Influence of a percolation pattern on removal of soluble elements in downward water and cadmium transfer using a stratified paddy field model

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1. Introduction

The stratified paddy field simulation model was used to clarify the influence of a percolation pattern on the removal of soluble elements in downward water and uptake of toxic metal cadmium. There are two types of percolation systems: water flow in an open system and it in a closed system. Sasaki et al. (2003) used the percolation models that had high and low drainage level in the subsoil. Therefore in this study, condition of the subsoil layer was divided two parts by ground water table: upper part of the subsoil above ground water table and lower part below it. In open percolation system ground water level is lower than in closed percolation system. The ground water table is higher model, the subsoil below the ground level we considered it ill-drained paddy fields.

2. Experimental design and method

The stratified paddy field models were performed (2 types of 4 models) in according to the condition described as shown Table 1. The experiment ② and ④ were designed to closed percolation system, high ground water table was keeping (ill-drained paddy fields). Experiment ①and ③ were made in open percolation system, low ground water table was controlled below upper subsoil (well-drained paddy fields).

Velocity of the percolation in the column model was 15-25 mm/day by water loss in depth. In this experiment with open and closed percolation system models we were compared in the plow sole portion and upper portion in subsoil: removal solution elements, the efficiency of accumulation cadmium, to observation to root activity and effect to plant growth, and the number of microbe of those models. The measurement items of this experiment as follow; the pressure head of downward water, oxidation-reduction potential and the quality of peculation water once a week.

Table 1　Experimental design

Layer \ Experiment / Model	Soil column model 2003			
	①	②	③	④
condition	About 20 mm/day			
I : plow layer (puddling and leveling)	● Alluvial soil		● Alluvial soil	
II : plow sole (compacted layer)	[Cd] ○	●	[Cd] ○	●
IIIo : subsoil (compacted layer)	Gravel R ○	●	Gravel Mt. ○	●
IIIu : subsoil (compacted layer)	Gravel R ●		Gravel Mt. ●	

○ : The open system percolation, ● : The close system percolation

Gravel R : From the Iwaki river, Gravel Mt. : From the Mt. Iwaki

Alluvial soil: Cadmium accumulation soil

3. Result and discussion

The pressure head distribution in the every layer of closed percolation system was positive pressure. However, in the case of open percolation system was changed from positive pressure in plow layer to negative pressure in the plow sole layer and became similar negative pressure in upper subsoil portion (Fig. 1).

The Eh value in closed system percolation experiment ②, Eh values of the plow layer, plow sole layer and subsoil layer became under 300 mV. These values were judged the reduction layers. But, in the experiment ①, second layer was became the oxidized layer. The diffusion of dissolved oxygen (DO) of in the second layer

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and upper subsoil portion of open system percolation (5-8 mg/L) was more than in the closed system percolation (1-3 mg/L). Fe concentration in Experiment ② of the first and second layer iron concentration increase to about 20-25 mg/L (Fig. 1) in closed system percolation condition. That concentrations were more than in Experiment ① in the similar level.

Yellowish part length of rice plant was measured during growth period. Experiment ② and ④ percentage of yellowish part were rapidly increased more than Experiment ① and ③ became 2-3 times (Fig. 2).

Concentration of Cd in rice grain was estimated, Cd content in rice grain of Experiment ① was higher than Experiment ②. Therefore percolation pattern is important for rice quality (Table 2).

The numbers of aerobic or facultative anaerobic bacteria were 10^6-10^7 g^{-1} at the first layer and second layer and steeply reduced at the third layer (10^5-10^6 g^{-1}) in each model.

4. Conclusion

Differences of the percolation pattern in stratified paddy field model were affected to soluble removal in downward water, rice plant growth. And the rice plant uptake Cd from contaminated soil was affected to Cd accumulation content in the rice.

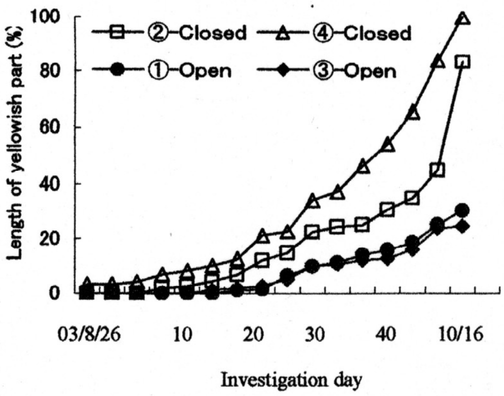
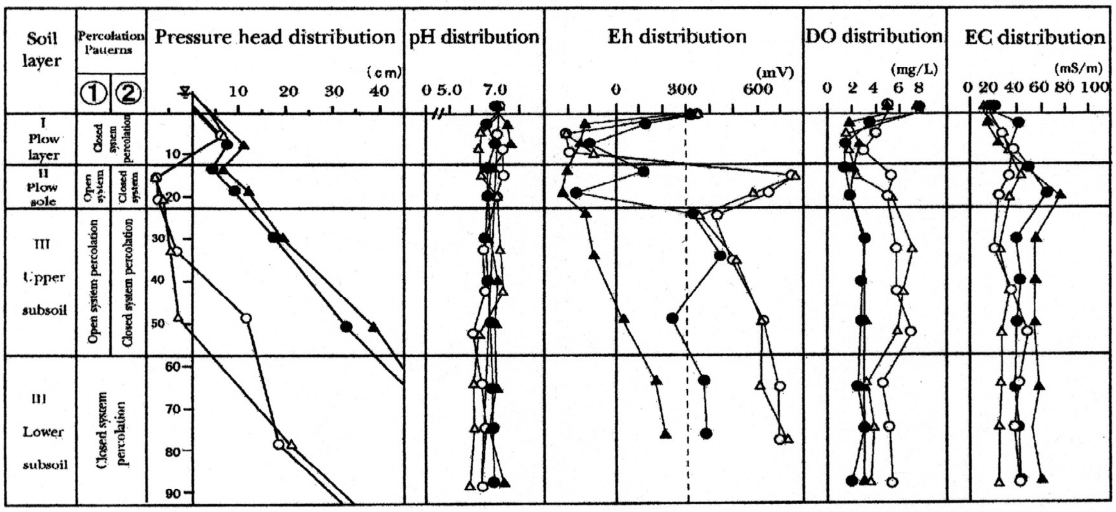


Fig.2 Yellowish part length of 13th blade at the rice plant

Table 2 Cadmium concentrations in the rice grain

Rice grain sample	Cd (mg/kg)
Control	0.037
Experiment ①	0.167
Experiment ②	0.018



O: 24th day of Experiment ①, Δ: 80th day of Experiment ①, ●: 24th day of Experiment ②, ▲: 80th day of Experiment ②

Figure 1 Distribution of hydraulic profile in downward water, pH, Eh, DO, and EC on stratified paddy field with Alluvial soil

Reference

Sasaki, C., 2003. Experimental reflections of influence of percolation pattern on the removal of soluble elements in stratified paddy fields with rice and Alluvial soil. JSIDRE. 223.19-27

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