objectives of this experiment were (1) to determine the effect of exogenous Cd pollution on Cd concentration in red soil and (2) to measure the effect of exogenous Cd pollution on Cd uptake and yield of wheat. The wheat cultivar was Wanmai 52. The study was done in Yujiang county, Yingtan city, Jiangxi province. Three Cd concentrations of 0, 0.3, 0.6 mg/kg were applied in a randomized complete block design with three replications. Cadmium concentrations were determined with an atomic absorption spectrophotometer. The results indicated that exogenous Cd pollution had no significant effect on the grain yield, straw biomass, and total above ground biomass. The total soil Cd concentration increased significantly after Cd contamination. The Cd concentration in the 0.6 mg/kg treatment was nearly three times that in the 0.3 mg/kg treatment. Exogenous Cd pollution significantly increased Cd uptake by wheat grain. The uptake increased as Cd concentration increased. The effects of Cd pollution on Cd uptake by wheat and above ground biomass were not significant. In conclusion, the control of exogenous Cd input to soil is the fundamental way to reduce soil Cd pollution and improve crop quality.

1. Introduction

In the process of industrialization, urban pollution has intensified, the types and quantities of agricultural chemicals have increased, the level of heavy metal pollution in the soil is intensifying, and the area of pollution has been expanding year by year [1]. Cadmium is a type of heavy metal with high toxicity, strong biological mobility, long residence time in soil, not easy to be decomposed by microorganisms, and easy to be enriched by plants. Cadmium pollution causes a series of damage to the growth and development of plants, such as inhibiting plant growth and hindering Absorption of nutrients, reduction of plant photosynthetic rate and respiration, misalignment of carbohydrates and other metabolic



disturbances, resulting in reduced growth and yield [2]. The amount of cadmium-contaminated farmland in China is about 10,000 hm^2 [3]. Therefore, it is extremely urgent to solve the problem of soil cadmium pollution. Absorption and accumulation of cadmium in wheat are closely related to its cadmium content in growing soil, physicochemical properties of soil, and activity of cadmium in soil [4]. Therefore, it is of great theoretical and practical significance to carry out the heavy metal pollution threshold in the soils of major agricultural products. This experiment studied the effect of adding different concentrations of heavy metal cadmium on the cadmium content of heavy metals in red soil and wheat plants, aiming at risk early warning of soil heavy metal pollution in agricultural production areas in China at different scales, and proposed countermeasures.

2. Materials and Methods

2.1. Research area overview and test materials

The research area is located in the Red Soil Ecological Experimental Station of the Chinese Academy of Sciences of Yujiang County, Yingtan City, Jiangxi Province. It is located in the eastern part of the central and subtropical region of China. The climate is warm and rainy, with an average annual temperature of 19.56°C and an annual rainfall of 1766.8mm [5]. The test crop was Wanmai 52.

2.2. Test Design

Three treatments were used in the trial: no cadmium control treatment (CK), low-concentration cadmium treatment (Cd1) and high-concentration cadmium treatment (Cd2), and the concentrations of added cadmium were 0, 0.3, and 0.6 mg/kg, respectively. In the 0-20cm surface soil, 3 replicates were set for each treatment. The sowing amount of wheat is 10 kg/mu; the application amounts of N, P and K fertilizers are 225, 75, and 75 kg/hm² in turn.

2.3. Sample Collection and Processing

Collect 0-20 cm of topsoil, randomly select 9 points in each plot to mix, repeat 3 times, and air-dried nylon screen with 0.149 mm aperture. The plant sample was baked at 105°C for 30 minutes, cooled to 60-70°C, and after the water was used up, it was crushed with a pulverized and put into a plastic bag for use.

2.4. Test Methods

The sample was digested by a microwave digestion apparatus and measured with an atomic absorption spectrophotometer at a wavelength of 228.8 nm [6].

2.5. Data Processing

Total soil Cd content (mg/kg) = (sample mass concentration - blank mass concentration) (mg/L) × constant volume (ml) × multiples taken up / soil sample mass (g)

Plant cadmium content (mg/kg) = (sample mass concentration - blank mass concentration) (mg/L) × constant volume (ml) × fraction multiplex/sample mass (g)

Use Excel to perform data processing according to the formula.

3. Results and Analysis

3.1. Effect of Exogenous Cadmium Pollution on Wheat Yield

As can be seen from Figure 1, the yield of grains under Cd1 concentration is slightly higher than that of CK, while the yield of grains under Cd2 concentration is decreased, but the effect of different cadmium additions on the grain yield of wheat is not significant; straw yield and aboveground The yield and grain yield changes show CK>Cd1>Cd2. This may be due to the fact that both Cd1 and Cd2 additions have not reached the level of toxicity to wheat and therefore have little effect on wheat grain, straw, and aboveground yield.

