

WATER MANAGEMENT FOR INTEGRATED FARMING; REUSE OF WATER FROM
Macrobrachium rosenbergii FARMING FOR OFF-SEASON RICE PRODUCTION
การจัดการน้ำเพื่อการเกษตรเชิงบูรณาการ; การใช้น้ำจากบ่อเลี้ยงกุ้งก้ามกรามเพื่อการทำนาปรัง

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received : November 15, 2008

accepted : June 1, 2009

Abstract

Water management for integrated farming, reusing of water from shrimp (*Macrobrachium rosenbergii*) farm for off-season rice production was studied at Ban Na Vee, Khoawong District, Kalasin Province. The experiment was conducted in 2008 during dry season, from February to June. The integrated rice cultivation was using left-over water from shrimp rearing pond compare with that using water directly from the reservoir - for field preparation and rice growing throughout 4 months period. Factors on quality of water and sediment in the rice fields were monitored monthly. Additionally, indexes on rice growth and production were also determined monthly. Later, the

partial cost-benefit was used to interpret the benefit of each treatment.

The results indicated that water quality factors of the rice field using water from shrimp rearing pond, i.e. pH, alkalinity, COD, TKN and phosphate were significantly higher than those of the field using water directly from the reservoir. Soil quality factors of rice field using water from shrimp rearing pond, for example pH, ammonia-N, TKN and TP were higher than those of rice field using water directly from the reservoir. Indexes on rice growth - height and number of shoot of rice field using water from shrimp rearing pond were higher than those of the rice field using water directly from the reservoir. Furthermore, the yield from the rice field using water

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from shrimp rearing pond was about 5% higher than that of the field using water directly from the reservoir. These could be concluded that left-over water from the shrimp rearing pond can be reused for off-season rice growing. Consequently, the farmers get higher rice production and additional benefit from shrimp production from the integrated farming.

Keywords: off-season rice, *Macrobrachium rosenbergii*, water quality.

บทคัดย่อ

การจัดการน้ำเพื่อการเกษตรเชิงบูรณาการนี้ เป็นการศึกษาการทำนาปรัง ณ พื้นที่บ้านนาวี ตำบลสงเปลือย อำเภอนาหวาง จังหวัดกาฬสินธุ์ โดยเปรียบเทียบการทำนาโดยใช้น้ำจากบ่อเลี้ยงกุ้งก้ามกราม (NP1) กับการทำนาโดยใช้น้ำจากอ่างเก็บน้ำโดยตรง (NP2) โดยเริ่มศึกษาตั้งแต่เดือนกุมภาพันธ์ 2551 และสิ้นสุดในเดือนมิถุนายน 2551 ประกอบด้วยการเก็บข้อมูลคุณภาพน้ำ ตะกอนดิน ตรวจวัดการเจริญเติบโต วัดผลผลิตข้าว จากนั้นนำมาเปรียบเทียบการใช้น้ำ ต้นทุน และผลตอบแทนที่ได้ของทั้งสองระบบ

จากการศึกษาพบว่า นาข้าวที่ใช้น้ำจากบ่อเลี้ยงกุ้งมีค่าองค์ประกอบคุณภาพน้ำเป็นดังนี้ คือ อุณหภูมิ (NP1=NP2), pH (NP1>NP2), alkalinity (NP1>NP2), COD (NP1>NP2), BOD (NP1>NP2), TOC (NP1>NP2), TKN (NP1>NP2) และ total phosphorus (NP1>NP2) และมีองค์ประกอบส่วนตะกอนดิน ได้แก่ แอมโมเนีย ไนโตรเจนทั้งหมด และฟอสฟอรัส สูงกว่านาข้าวที่ใช้น้ำจากอ่างเก็บน้ำอย่างมีนัยสำคัญ ($P<0.05$) เนื่องจากน้ำจากบ่อเลี้ยงกุ้งก้ามกรามได้ผ่านการจัดการน้ำเพื่อการเลี้ยง การให้อาหาร การเติมปูนมาร์ล ซึ่งองค์ประกอบที่ต่างกันนี้ส่งผลให้การเจริญเติบโตของข้าวที่ได้รับน้ำจากบ่อเลี้ยงกุ้ง เช่น ความสูง และการแตกกอในแต่ละช่วงอายุข้าวสูงกว่าข้าวที่ใช้น้ำจากอ่างเก็บน้ำอย่างมีนัยสำคัญ ($P<0.05$) และให้ผลผลิตข้าวในปริมาณน้ำที่ใช้เท่ากันสูงกว่าประมาณ 5 เปอร์เซ็นต์ เมื่อเปรียบเทียบต้นทุนการผลิต บางส่วนต่อผลตอบแทน พบว่าการปลูกข้าวมีต้นทุนการ

