COMPARING NITROGEN BUDGETS IN SHRIMP AND RICE-SHRIMP PONDS IN VIETNAM

Duc Dien Luu[1,2], Huu Hiep Le[2], Michele A. Burford[1], Jesmond Sammut[3]

[1] Griffith University, 170 Kessels Road, Nathan, Queensland 4111, Australia, www.griffith.edu.au, Email: ducdien.luu@griffithuni.edu.au

[2] Research Institute for Aquaculture No.2, 116 Nguyen Dinh Chieu Street, District 1, Ho Chi Minh City, Vietnam

[3] University of New South Wales, Kensington 2052, Australia

INTRODUCTION: Shrimp farming is one of the most valuable sectors of the Vietnamese economy and approximately 76% of Vietnam's shrimp production occurs in the Mekong Delta. Even though shrimp farming has been undertaken in intensive systems with high stocking densities, recent years have seen the expansion of new integrated rice-shrimp production farms. The rice-shrimp farming systems involve growing rice (and in some cases combined with shrimp) in the wet season, while only shrimp are farmed during the dry season. The adoption of this practice has substantially increased in Vietnam over the last years, growing from around 40,000 ha in 2000 to 160,000 ha in 2015. Despite this, there have been few studies of the long term sustainability of these systems. One measure of sustainability of rice-shrimp systems is associated with nutrient processes, including identifying the key inputs and outputs of N. However, there has been no research focussed on this aspect with previous studies only focussed on nutrient budgets in intensive aquaculture ponds. In this study, we compare N budgets in rice-shrimp ponds and adjacent intensively stocked grow-out ponds to identify the dominant inputs and outputs and the relative effectiveness of nutrient utilization by shrimp in the two systems.

MATERIALS AND METHODS:

The study investigated 12 farms along a canal in Ca Mau province, Vietnam, over the period of Feb 2014 to Jan 2015. Of these, six farms employed exclusively the rice-shrimp cultivation method, consisting of a platform with shallow water and a surrounding ditch, known as the **control group**. The remaining six farms adopted a combination of the rice-shrimp system and adjacent newly constructed grow-out ponds with shrimp grown in semi-intensive or intensive conditions, known as the **trial group**.

Temperature, salinity and oxygen were measured weekly using calibrated loggers, whereas water samples for N analysis were collected monthly. N-NH_4^+ was analysed using the phenate method; N-NO_2^- and N-NO_3^- using the cadmium reduction and TN and TDN using the persulfate method (APHA, 2005). In the grow-out ponds, sediment samples were collected by taking different cores from each pond and mixed in a composite sample for analysis. TN inputs and outputs in the culture system were calculated as follows:

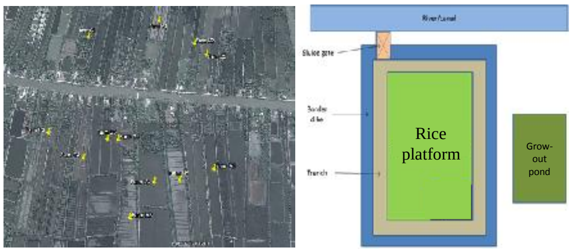

Figure 1: Diagram of 12 rice-shrimp farms (left) and typical design of one farm in trial group (right)

N input in water = N concentration in inlet water × total amount of water supplied.
N input in fertilizer = N concentration in fertilizer × total amount of fertilizer supplied.
N input in feed = N concentration in feed × total amount of feed supplied.
N input in shrimp = N concentration in shrimp stocking × total shrimp stocking.

N output in water = N concentration in outlet water × total amount of water released.
N output in shrimp = N concentration in shrimp harvesting × total shrimp biomass.
N output in sediment = N concentration in the sediment × total sediment settle.
N output in crab = N concentration in crab harvesting × total crab biomass.