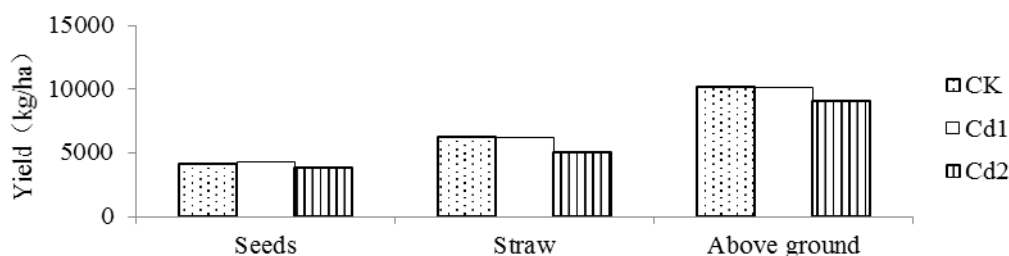


Figure 1. Effect of external cadmium addition on wheat yield

3.2. Effect of Exogenous Cadmium Pollution on Total Cadmium in Soil

It can be seen from Fig. 2 that when no heavy metal cadmium was applied, there was no significant difference in the total cadmium content in the three concentrations. After application of heavy metal cadmium, the total cadmium content in soils applied 0.3 mg/kg and 0.6 mg/kg increased significantly, which increased by 0.29 mg/kg and 0.75 mg/kg, respectively. When wheat was harvested, the total cadmium content in the soil under CK treatment, Cd1 treatment, and Cd2 treatment was lower than that after adding cadmium. This may be due to the fact that part of the Cd added to the soil was absorbed by the wheat, and there may be some Cd leaching. The effect of migration to the lower soil layer, but because we only measured and analysed the cadmium concentration in the surface 0-20cm soil layer, this speculation has yet to be confirmed by further sampling and analysis.

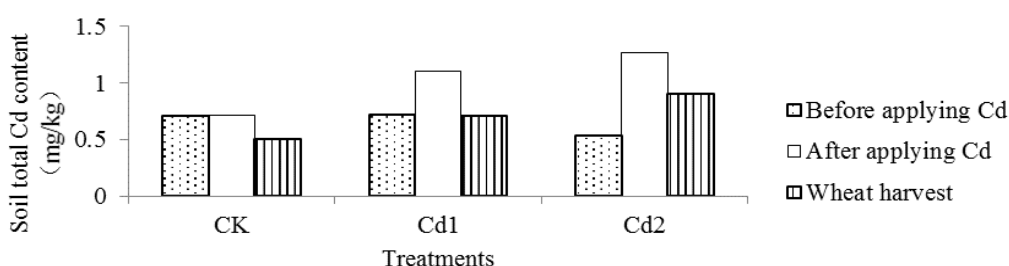


Figure 2. Effect of external cadmium addition on soil total cadmium in different periods

3.3. Effect of Exogenous Cadmium Pollution on Absorption of Cd in Wheat

3.3.1. Effect on Grain Cd Concentration and Absorption. As can be seen from Figure 3, adding cadmium to the soil will increase the cadmium content in wheat grains, and the concentration of Cd in wheat grains increases significantly with the increase of the concentration of added Cd. The results of variance analysis (Table 1) also showed that the effects of cadmium treatment on the cadmium content of wheat grains reached a significant level of 1%, while the difference between the groups was small, reaching a significant level of 5%. It is generally considered that when the cadmium content in the soil is less than 0.5 mg/kg, it is a safe concentration, but depending on the soil texture, the upper limit of safety may reach 3 mg/kg [7]. After the cadmium was added to the tested soil of this experiment, the cadmium content did not exceed 3 mg/kg, but the cadmium content in the wheat grain exceeded the national grain hygiene standard (0.1 mg/kg), which may be due to the cadmium content in red soil. The safe concentration is low. After adding cadmium to the soil, the cadmium content in the soil exceeds the standard, causing the cadmium content in the wheat grain to exceed the standard; it may also indicate that even if the wheat grows on non-polluted soil, it may be affected by Pollution of cadmium pollution sources such as the atmosphere caused the content of cadmium in grains to exceed the edible standard [8].