ผลิตในแปลงนาเท่ากันคือ 925 บาท ผลตอบแทนของนาข้าวที่ใช้น้ำจากอ่างเก็บน้ำคิดเป็นเงินสุทธิ 4,582 บาทต่อไร่ ส่วนนาข้าวที่ใช้น้ำจากบ่อเลี้ยงกุ้งคิดเป็นเงินสุทธิ 4,863 บาทต่อไร่ สรุปได้ว่าจากการใช้น้ำมวลเดียวกันนาข้าวที่ใช้น้ำจากบ่อเลี้ยงกุ้งก้ามกรามให้ผลผลิต และผลตอบแทนสูงกว่าแปลงข้าวนาปรังที่ใช้น้ำจากอ่างเก็บน้ำ

คำสำคัญ: นาปรัง, กุ้งก้ามกราม, คุณภาพน้ำ

Introduction

Water resource management plays a key role in success of farming. Currently, majority of the agricultural practices in Thailand rely on rainfall or natural stream as the main source of water. Due to lacking of the water resource management, yields of cultivation closely depend on the quantity of water. In abundant year, the farm could obtain good yield whereas in the drought year, the farmer would face the loss⁽¹⁾.

Based on the problem, an integrated farming combining with water resource management practice is proposed to make the most out of available water resource. The study was conducted at the upstream area of Phaya Young watershed in Khoawong District, Kalasin Province. In the area, there was a small reservoir able to supply limited amount of water during dry season which was not sufficient for the off-season rice cultivation in large scale. An integrated farming, combining shrimp farming and rice cultivation, was one of the schemes that give promising perspective. Shrimp farming takes 8 months per round of cultivation. If the

farmer started the cultivation during rainy season, the time frame will overlap with the dry season. At that time, the water from the shrimp pond will be valuable. The water together with the nutrients from shrimp wastes or from left-over feed could provide sensible off-season rice cultivation. This scheme makes a good use of water that might be left as waste and also provides excellent water treatment, thus, helps improve the surrounding environment, collaterally. This efficient uses of water resource could also give a ground for sustainable agricultural practice which is highly advantageous⁽²⁾.

Research Methods

Site Selection

The study was conducted during February -June 2008, in an area within the Nam Young watershed, a small 3 rais farm at Ban Navee of

Khaowong District, Kalasin Province. The shrimp rearing pond (PR) was 40 m. width by 60 m. long, made up of 2,400 m² meters space. The pond contained 1.2 m. depth of water, made up of 2,880 m³. At the time of need, the water from the shrimp pond at the 20 cm. height from the floor will be transferred via a pipe to the designated rice field in adjacent area. The 30 m. by 40 m. or 1,200 m² rice field (NP1) was designed to rely on the water from the shrimp pond (Figure 1). As a comparable study, another rice field (NP2) with the same size was assigned to rely solely on the water from the reservoir, the Phaya Young (Figure 2). Both rice fields were planted with Chai Nath 1 rice variety. Sampling points for water and sediments were assigned as the plus sign in a circle symbols as in Figure 3, four spots for each pond. During the study, the samples were collected four times - on day 0, 30, 70 and 100, taking from the planting date.

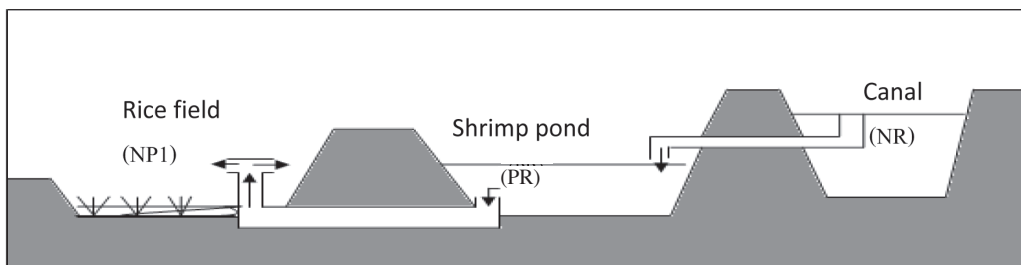


Figure 1 Diagram presents the water allocation design of the integrated use; the water was transferred from the Canal (NR) to the shrimp pond (PR). Then, when need, the water from the shrimp pond was piped in to the designated rice field (NP1).

