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Research Paper

Cadmium content of rice planted in Organic and conventional farming system

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Abstract
The impact of agricultural activities such as the application of organic and chemical fertilizers will be causing a Cadmium (Cd) contamination. Information on the presence of Cadmium (Cd) both in the soil and Rice Plants in North Talang Ubi, Talang Ubi District, Penukal Abab Lematang Ilir of South Sumatera, Indonesia is still very limited and difficult to obtain for the issue of heavy metal of cadmium (Cd). This study aims to analyze the cadmium content in paddy fields with two different cultivation systems, namely organic and conventional farming systems. This research was a survey method and soil analysis conducted in two locations which were soil from Rejosari with organic farming system and other coming conventional farming system. The soil sampling was done from March 2023 to June 2023. The results of this study showed that the cadmium content in soil in the two cultivation systems is still below the cadmium quality standard, with the highest soil Cd content found 0.00478 mg/kg in the conventional cultivation system where the threshold limit is 0.5 mg/kg. The cadmium content of rice shoot and roots in the two cultivation systems was also still below the quality standards of cadmium, where the highest Cd content was found around 0.03303 mg/kg in the conventional cultivation system where the threshold limit was 0.1 mg/kg.

Keywords
Cadmium (Cd); rice cultivation; organic; conventional farming

1. INTRODUCTION

Long-term management of paddy fields with intensive application of synthetic fertilizers can reduce soil productivity and soil quality (Ye et al., 2020). The use of organic and chemical fertilizers affect the accumulation of heavy metals/metalloids in plants (Wajid et al., 2020). The use of chemical fertilizers and pesticides also contributes to heavy metal contamination in paddy soil (Zakaria et al., 2021). Agricultural activities such as continuous application of inorganic and organic fertilizers increase the content of contaminants in soil, including heavy metals Co, Zn, Cd, Fe, Pb, Cu, and Cr (Ugulu et al., 2021). In addition, consumer demands for safe, hygienic or high nutritional value and contaminant-free food or agricultural products are a public concern for environmental quality and human health. Consuming rice grown in contaminated soil that has high levels of cadmium (Cd) is a health risk (Khum-in et al., 2020). The occurrence of Cd contamination in paddy soil mainly comes from mining activities, intensive application of phosphate fertilizer and electronic waste (Zou et al., 2021). In addition, Cd heavy metal content can also inhibit rice growth and pollution from Cd accumulation can cause more serious soil and environmental damage (Xiao et al., 2021). Heavy metals have an adverse impact on rice growth and productivity through soil-heavy metal-plant interactions (Ashraf et al., 2020).

Information on the presence of heavy metal of Cadmium (Cd) both in soil and rice plants in North Talang Ubi is still very limited and difficult to obtain for the issue of cadmium (Cd) heavy metal content. Therefore, the author is interested in conducting research on the analysis of Cadmium (Cd) content in soil as well as the analysis of several chemical properties such as pH, Cation Exchange Capacity (CEC), and soil C-Organic. By conducting this study and analysis, it can be known which type of cultivation system is better in minimizing the presence of cadmium accumulation in the soil.

2. EXPERIMENTAL SECTION

2.1 Experiment Site

This research was conducted from March to July 2023 in North Talang Ubi, Talang Ubi District, Penukal Abab Lematang Ilir of South Sumatera, Indonesia with two different field locations. The research location was divided into 2 locations for the division of the first location field rejosari (2°42’26.27 "S, 105°02’11.12 "E) for the organic farming system. The second sample location was carried out in field project (2°43’06.02 "S, 105°00’45.65 "E) with a conventional cultivation system. While the analysis of soil chemical properties was carried out at the Laboratory of Chemistry, Biology and Soil Fertility, Department of Soil, Faculty of Agriculture, Sriwijaya University for swoil pH, CEC, C-organic and for the analysis of Cadmium (Cd) was carried out at PT. Global Quality Analytical, Bogor City, West Java.

2.2 Material and Methods

The research used several materials ranging from Belgi drills and various materials in soil sampling. Camera was also used as a documentation tool and stationery to record existing activities. The research used survey methods and direct observation in the field. The research location was divided into 2 locations for the division of the first location ataran Rejosari on the organic farming system. The second sampling was carried out ataran project with a conventional cultivation system. For each location, 5 (five) samples were taken which had been composited to becoming 3 (three) samples with a total of 10 samples from both places. The software used is Ms.Excel and SPSS in the analysis.

