Omonrice 12: 52-57 (2004)

DYNAMIC CHANGES IN WATER QUALITY AND SOIL FERTILITY UNDER MONO- RICE CULTURE AND RICE - FRESH WATER SHRIMP SYSTEMS IN MEKONG DELTA

Tran Thi Ngoc Son[1], Bui Dinh Duong[1], Truong Thi Minh Giang[1] and R. Yamada[2]

ABSTRACT

Demonstration on the effect of different farming system viz., rice – rice and rice – shrimp culture since 2001 (first year) up to 2003 (third year) to study about water quality and soil fertility. The monitored data of water quality viz., pH, dissolved oxygen, NH_4- N concentration and temperature were good enough for shrimp growth under good management. In term of soil fertility under rice – shrimp system also got significantly higher value such as soil organic matter, available nitrogen, phosphorus and potassium as compared to the monoculture rice – rice system to an extent of 28.87; 37.73; 56.52; 36.28 %, respectively. At the same time, the economic efficiency of rice shrimp model also got more net return to an extent of 39.054 million VND/ha/year as compared to rice monoculture only 9.20 million VND/ha/year.

Key words: available nitrogen, dissolved oxygen, economic efficiency, marginal benefit ratio cost, NH_4-N concentration, organic matter, phosphorus and potassium.

RATIONAL

Diversification in agriculture can help farmers eradicate hunger and alleviate poverty in the Mekong Delta of Vietnam. At present, development of models with the gross return about 70,000,000 VND/ha/year is encouraged and recommended by the Ministry of Agriculture and Rural Development. Nowadays, there are many ways to obtain this target, among that model of rice - fresh water shrimp is considered as suited to the alluvial soil. The rice - fresh water shrimp model can bring about many benefit such as agricultural economic, social society and grain yield of rice increased from 3% to 22% as compared to rice monoculture (Ling et al. 1999). However, development of rice – shrimp system is still facing many risks since producers have not been trained about technology. Therefore understanding about environment such as water quality changes and soil fertility after harvest shrimp is needed. An attempt has been made to study "dynamic changes in water quality and soil fertility under rice monoculture and rice - fresh water shrimp systems in the Mekong Delta"

MATERIALS AND METHODS

1. Pilot site:

The demonstration models is conducted at plots 4A and 5A which belonging to the seed farm of Cuu Long Delta Rice Research Institute during 2002, 2003 winter-spring, and 2002, 2003 Summer- Autumn seasons. Initial soil pH was 5.2 (1:1 H_2O). Soil initial nutrient components were 3.2 % organic carbon, 0.26 % total nitrogen, 0.04 % total P; total K: 0.07 %. Soil texture components are as sand: 12%; silt: 26%; clay: 52%; pH 5.2; CEC 32.7 meq/ 100 g of soil. Demonstration fields were conducted on rice – rice at plot 4A and the rice - shrimp system in 5A.

2. Methods: Cultural practices followed the recommendation methods by CLRRI, rice was cultivated in November and harvest in February.

Stocking of shrimp fingerling was done in March, with post shrimp size of 27mm and 3 fingerlings/m^2 rate. Harvested shrimp took place in November every year. Lime ($CaCO_3$)

[1] Cuu Long Delta Rice Research institute, O Mon, Can Tho, Vietnam
[2] Japan International Research Center for Agricultural Sciences, Tsukuba, Ibaraki 305-8686, Japan

was applied at the rate of 500kg/ha.

Water samples were collected at two-week interval and analyzed by test kit of pH test, O_2 test, alkalinity test, NH_4 test and water analyzer. Soil samples were randomly collected from 30 different sites of each plot at the time of harvesting to analyze available N, P, K, pH, EC and organic carbon.

RESULT AND DISCUSSION

1. Water feature

Water under natural condition is a direct factor in influencing to shrimp growth and development. Dynamic change of water quality in shrimp cultivation is an important element to be monitored.

a. pH: Almost fresh water pond recorded pH value changes from 6-9 and the variation of pH every day from 1-2 units (Boyd 1998). pH of water is very important, it has direct influence to the shrimp growth and plankton (Chanratchakool et al. 2002). Optimum pH for shrimp growth varies from 7.5-8.35 and the variation should not exceed 0.5. Data recorded from demonstration model showed that pH value did not vary too much, minimum value as 6.59 and maximum as 8.10. This indicated that pH value is suited for shrimp growth (Fig.1). This research finding is lines with Kungvankij et al. (1986)

b. Dissolved oxygen (DO)

Concentration of dissolved oxygen reduced, it means possibly lead to the death of shrimp in the pond. In the pond with low in concentration of dissolved oxygen, shrimp will decrease feeding capacity and lower feeding transformation as compared to normal pond with high dissolved oxygen concentration (Boyd 1998).