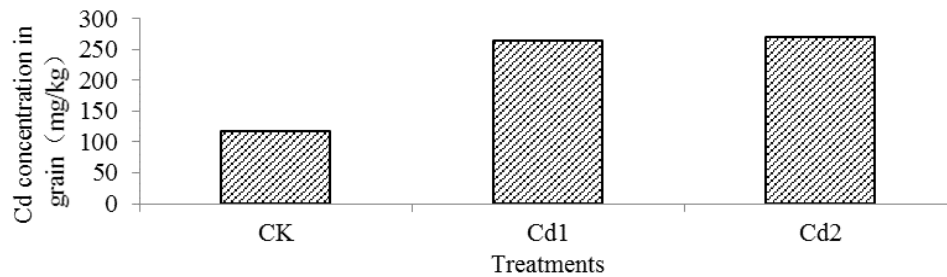


Figure 3. Effect of the addition of exogenous cadmium on the concentration of Cd in wheat grains

Table 1. Analysis of Variance of Cadmium Content in Wheat Grain

Variant factors	SS	df	MS	F	F0.05	F0.01
Treatments	13.5195	2	6.75974	83.7	6.94	18.0
District Group	2.2419	2	1.12093	13.88	6.94	18.0
error	0.3231	4	0.08077			
Total variation	16.0844	8				

From Figure 4, it can be seen that the application of cadmium to soil will increase the absorption of Cd in wheat grains. The higher the concentration of cadmium applied, the higher the amount of Cd absorbed by wheat grains, and the difference between each treatment was significant.

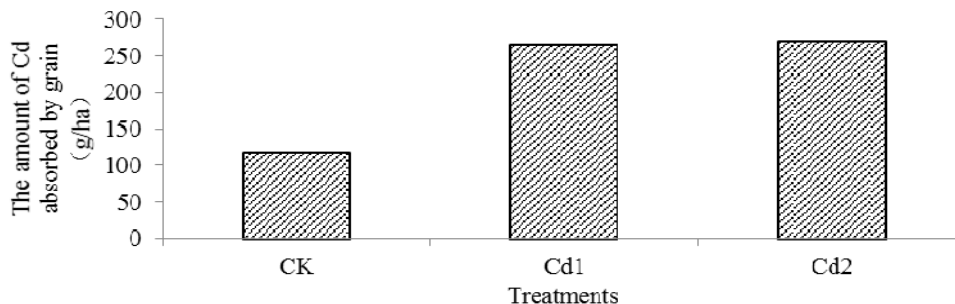


Figure 4. Effect of the addition of exogenous cadmium on the absorption of Cd in wheat grain

3.3.2. Effect on Straw Cd Concentration and Absorption. As can be seen from Figure 5, under the treatment of Cd1 and Cd2, the content of cadmium in straw was significantly higher than that of CK, but compared with Cd1, the content of cadmium in straw was only slightly increased, and there was no significant change, indicating that it was added to soil. Cd will increase the cadmium content in the straw. In addition, there was no significant difference in cadmium content in straw between the concentrations of Cd1 and Cd2, which may be due to less treatment in this experiment, which affected the correlation between cadmium concentration and cadmium content in straw. The results of variance analysis (Table 2) showed that the effects of cadmium treatment and cadmium treatment on the cadmium concentration of wheat straw were not significant, which may be due to the large difference in cadmium concentration of Cd1 treated straw.

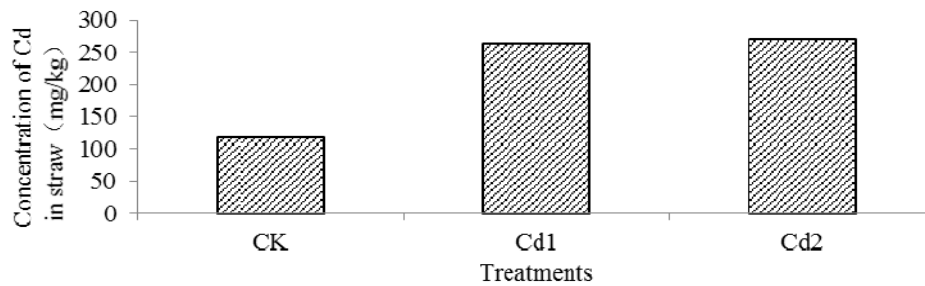


Figure 5. Effect of the addition of exogenous cadmium on the concentration of Cd in wheat straw

Table 2. Analysis results of variance of cadmium in wheat straw

Variant factors	SS	df	MS	F	F0.05	F0.01
Treatments	61.483	2	30.7417	3.5	6.94	18.0
District Group	5.819	2	2.9093	0.33	6.94	18.0
error	35.144	4	8.786			
Total variation	102.446	8				

As can be seen from Figure 6 the application of cadmium to soil increases the absorption of wheat straw Cd. As can be seen from Figure 6, the addition of Cd will increase the amount of Cd absorbed by wheat straw, and Cd1 will have the highest uptake of Cd by straw, but when the concentration of Cd is increased to Cd2, the absorption of Cd by straw will decrease. This is probably because In the group I, the yield of grain and straw treated by Cd2 was low, which may be the poor soil fertility in this area, which affected the growth of wheat, which resulted in a lower yield and further affected the absorption of Cd.