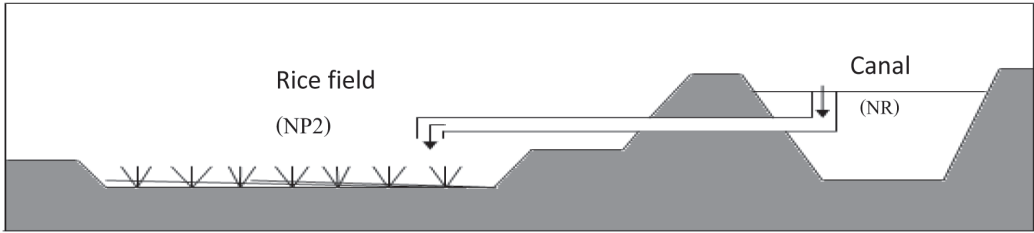


Figure 2 Diagram represents the water allocation design of rice field (NP2) to rely on water from the reservoir via a canal (NR).

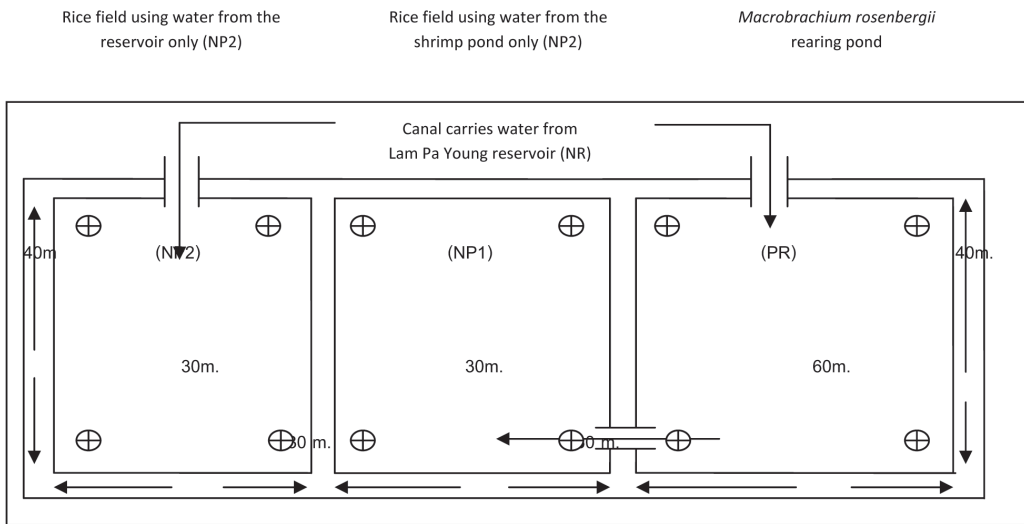


Figure 3 Diagram representing the scheme of the study.

Field Preparation and Treatment

Both rice fields were prepared by releasing the water from each source; water from reservoir to the NP2 and water from the shrimp pond to the NP1, by keeping equal height. Then, they were plowed and left standing for a week, later, furrowed into level. The seeds were soaked for 24 hr and covered for 48 hr before planting, at 20 kg/rai. After day 15-20, the water was released and controlled to be at about

5-10 cm. in both fields. The water level was maintained throughout the period until day 105 which the water was discharged out of both fields. At that stage, the rice was ready to be harvested.

Water, Sediment Sampling and Rice Growth Index

Water samples were collected at each point indicated in the diagram (Figure 1). Some

factors i.e. temperature, pH were measured on the spot. On the other hand, the other factors were analyzed at the specific laboratory of the Environmental Research Institute of Chulalongkorn University.

The sediments were also collected in the same manner.

The growth indexes of the rice were height and number of stems. Those were recorded on day 0, 30, 70 and 100, respectively. The rice was harvested at day 120. The harvest was by sampling from 1 m² area, four samplings from each rice field.