2.3 Data Collection

This data collection consists of primary and secondary data conducted by direct observation and interviews in the field. Data collected in the form of cultivation activities, Cd of rice plants and some soil chemical properties namely Soil Cd, Soil pH, Soil CEC, and Soil C-Organic on cultivated land in the April-September 2024 growing season. Cultivation activities were carried out by interviewing farmers and direct observation on rice cultivation land.

2.4 Data Analysis

Data analysis in this study used various methods according to the needs and presentation of the required data. Data analysis used tabulation, simple and multiple linear regression and correlation. The results of further analysis are explained descriptively based on the literature study obtained, then the final data is presented in the form of tabulations and equations.

3. RESULTS AND DISCUSSION

3.1 Rice Cultivation

The rice cultivation activities in North Talang Ubi were carried out in two locations, namely field Rejosari with an organic farming system and field Project with a conventional cultivation system. Cultivation activities starting from planting preparation activities, fertilizer application and pest control can be seen in Table 1.

3.1.1 Rice Cultivation with Organic Farming System

Land preparation activities for rice cultivation in organic cultivation systems begin with plowing using a *handtractor* twice with a distance of one week from the first plowing which aims to cultivate the land so as to improve soil physical properties and to overcome existing weeds. The second plowing is aimed at preparing the land for planting activities. However, before planting activities, fertilization activities are carried out using compost at a dose of 2 tons per hectare by spreading it on the surface of the land. Planting preparation by preparing the nursery is done by soaking the seeds in water and keeping them overnight and then spreading them in the nursery. For the number of seeds needed as much as 5 kg / ha with the variety used is *Inpari* 22. For planting distance using legowo 2:1, namely with a distance of 30 cm x 15 cm x 60 cm. Fertilizer application activities in the organic cultivation system of rice plants are fertilized twice, namely after the second plowing and 15 DAP (Days After Planting). Furthermore, spraying of local microorganisms (MOL) in the form of conch MOL and Bael Fruit MOL and bamboo shoot MOL. This spraying was carried out twice, namely when the rice plants were 25 DAP with mole conch fruit maja and 45 DAP using bamboo shoot mole. The application of MOL in 1 tank size of 15 liters with a ratio of 1 liter of mole:14 liters of water. The dosage for one hectare area is 20 tanks. In addition to mole spraying, vitamin spraying is also carried out three times, namely when the rice plants are 55 DAP, 85 DAP and 100 DAP using honey, eggs and milk. A 15 liter tank of water contains 1 chicken egg, 3 spoons of honey and 40 grams of milk. This spraying dose is 10 tanks / Ha. Pest control in this organic cultivation system includes weed and pest control. Weed control is done mechanically by using hedgehogs or *gosrok*. Pest control is carried out by integrated control, namely by using natural enemies and vegetable pesticides.

3.1.2 Rice Cultivation with Conventional Cultivation System

Land preparation activities for rice cultivation in conventional cultivation systems begin with plowing using a handtractor twice with a distance of one week from the first plowing which aims to cultivate the land so as to improve soil physical properties such as structure, porosity to overcome existing weeds. The second plowing is aimed at preparing the land by conducting basic fertilization activities using 50 kg/ha of NPK fertilizer by spreading it on the surface of the land. Planting preparation by preparing the nursery is done by soaking the seeds in water and keeping them overnight and then spreading them on the nursery land. The number of seeds needed is 100 kg/ha with the variety used, Inpari 22. The planting distance is 25 cm x 25 cm. Fertilizer application activities in the conventional cultivation system of rice plants are fertilized twice, namely when after the second plowing with 50 kg/ha NPK and the second 45 DAP giving urea as much as 50kg/ha.

Pest control in this conventional cultivation system includes weed and pest control. Weed control is done by applying herbicides. This pest control is carried out when

Table 1. Planting preparation activities, fertilizer application and pest control

Observation Parameters	Rice Cultivation System	
	Organic	Conventional
Planting Preparation		
Planting Time	03 April 2023	24 Mar 2023
Planting Method	*Jajar legowo* 2:1	*Tegel*
Planting Distance	30 x 15 x 60 cm	25 x 25 cm
Seed Variety	*Inpari* 22	*Inpari* 22
Number of seeds	5 Kg	100 Kg
Application of Fertilizers		
Fertilization Amount	2 times	2 times
Fertilizer Type	Organic	Chemical
Fertilizer Dosage	2 ton/ha	50 kg/ha
Fertilization Time	2 ton/ ha Pre-planting and 15 DAP	Pre-planting and 45 DAP
Pets Controls		
Pets Type	Plant-based, natural enemy, and mechanical pesticides	Chemical pesticides

about one week before the application of fertilizers which aims to optimize the absorption of nutrients to rice plants. Insect pest control is carried out by applying insecticides with target pests in the form of leafhoppers, caterpillars and grasshoppers. This application time is done when the rice is 15 DAP (Days after planting). Meanwhile, fungicides and herbicides are applied together at the same time when the rice is 35 DAP.

