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Agro-Bio Tech

Le Corps professoral de

Gembloux Agro-Bio Tech - Université de Liège vous prie

de lui faire l'honneur d'assister à la défense publique de la dissertation originale que

Madame LI Fengbo,

Titulaire d'un diplôme de *master of agriculture*,

présentera en vue de l'obtention du grade et du diplôme de

DOCTEUR EN SCIENCES AGRONOMIQUES ET INGENIERIE BIOLOGIQUE,

le 27 juin 2019, à 14h00 précises (personne ne sera admis après cette heure),

en l'auditorium ZT1 (Zootechnie - Bât. 1),

Passage des Déportés, 2, à 5030 GEMBLOUX.

Cette dissertation originale a pour titre :

« Effects of the Rice-fish Co-cultures on Nitrogen Balance, Sediment and Nutrient Resuspension and Oxygen Consumption in Intensive Aquaculture Ponds ».

Le jury est composé comme suit :

Président : Prof. P. du JARDIN, Professeur ordinaire,
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Summary

Aquaculture, accounting for nearly half of fish sources, plays an important role in ensuring the rapidly increasing demand for fish food. Intensive aquaculture with large number of artificial pelleted feed and organic fertilizer applications is widely practice in modern aquaculture industry to achieve high yield and economic benefit. However, intensive aquaculture also leads to serious environmental problems, such as eutrophication and hypoxia. Therefore, it is very important to remediate the eutrophic water and ameliorate hypoxia for sustainable development of intensive aquaculture.

Rice-fish co-culture is a traditional cultivation system and has existed over 2,000 years in Asian countries. It is now receiving renewed interest, because rice plays a key role in purifying eutrophic water. Previous studies have focused on mutual relationship between rice and fish, greenhouse gas (GHG) emissions, nutrient balance, and economic benefit of rice-fish co-culture conducted in paddy field or by floating-bed. However, this co-culture system was rarely conducted in aquaculture pond because of the limitation of rice height. Therefore, a new rice variety with the height of 1.85m is applied and planted in the bottom of pond. This new system may be available and efficient for remediation of eutrophic water and benefit for fish growth, yield and safety. But the real effect of rice-fish co-culture on nutrient remediation is not clear. Therefore, it is very important to investigate the ecological impact of rice-fish on nitrogen balance, sediment and nutrient resuspension and oxygen consumptions for application of rice-fish co-culture in practice.

An innovative rice-fish/shrimp co-culture system in yellow catfish and freshwater shrimp ponds by using a high-stalk rice variety was conducted to investigate the effect of rice-fish/shrimp co-culture nitrous oxide (N_2O) emission and ammonia (NH_3) volatilization, sediment resuspension induced nutrient release, and oxygen depletion in intensive aquaculture ponds.

Research on gaseous nitrogen (N) emission showed that rice-fish/shrimp co-culture reduced the N_2O and NH_3 emission from rice platform of fish and shrimp ponds, and also mitigated the N_2O and NH_3 emission from the ditch without rice planted. The reduction of gaseous nitrogen emissions mainly attributed to the significant reduction of available N in pond water caused by rice cultivation. Co-culture was more effective on the mitigation of N_2O than NH_3. The total amount of N_2O emission was reduced by 85.6% and 108.3 % for fish and shrimp ponds, respectively, whereas NH_3 was only reduced by 26.0% and 22.6% for fish and shrimp ponds, respectively. The absorption of available N by rice in pond water and bottom soil was the dominant pathway to reduce the N_2O emission from fish and shrimp ponds. The effects of rice on water parameters, such as chemical oxygen demand (COD), water turbidity and temperature, played an important role in the inhibition of NH_3 volatilization.

Research on sediment resuspension and nutrient release showed that rice-fish/shrimp co-culture significantly reduced nutrient release rate through sediment resuspension from catfish pond and shrimp pond, due to the significant reduction of sediment resuspension rate caused by rice cultivation. The total amount of N and P release by sediment resuspension were mitigated by 44.1% and 37.8% in catfish pond, by 42.1% and 24.0% in shrimp pond, respectively, which was higher than that accumulated in rice plants. The amount of sediment resuspension and nutrients release through this pathway increased with rice planting density in co-culture ponds. The results indicated rice-fish co-culture is an effective way to restrain sediment resuspension and eutrophication in intensive aquaculture ponds.

Research on oxygen consumption revealed that rice-fish co-culture reduced the nutrients concentration and dissolved oxygen content in the water of fish and shrimp ponds. However, seasonal changes of dissolved oxygen in the water of fish and shrimp ponds were observed both in catfish pond and shrimp pond. Rice-fish co-culture not only reduced the total amount of oxygen consumption but also optimized oxygen consumption structures in the two culture models. The respiration rates in water and sediment of ponds with rice cultivation were significantly reduced by 66.1% and 31.7% in the catfish pond, and 64.4% and 38.7% in the shrimp pond. Rice-fish co-culture decreased the proportions of sediment respiration and water respiration, while increased the proportion of fish respiration. These results suggest that rice-fish co-culture is an efficient way to reduce hypoxia in intensive aquaculture pond.

In conclusion, this new rice-fish co-culture system in aquaculture pond could significantly reduce the eutrophication by uptaking by rice, decreasing gaseous N emission, reducing resuspended nutrient release, and also depress hypoxia by optimizing oxygen consumption structures. Therefore, rice-fish co-culture is an effective model to achieve the sustainable development of intensive aquaculture.