Laboratory Test Method

Factors of water quality; temperature, pH, Alkalinity, COD, DO, TOC, TKN, total phosphorus were determined according to Strickland & Parson,⁽⁴⁾. Also, factors of the sediments: pH and nutrients (nitrogen-ammonia and nitrate; and, available phosphorus) were verified according to Strickland & Parson,⁽⁴⁾.

Data Analysis

Analysis of variance; ANOVA method was used to compare factors of water quality, sediments from each rice field and factors on

growth of rice; height, number of stems and rice yield.

Results

Water Usage

The profile of water usage for the 2,400 m² shrimp-pond is as following: at initial stage, 1,920 m³ of water was filled at 80 centimeters deep; then, at the initial of 1st month, 960 m³ of water was added to the 120 centimeters deep; during the 2nd and 3rd month, the water was released out depends on the environment; in the 4th month, the water was being drained to be used in the rice field (NP1).

In both rice fields, in each 1,200 m², initially, 240 m³ of water was released into the field. During, days 15-20, 120 m³ of water was added and kept at the level of 10 centimeters from the ground. During day 45-50 and day 80-85, twice, the water was added to the rice fields to keep the level of water at 20 cm. from the ground. The water usage was 180 m³ each. In total, the water for rice cultivation in each field was 720 m³. While, 5,040 m³ of water was used for shrimp rearing. Among those number, 2,160 m³ was taken out of the pond.

Table 1 Water Use Profile of Shrimp rearing and off season rice cultivation

Water uses	Type of water uses (m ³)		
	PR	NP1	NP2
1 Shrimp pond preparation; start shrimp rearing	1,920	-	-
2 at initial of the 1 st month	960	-	-
3 in the 2 nd month	720	-	-
4 in the 3 rd month	720	-	-
5 Preparation of the rice fields; start rice cultivation	240	240	240
6 during day 15-20	120	120	120
7 during day 45-50	180	180	180
8 during day 80-85	180	180	180
Total water uses	5,040	720	720

Note: PR = Shrimp rearing pond

NP1 = Rice field using water from the shrimp rearing pond

NP2 = Rice field using water from the reservoir

Water Quality

Factors on water quality - pH, alkalinity,

COD, TOC, total nitrogen or total phosphorus of each location were displayed in Figure 4.