3.2 Analysis of Soil Characteristics

In this study, several chemical properties were analyzed, namely pH, CEC and C- Organic Soil. The results of the analysis can be seen in Table 2.

Table 2. Financial feasibility analysis of oil palm replanting

Variables	Organic	Conventional
Soil pH	4.622 [a]	3.958 [va]
CEC of Soil (Cmol $^{(+)}$/kg)	13.5 [l]	19.5 [m]
C-Organic (%)	0.41 [vl]	0.88 [vl]

Note: va=very acidic, a=acidic, vl=very low, l=low, m=medium

Rice fields in North Talang Ubi tend to have acidic soil pH so that in its management requires the addition of organic matter or agricultural lime to increase soil pH. It can be seen from Figure 1. Soil pH of both land cultivation systems fall into the category of acidic and very acidic pH classes. According to Oktavian et al. (2024) soil acidity affects the presence and solubility of heavy metals. The lower the pH or the more acidic the soil, the more heavy metals can dissolve in the soil.

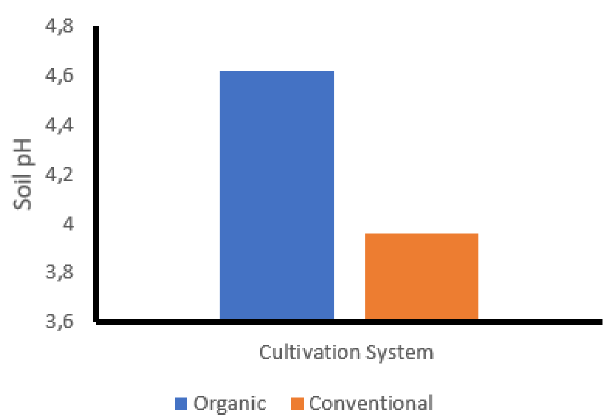

Figure 1. Results of Soil pH analysis

From Figure 1, It shows the results of pH analysis in paddy fields with the highest pH of only 4.62 found in the organic cultivation system and the smallest value of 3.98 obtanied in the conventional cultivation system. According to Sukristiyonubowo et al. (2019) organic rice cultivation is generally better than semi-organic and conventional rice cultivation in increasing soil pH, the application of manure has higher organic matter. With these pH results will have an impact on the results of Cd content and rice production.

Soils with higher CEC values have a greater ability to retain cations including Cd metal cations, which means that with higher CEC, the solubility of Cd in the soil decreases, so it can be said that with higher soil CEC, the tolerance limit for one of the metal pollutants also increases (Syachroni, 2020). In the two cultivation systems for soil Cultivation System CEC values have different values as shown in Figure 2.

Figure 2. Results of soil CEC analysis

From Figure 2, it shows that the CEC value for the conventional cultivation system is included in the medium class, and the organic cultivation system is included in the low class. The lowest CEC value reached 13.5 Cmol (+)/kg precisely in the organic cultivation system and the highest value with the Medium class is in the conventional cultivation system with a value of 19.5 Cmol (+)/kg. The content of organic matter in soil is assessed based on C-organic content, which is an indicator of soil fertility. Measurement of C-organic content is used to describe how fertile the soil is (Kamisah and Kartika, 2024). For soil C-Organic values in various cultivation systems fall into the very low class. For the highest c-organic value of 0.88% and the lowest of 0.41%. For the value of soil C-Organic in two cultivation systems can be seen in Figure 3.

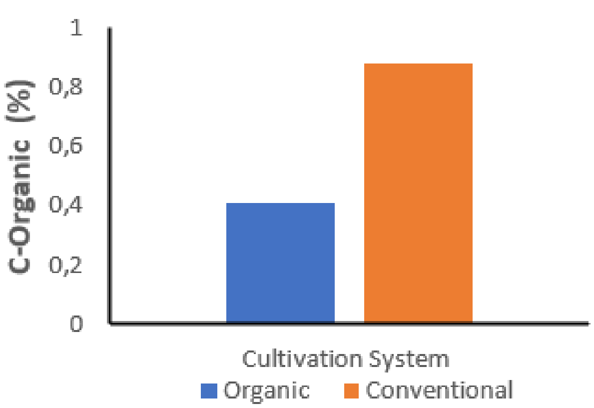

Figure 3. Results of soil C-organic analysis

3.3 Cadmium (Cd) Content in Two Cultivation System

The results of the Cd analysis can be seen in Table 3.