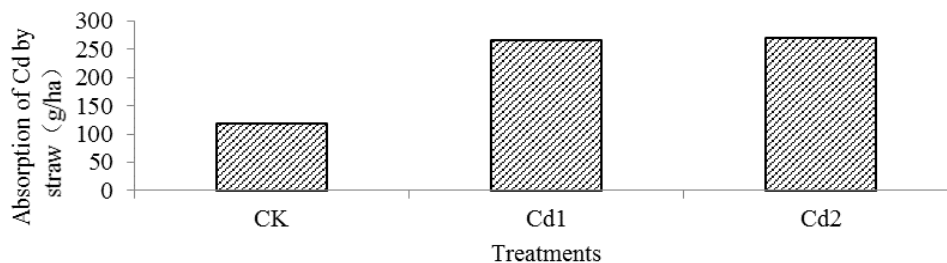


Figure 6. Effect of the addition of exogenous cadmium on Cd uptake of wheat straw

3.3.3. Effect on total absorption of wheat aboveground

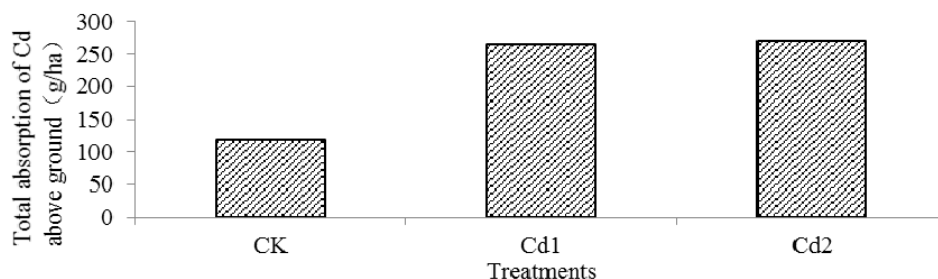


Figure 7. Effect of the addition of exogenous cadmium on total absorption of Cd in wheat shoots

From Figure 7, we can see that the addition of Cd will significantly increase the absorption of wheat above the ground, increase the concentration of added Cd, the total absorption of the above ground increases. The total amount of above-ground absorption under the treatment of Cd1 and Cd2 in the figure is very small, which may be related to the lower yield of Cd2 treatment in the above-mentioned group I.

4. Conclusion

(1) In this experiment, cadmium addition had no significant effect on wheat grain, straw and aboveground yield. (2) Adding heavy metal cadmium to soil will increase the cadmium content in wheat grain, and the content and uptake of Cd in wheat grain increase significantly with the increase of Cd concentration. The addition of Cd will increase the Cd content of wheat straw and the absorption of Cd, and increase the total absorption of wheat above the ground. (3) The addition of heavy metal cadmium to the soil significantly increased the total cadmium content in soil, and it increased significantly with the increase of the concentration. Controlling the input of external cadmium into the soil is the fundamental way to reduce soil pollution and improve crop quality.

References

- [1] Lin Fanhua, Chen Haibo, Bai Jun. Study on the Harm of Heavy Metal Pollution in Soil Environment [J]. Environmental Science and Management, 2007, (07): 74 - 75.
- [2] Zhu Zhiyong, Li Youjun, Hao Yufen et al. Effect of cadmium on dry matter accumulation, metastasis and grain yield of wheat (*Triticum aestivum*) [J]. Journal of Agro-Environment Science, 2012, (02): 252 - 258.
- [3] Zhang Jing, Su Dechun. Decomposition dynamics of straw and carbonized straw on different cadmium-contaminated soils and their adsorption characteristics of soil Cd [J]. Chinese Journal of Environmental Engineering, 2013, (10): 4097 - 4102.
- [4] Zhao Jing, Feng Wenqiang, Qin Yusheng, et al. Effect of different nitrogen fertilizers on wheat growth and uptake of cadmium [J]. Journal of Environmental Biology, 2010, (01): 58 - 62.
- [5] Shi Yang, Dai Chuanchao, Lu Ling. Investigation on Microorganisms in Different Soils of Red Soil Ecological Station of the Chinese Academy of Sciences [J]. Journal of Nanjing Normal University (Natural Science Edition), 2002, 25 (2): 32 - 36.
- [6] Lu Rukun (Editor-in-Chief). Soil Agrochemical Analysis. Beijing: China Agricultural Science and Technology Press, 1999.
- [7] Benavides M, Gallego MS, Tomaro ML. Cadmium toxicity in plants [J]. Braz J Plant Physiol, 2005, 17 (1): 21.
- [8] Guoping Zhang. Motohiro Fukami and Hitoshi Sekimoto. Genotypic differences in effects of cadmium on growth and nutrient composition in wheat [J]. Journal of Plant Nutrition, 2000, 23 (9): 1337 - 1350.