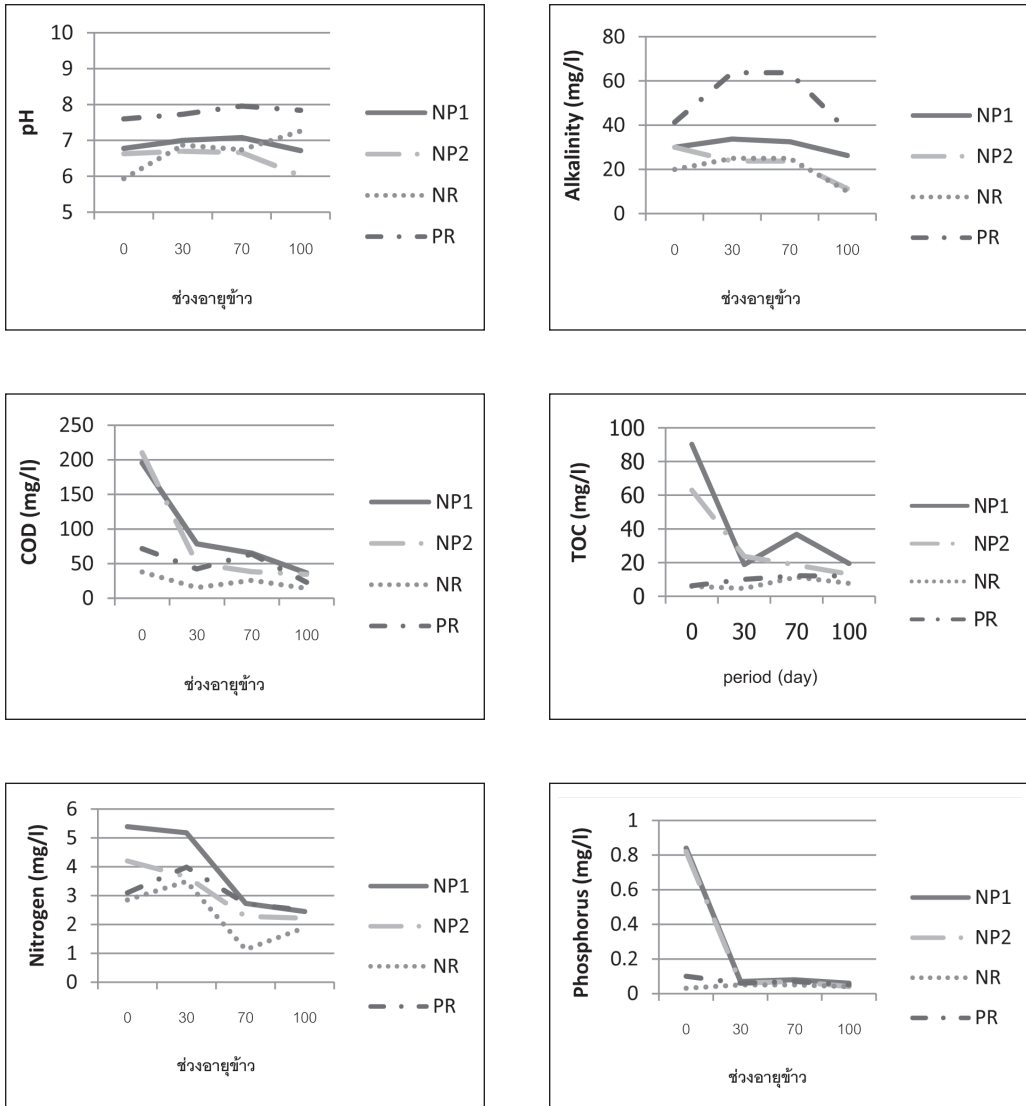


Figure 4 Factors on water quality - pH, Alkalinity, COD, TOC, Total nitrogen and Total phosphorus of each source: canal (NR), shrimp rearing pond (PR), rice field which rely on water from the shrimp rearing pond (NP1) and rice field which rely on water from the canal (NP2)

Temperature

There was no significant difference in temperature of the rice field which rely on water from the shrimp rearing pond (NP1) and rice field which rely on water from the canal (NP2). Moreover, those were within the threshold of the safety standard for aquatic creatures^[5].

Salinity

The salinities of the water in both rice fields were quite low, at 0-0.1 ppt. Those could be an effect from dissolving of minerals from the soil which considered benefit for rice cultivation.

Dissolved Oxygen (DO)

DO of those 4 sources was not significantly difference, and was within the standard for agricultural uses.

pH

pH of the water samples from the rice field using water from the shrimp rearing pond was higher than the others, resulting from the water treatment by adding lime during shrimp rearing.

Alkalinity

Alkalinity of the water samples from the rice field which was using water from the shrimp rearing pond was higher than the others, resulting from the water treatment by adding lime during shrimp rearing.

Chemically Oxygen Demand (COD)

On day 0, the COD of both tested fields was rather high and about equal. However, on day 30, 70 and 100, COD of the rice field using water from the shrimp rearing pond was slightly higher. On overall the COD were decreasing overtime.

Total Organic Carbon (TOC)

The TOC of each rice field gave no significantly difference. The number of each was decreasing over time, taken out via rice growing process.

Total Kjeldahl Nitrogen (TKN)

The numbers of TKN of the rice field using water from the shrimp rearing pond were higher than that using the water from the reservoir. These should be the results of the left over shrimp feed and the organic waste from the shrimps. Overtime, those numbers were lower, most likely; the nitrogen was taken by the rice growing process.

Total Phosphorus

The total phosphorus in the rice field using water from the shrimp rearing pond were slightly higher than that using the water from the reservoir. Overtime, those numbers were lower, most likely; the phosphorus was taken by the rice growing process.