Optimum concentration of dissolved oxygen for shrimp growth varied from 5 to 6 mg.l^{-1}. At the lower concentration of dissolved oxygen of 4 mg.1^{-1} the feeding capacity of shrimp will be less efficiency, concentration of dissolved oxygen reduced up to 2-3 mg.1-^{1}, shrimp will stop catching a beat of pray and will be asphyxiated at the concentration of dissolved oxygen of below 2 mg.1^{-1} (Chanratchakool et al. 2002). This showed that the max DO fallen at fifth month after stocking. Concentration of dissolved oxygen varied from 4.25 to 5.55 mg.1^{-1} (Fig. 2). According to the international standard, concentration of dissolved oxygen of 4 mg/l confirms enough oxygen for supplying to shrimp growth (Nguyen Thanh Phuong et al. 2001).

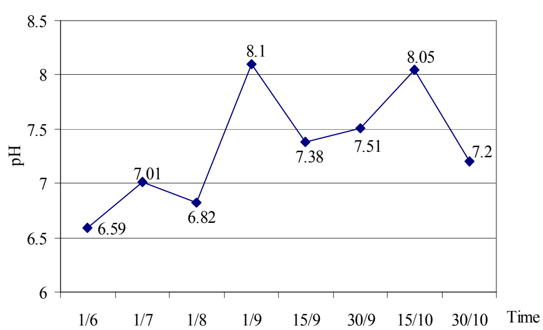

Fig. 1. Dynamic changes in pH value with time in rice -shrimp model

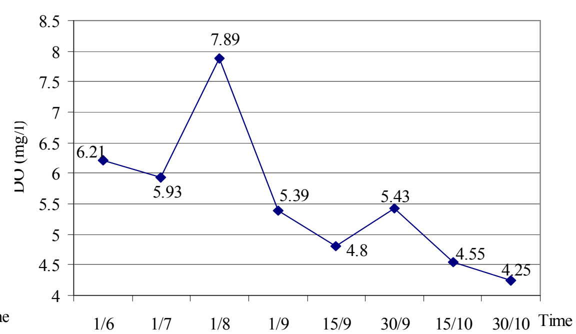

Fig. 2. Dynamic changes in DO value with time in rice -shrimp model

Notes:

Oxygen concentration	Evaluation
2 mg/l (ppm)	Dangerous, oxygen is not sufficient for shrimp growth
4 mg/l (ppm)	Oxygen is sufficient for shrimp growth.
6 mg/l (ppm)	Good, oxygen is more than enough for shrimp growth

c. NH_4-N concentration

The aquatic plants can absorb a huge amount of NH_4^+ and they influenced in the control of NH3-N concentration in water pond. The aquatic plants that can be consumed by creature or they can be died and decomposed to supply again inorganic N (Boyd 1998).

Variation of NH_4-N concentration at different ponds depend upon soil characteristics, fertilizer application, timing of fertilization, decomposition of creature and consumption of floated living things (Hein and Rienmann 1995, Lai and Lam 1997, Lewis 1974, Noriega-Curtis 1979). Critical standard of optimum N-NH_4 concentration for shrimp growth is 0.003- 0.01 mg/l. Based on the results, NH_4-N concentration in the field got a big variation. The lowest value was 0.003 mg/l and the highest as 0.05 mg/l. Almost at different stages of shrimp growth, the value of NH_4-N concentration was recorded at lower dangerous level, except at 2 stages as 1/9 and 15/10, this maybe due to decomposition of microorganisms and direct consumption of floating creature. However, NH_4-N concentration has been recovered as normal after changing of water from canal and this phenomenon did not cause any harmful effect to shrimp growth (Fig . 3)

d. Temperature

The dynamic changes of temperature showed in fig.4 indicated that temperature in the field did not vary much, the lowest value as 27.9 °C and the highest value as 31.34°C. These value were lower as compared to the critical standard, therefore there is unfavorable condition for shrimp growth (Fig.4)