RESULTS AND DISCUSSION:

Table 1. Production and related data for the 12 rice-shrimp ponds (trial group and control group)

Group	Pond area (m^2)	Survival (%)	Culture period (months)	Shrimp yield ($kg.ha^{-1}$)	Crab yield ($kg.ha^{-1}$)
Control	20,417 ± 4,224	4.3 ± 1.6	12	103.2 ± 40.3	17.4 ± 22.5
Trial	24,500 ± 9,439	5.6 ± 2.7	12	113.2 ± 37.5	38.4 ±17.3

Table 2. Production and related data (mean ± SD) for grow-out ponds (trial group)

Shrimp	Pond area (m^2)	Survival (%)	Culture period (days)	Harvest size ($shrimp.kg^{-1}$)	Shrimp yield ($kg.ha^{-1}$)	FCR
P. monodon	2,462 ± 749	82.3 ± 14.1	84 ± 20	66 ± 23	5,358 ± 2,325	1.2 ± 0.1
P. vannamei	2,417 ± 984	66.4 ± 14.2	141 ± 23	49 ± 17	2,069 ± 708	1.6 ± 0.3

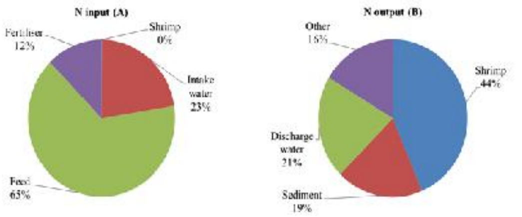

Figure 2. Percentage N input (A) and output (B) in grow-out ponds

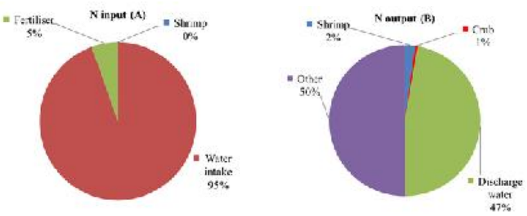

Figure 3. Percentage N input (A) and output (B) in rice-shrimp ponds

The N input in grow-out ponds was 243 kg N ha^{-1}, where feed contributing the most (65% - 159 kg N ha^{-1}) to sustain an average stocking density of 30 post-larvae.m^{-2}. Similar results were observed in Chinese shrimp farms studied by Xia et al. (2004), where N input in shrimp ponds was 193 kg N ha^{-1} with a stocking density of 50 post-larvae.m^{-2}. However, the N input due to feed in our study was much lower than the one reported by Sahu et al. (2013) on intensive ponds (95% - 44 to 104 kg N $crop^{-1}$). These N budgets indicate that grow-out ponds are relatively efficient in transferring N inputs to shrimp harvest (Alongi et al., 2000).

Rice-shrimp ponds were less efficient, with low shrimp survival and relatively low N recovery into shrimp. Compared to N concentrations in water outlets from grow-out ponds, N concentrations in water discharged from rice-shrimp ponds were substantially lower. It may be suggested that as the rice-shrimp culture system did not get any formulated feed, this would have contributed to reducing the N concentration in the water.

Some unaccounted N output in the rice-shrimp system was sequestered by the sediment through accumulation of organic sludge. Hence, sediment accumulation was likely to be responsible for a significant percentage of the N output. The management of benthic algae in rice-shrimp ponds could be important because this is the natural source of nutrients for shrimp. At times, large amounts of nutrients are stored in macrophytes and benthic microalgae on the platform, but this biomass was found to vary considerably over time and between farms. It is unclear what drives this variability but the changes in salinity and temperature may affect algal biomass production.

CONCLUSION: In grow-out ponds, feed was the major input of N (65%), followed by intake water (23%). For rice-shrimp ponds, water intake was the main input (95%), and shrimp only accounted for 2% of N output. The nutrient budget indicates that good production and low FCRs can be achieved from well managed grow-out ponds, whereas rice-shrimp ponds appear inefficient systems for transfer of N with low shrimp survival. Therefore, solutions for the sustainability of the rice-shrimp model are necessary to improve shrimp productivity.