Soil Quality

Factors on soil quality - pH, ammonia,

nitrate or total phosphorus of each location were displayed in Figure 5

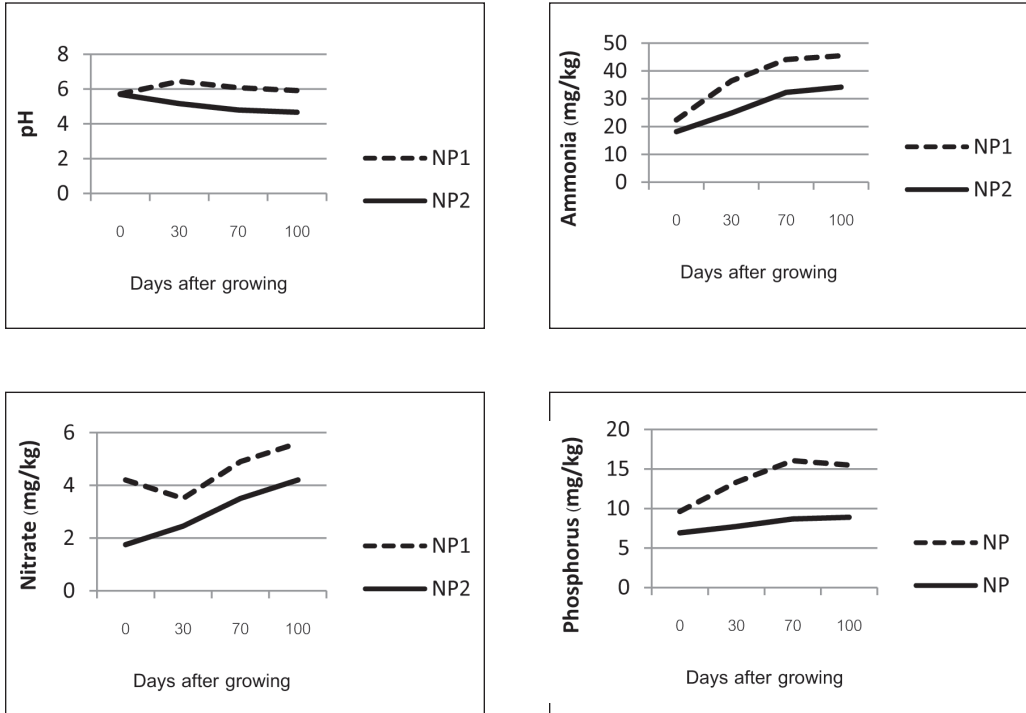


Figure 5 Factors of soil quality; pH, ammonia, nitrate and phosphorus of the rice field using water from shrimp rearing pond (NP1) compare with the one from the rice field using water from Phaya Young reservoir (NP2)

Soil pH

The pH values of the soil in the rice field using water from the reservoir were significantly lower than the one using water from the shrimp rearing pond (Figure 5). Samples of day 70 and day 100, gave the pH of 4.80 and 4.67,

respectively. Those were considered rather acidic⁽⁹⁾. However, those of the samples from the rice field using water from the shrimp rearing pond were average 5.72-6.45, which are suitable for rice farming given those were around 5.0-6.5⁽³⁾.

Nutrients

The laboratory test on soil samples shows that soil from the rice field using water from the shrimp rearing pond at every sampling periods contained more ammonia, nitrate and phosphorus than the one from the rice field using water directly from the reservoir. This indicated that the left over feed and shrimp waste had provided nutrients to the field.

Rice Growth Monitoring

Rice growth was monitored based on its height and number of shoots. Those indexes were recorded on day 30, 70 and 100. Average height and average number of shoots of each case were presented as Figure 6.

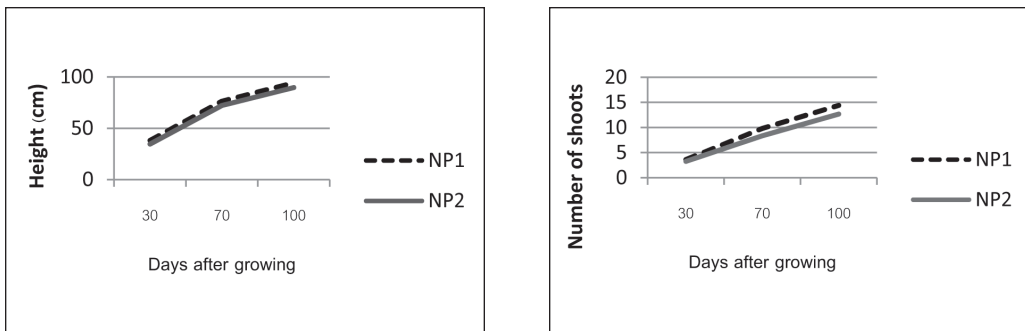


Figure 6 Rice growth pattern indicated by its height and number of shoots at each stage of the rice; those of rice field relying on water from shrimp rearing pond (NP1) compared with those of rice field relying on water directly from the reservoir (NP2)

From the study, at each stage of the growth, the average height and average number of shoots were higher in rice using water from the shrimp rearing pond than the ones using water directly from the reservoir. These together with the data on water quality and soil quality indicated that the water from the shrimp rearing pond could provide suitable environment and nutrients for rice farming.