The cadmium content in the soil of each cultivation system is in the low category and is below the quality standard of cadmium in soil which is 0.5 mg/kg. For the results of cadmium content in soil can be seen in Figure 4.

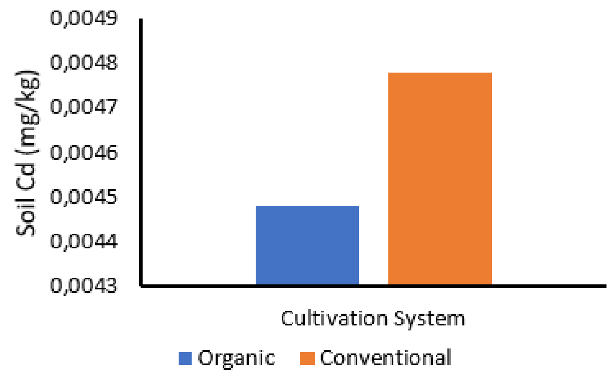

Figure 4. Soil Cd in two farming systems

From Figure 4 where the Cd content in the soil is still low and is below the quality standard of cadmium in soil which is 0.5 mg/kg. From the whole land the highest Cd value is only 0.00478 mg/kg so that the content in the soil is still safe. The value of Cd content in the soil in the organic cultivation system has a lower value of 0.00448 mg/kg than the Cd content in the soil in the conventional cultivation system. This shows the effect of the addition of organic matter on the accumulation of cadmium in the soil. This is in accordance with what is conveyed by (Ginting et al., 2024) the addition of manure increases pH while reducing the availability of Cd. This indicates that, when the pH increases, Cd binds to hydroxide compounds so that its solubility in the soil decreases. The increased amount OH^- causes the bonding between Cd^{2+} and OH^- to form $Cd(OH)_2$ which settles in the soil.

The results of the analysis of cadmium content in the roots of rice plants can be seen in Figure 5.

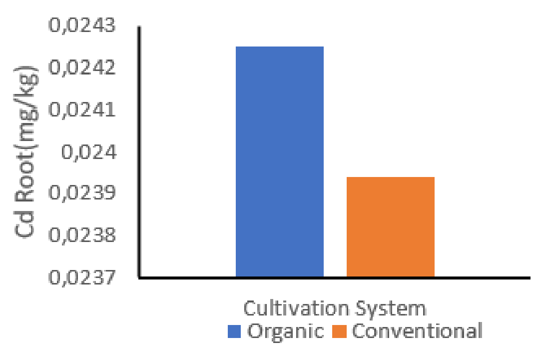

Figure 5. Root Cd analysis results

Cadmium content in roots, the threshold for cadmium

Table 3. Average results of soil, root, and shoot Cd analysis in different Cultivation Systems

Variables	Cultivation System Organic	Cultivation System Conventional	Quality Standard *
Soil Cd (mg/kg)	0.00448	0.00478	0.5
Root Cd (mg/kg)	0.02425	0.02394	0.1
Shoot Cd (mg/kg)	0.01813	0.03303	0.1

Notes: * =Based on National Standardization Agency (2009)

content in plants is 0.1 mg/kg. The hydrotopography of this land is overall below the cadmium threshold where the highest value only reaches 0.02425 mg/kg. The overall value does not exceed 0.05 so that the cadmium content in the roots is still far from the cadmium threshold in plants. The results of cadmium content in rice plant canopy can be seen in Figure 6.

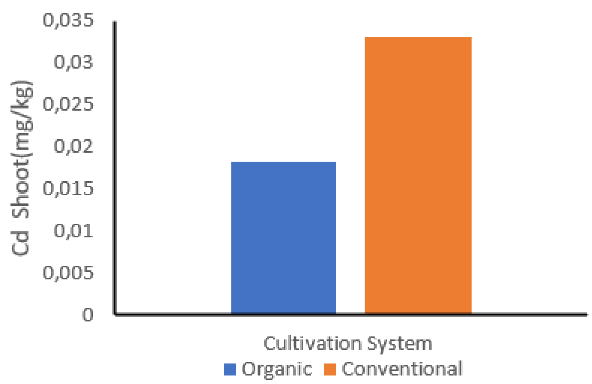

Figure 6. Results of shoot Cd analysis

Cadmium yield in the shoot with the threshold value of cadmium content in plants is 0.1 mg/kg. In both cultivation systems, overall, it is below the cadmium threshold with the highest value only reaching 0.03303 mg/kg so that the cadmium content in the shoot is still far from the cadmium threshold in plants. The value of Cd content in the plant canopy in the organic cultivation system has a lower value of 0.01813 mg/kg compared to the Cd content in the plant canopy in the conventional cultivation system. This is in accordance with what is conveyed by (Alfandi, 2018) the use of organic materials, especially in the form of straw compost, is known to have a significant ability to reduce the level of Cd absorption by plants. This is due to the nature of organic matter that is able to bind heavy metals, thus reducing their availability to plants. In addition, the presence of high organic matter content in the soil has a positive effect by reducing heavy metal concentrations, making the soil safer and healthier to support plant growth.