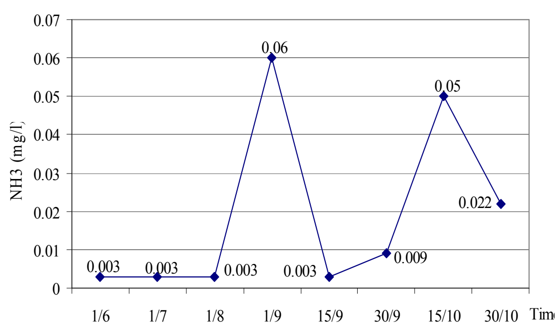

Fig. 3. Dynamic changes in NH4-N concentration with time in rice -shrimp model

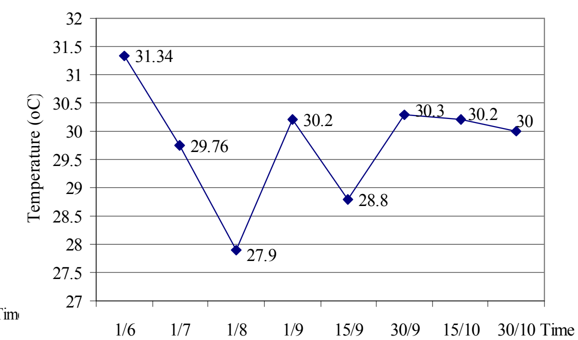

Fig. 4. Dynamic changes in temperature with time in rice -shrimp model

2. Soil characteristics

a. Soil organic carbon:

The organic matter in the pond mainly initiated from the excreta of shrimp, extra feeding mill and wastes of plankton. Accumulation of organic carbon will occur quickly and increase soil organic matter in pond (Chanratchakool et al. 2002).

Statistical analyses of organic carbon at 30 different sites in the rice - shrimp (3.85%) as compared to rice monoculture (2.98 %). It addressed a significant difference, with t value as = 4,684 **. Organic carbon increased 28.87 % under rice - shrimp field as compared to rice monoculture

b. Soil available nitrogen:

Soil available nitrogen got significantly higher value in rice - shrimp field as compared to rice monoculture. Soil available N under rice - shrimp field was 0.763 meq/100g of soil as compared to rice monoculture as 0.554 meq/100g with t value as 0.884 **. Soil available N contributed to the rice –shrimp system was 37.73 % as compared to rice monoculture

c. Soil available phosphorus:

The planitophyte can absorb quickly phosphate from water, dissolved phosphate from fertilizers or from organic in pond bottom to response their own living need. When the planitophyte die, they become feeding source of plankton or settled down and decomposed later. The former result showed that there was 70% phosphate added to the pond in the form of fertilizer of feeding that accumulated in the mud of pond bottom (Masuda and Boyd 1994).

Soil available phosphorus also got significantly higher value in rice - shrimp field as compared to rice monoculture. Soil available P under rice - shrimp field was 1.969 ppm as compared to rice monoculture as 1.258 ppm with t value as 3.204 **. Soil available N contributed to the system as 56.52 % as compared to rice monoculture

d. Soil available K:

Soil available potassium also got significantly higher value in rice - shrimp field as compared to rice monoculture. Soil available K under rice - shrimp field was 76.43 ppm as compared to rice monoculture as 56.8 ppm with t value as 6.556 **. Soil available N contributed to the system as 36.28 % as compared to rice monoculture.

Table 1. Differences in soil characteristics under rice - shrimp and rice monoculture

Parameter	System		Difference	Difference percentage (%)	T value
	Rice - Shrimp	Rice - Rice			
Organic C (%)	3.848	2.986	0.862	28.87	4.684**
N (meq/100g)	0.763	0.554	0.209	37.73	6.884**
P (ppm)	1.969	1.258	0.711	56.52	3.204**
K (meq/100g)	76.426	56.081	20.345	36.28	6.556**

ECONOMIC EFFICIENCY OF RICE – SHRIMP MODEL

Economic efficiency of rice and shrimp model got benefited. Practical economic efficiency showed in table 2 , 3 and 4

Table 2. The economic efficiency of rice and fruit tree around the bund under rice shrimp system (CLRRI, 2003)

Parameters	Rice (Winter – Spring)	Fruit trees		Total
		Banana	Papaya	
Gross return (1000 VND/ha)	14.700	250	2.250	17.200
Gross input (1000 VND/ha):	10.297	40	995	11.332
Net return (1000 ®/ha)	4.403	210	1.255	5.868

*Notes: Price of rice in Winter – Spring season 2002-2003 is of 3000 VND/kg.