The results of the cadmium content in rice taken representative of each land cultivation system analyzed in the laboratory can be seen in Table 4.

In Table 4, it can be seen that the highest value of cadmium in rice is in the conventional cultivation system which is 0.0021253 mg/kg, from the results of the analysis of cadmium content in rice shows results that are far below the quality standard of cadmium in plants which is 0.1 mg/kg.

Table 4. Results Rice Cadmium (Cd)

Cultivation System	Rice Cd (mg/kg)	Threshod (mg/kg)*
Cultivation System Organic	0.0021103	0.1
Cultivation System Conventional	0.0021253	0.1

Notes: * =Based on National Standardization Agency (2009)

3.4 Multiple Linear Regression Relationship Analysis

Multiple linear regression analysis was conducted to determine the effect of several X variables on one Y variable. In this study, 2 multiple linear regression analyses were conducted, namely between Cd Plant to Cd Soil and several soil chemical properties with Cd Soil. This multiple linear regression analysis was carried out to see the effect of Cd levels in plants, namely roots and shoots on Cd levels in soil. The results of multiple linear regression analysis can be seen in Table 5.

Table 5. Results of multiple linear regression analysis between plant Cd and soil Cd

Variables	Unstandardized Coefficients	
	B	Std. Error
(Constant)	0.000	0.000
Cd Root	0.005	0.006
Cd Canopy	0.010	0.004

In Table 5, it can be seen that there is a significant relationship between root Cd and shoot Cd to soil Cd which has the equation Y = 0.000 + 0.005 root Cd + 0.010 shoot Cd + $\mathcal{E}$. The R value is 0.479 and the R - Square is 0.230 so that it can be interpreted that root Cd and shoot Cd have a simultaneous influence on soil Cd by 23% and 77% is influenced by other factors outside the observed variables. In addition, from the Y equation we can interpret that the most dominant factor influencing the increase in Cd in soil is the Cd content in the shoot. While the factor that can affect the decrease in soil Cd is the Cd content in the roots and regardless of the increase in Cd levels in the soil is influenced by other factors that are not studied.

The results of multiple linear regression analysis can be seen in Table 6.

Table 6. Results of Multiple Linear Regression Analysis Between Several Chemical Properties and Soil Cd

Variables	Unstandardized Coefficients	
	B	Std. Error
(Constant)	0.000	0.001
Soil pH	-2.919	0.000
CEC of Soil	1.816	0.000
C-Organic	0.000	0.000

In Table 6, we can know that there is a significant relationship between soil pH, CEC and soil C-Organic to soil Cd. Where for the equation Y = 0.000 -2.919 soil pH + 1.816 soil CEC + 0.000 soil C-Organic + $\mathcal{E}$. And for the R value of 0.562 and R - Square of 0.316 so that it can be interpreted that pH, CEC and C-Organic have a simultaneous influence on soil Cd by 31.6% and 68.4% is influenced by other factors outside the observed variables . In addition, from the Y equation, we can interpret that the most dominant factors affecting the increase of Cd in soil are CEC and soil C-Organic. While the factor that can affect the decrease in soil Cd is the pH content of the soil and regardless of the increase in Cd levels in the soil is influenced by other factors that are not studied.

4. CONCLUSION

The results of this study show that the cadmium (Cd) content in soil in the two cultivation systems is still below the cadmium quality standard, with the highest soil Cd content of 0.00478 mg/kg was obtained in the conventional cultivation system where the threshold limit is 0.5 mg/kg and for cadmium content in rice plants both in the shoot, roots, and rice in the two cultivation systems are still below the quality standards of cadmium, where the highest Cd level is 0.03303 mg/kg found in the conventional cultivation system where the threshold limit is 0.1 mg/kg. There is a relationship between plant Cd and some soil chemical properties on soil Cd. Where Cd plants have a simultaneous influence on soil Cd by 23% and soil chemical properties have a simultaneous influence on soil Cd by 31.6% the rest is influenced by other factors outside the variables observed.

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