The total product of shrimp was 3,705 kg and equally to 260,809 million VND. Average shrimp yield was 823.3 kg/ha and total gross return from fresh water shrimp as 57.96 million VND/ha. Total gross input as 111.47 million VND, with net profit of rice shrimp model as 149.34 million VND. Average net profit was 33.186 million VND/ha. (table 3)

Table 3. The economic efficiency of shrimp under rice shrimp cultivation system (CLRRI, 2003)

Parameters	Total production	Average /ha
Productivity (kg)	3,705	823.3
Gross return (1000 VND)	260,809	57,958
Total input (1000 VND)	111,472	24,772
Net return (1000 VND)	149,337	33,186

Table 4. The economic efficiency of rice- shrimp cultivation system (CLRRI, 2003)

Parameters	Gross return (1000 VND/ha)	Total input (1000 VND/ha)	Net return (1000 VND/ha)	Marginal benefit cost ratio (1000VND/ha)
Rice , fruit trees	17,200	11,332	5,868	1.6
Shrimp	57,958	24,772	33,186	2.3
Total	75,158	36,104	39,054	2.1

CONCLUSION

Rice – shrimp model showed a great potential in sustainable agriculture in term of soil fertility and economic efficiency. The gross return of rice shrimp model was 75.16 million VND and the net return as 39.05 million VND/ha and marginal benefit cost ratio as 2.1 (>2) that can be accepted. Besides that soil fertility under rice –shrimp system also recorded significantly higher in term of soil organic matter, available nitrogen, phosphorus and potassium as compared to the rice monoculture. Therefore, the demonstration should be extended to advanced farmers in Mekong Delta.

REFERENCES

Boyd CE. 1998. Water quality for pond aquaculture. Research and development series No. 43, August 1998, 37pp.

Chanratchakool P, JF Turnbull, SJ Funge-Smith, IH Macrae and C Limswan. 2002. Health management in shrimp ponds. Third edition. Agricultural Publisher, TPHCM, 152 pages.

Hein M. and B Rienmann. 1995. Nutrient limitation of phytoplankton biomass or growth rate: an experimental approach using marine enclosures. Journal of Experimental Marine Biology and Ecology 188: 167-180.

Kungvankij P, TE Chua, J Pudadera, G Corre, LB Tibo, IO Potestas, GA Taleon and JN Paw. 1986. Shrimp culture: pond design, operation and management. NACA Training manual series No. 2: 68 pp.

Lai PCC and PKS Lam. 1997. Major pathways for nitrogen removal in waste water stabilization ponds. Water Air and Soil Pollution 94 (1-2): 125-136.

Lewis WM. 1974. Primary production in the plankton community of a tropical lake. Ecol. Monogr. 44(4): 377-407.

Ling BH, PS Leung and YC Shang. 1999. Comparing Asian shrimp farming: the domestic resource cost approach. Aquaculture 175 (1-2): 31-48.

Masuda K and CE Boyd. 1994. Phosphorus Fractions in Soil and Water of Aquaculture Ponds Built on Clayey, Ultisols at Auburn, Alabama. J. World Aquaculture. Soc. 25:379-395.

Nguyen Thanh Phuong Truong Quoc Phu, Cao Phuong Nam, Duong Tri Dung and Ta Van Phuong.2001. Study and suggest the fishery models with high sustainable and economic efficiency for the 2001-2005 stage and orientation for the year of 2010. The project collaboration of Fishery Institute, Agricultural Faculty, Can Tho university and Department of Sciences and Environmental Technology of Ca Mau province., March, 2001.

Noriega-Curtis, P. 1979. Primary productivity and related fish yield in intensely manured fish ponds. Aquaculture 17: 335-344.

SUMMARY IN VIETNAMESE

Nghiên cứu chất lượng nước và độ phì của đất trong hệ thống canh tác độc canh lúa và lúa- tôm ở ĐBSCL

Nghiên cứu ảnh hưởng về chất lượng nước và dinh dưỡng đất của 2 mô hình lúa-lúa và lúa -tôm đã được thực hiện từ năm 2001 đến năm 2003. Kiểm tra thường xuyên các chỉ tiêu về chất lượng nước bao gồm pH, oxy hòa tan, NH_4-N và nhiệt độ. Chúng được xác định để kịp thời hiệu chỉnh thích hợp cho tôm phát triển. Kết quả 3 năm cho thấy hệ thống canh tác lúa tôm đã nâng cao độ phì của đất như chất hữu cơ, đạm, lân, kali hữu dụng tương ứng ở các mức độ 28,87; 37,73; 56,52; 36,28%, so mô hình chỉ trồng thuần lúa. Hiệu quả kinh tế của mô hình lúa - tôm càng xanh rất cao với lãi thuần là 39.054.000 đồng so với chỉ độc canh 2 vụ lúa chỉ lãi có 9.200.000 đồng /ha /năm.