Rice Yield

Data in table 2 points out that the rice cultivation by using water from the shrimp rearing pond showed superior yield, either considering the number of rice grain, average rice weight, number of spike or average rice weight. The equivalent yield was 423 g/m² or 677 kg/rai, whereas the other was at 404 g/m² or 647 kg/rai. From the table, it is clearly shown

that yield from the rice cultivation using water from shrimp rearing pond (NP1) is higher by 5%

compared with the one using water directly from the reservoir (NP2).

Table 2 Rice yield of rice cultivation using water from shrimp rearing pond (NP1) compared with the one using water directly from the reservoir (NP2).

Rice yield indicators	Yield	
	NP1	NP2
1. Number of rice grain/spike	121.30 _{+10.14}	118.45 _{+8.54}
2. Average rice weight (gram/spike)	3.34 _{+0.09}	3.29 _{+0.07}
3. Number of spike/ square meter	126.75 _{+3.77}	122.75 _{+2.75}
4. Average rice weight (gram/square meter)	423.35	403.85

Cost and Benefit

The cost of rice cultivation using water from the shrimp rearing pond, considering the whole components, was as following: construction of the shrimp rearing pond 19,000 baht, young shrimp 4,500 baht, materials for shrimp rearing pond 3,600 baht, shrimp feed 6,000 baht, rice seeds 255 baht, fuel cost 300 baht, and rice harvesting cost 400 baht-or, 34,025 baht in total. On the other hand, the cost of rice cultivation using water directly from the Phaya Young reservoir was as following: rice seeds 225 baht, fuel cost 300 baht,

and harvesting cost 400 baht-or 925 baht in total. From the data, it could be seen that the investment cost for the total components of rice cultivation using water from shrimp rearing pond was much higher than that of the one using water directly from the canal of the reservoir. However, in the next round of cultivation, there will be no cost from the construction of the pond. Thus, the investment cost of the integrated system should be lower, whereas, the yield and income still the same-more profit received.

Table 3 Cost comparison of rice cultivation: A-an integrated farming using water from shrimp rearing pond, and B-using water directly from the reservoir

Item	Cost (baht)	
	A	B
1 construction of the shrimp rearing pond	19,000	-
2 fuel	300	300
3 rice seeds	225	225
4 young shrimps	4,500	-
5 rice harvesting	400	400
6 materials for shrimp rearing pond	3,600	-
7 materials for rice field	-	-
8 shrimp feed	6,000	-
9 labor cost	-	-
10 other cost	-	-
Total	34,025	925

The benefits per rai from each model were as following. Rice cultivation as an integrated farming using water from shrimp rearing pond had 6,096 baht of income and the net benefit was 4,863 baht, after adjusted the cost. Additionally, the giant freshwater shrimp gave the income of 26,527 baht or 4,460 bath of net profit. On the other hand, rice cultivation using water

directly from the canal of the reservoir gave an income of 5,815 baht or net profit of 4,582 baht. However, in the integrated farming case, if the cost on construction of the pond was not considered i.e. during next round of cultivation, the net benefit per rai would be 17,127 baht rather than 4,460 baht.

Table 4 Benefit and net profit comparison of rice cultivation, the cost of construction of the shrimp rearing pond was considered: A-an integrated farming using water from shrimp rearing pond, and B-using water directly from the reservoir

Item	Benefit (baht/rai)		Net profit (baht/rai)	
	A	B	A	B
rice	6,096	5,815	4,863	4,582
** giant freshwater shrimp	26,527	-	4,460	-
total	32,623	5,815	9,323	4,582

Table 5 Benefit and net profit comparison of rice cultivation, the cost of pond construction was not considered: A-an integrated farming using water from shrimp rearing pond, and B-using water directly from the reservoir

Item	Benefit (baht/rai)		Net profit (baht/rai)	
	A	B	A	B
rice	6,096	5,815	4,863	4,582
** giant freshwater shrimp	26,527	-	17,127	-
total	32,623	5,815	21,990	4,582

Note to Tables 4-5 As of October, 2008, price of the rice was at 9,000 baht/ton and the giant freshwater prawn was at 150 baht/kg. After June, 2008, there leftover shrimp in the pond could also give some yield.

Conclusion and Discussion

The study clearly indicates that integrated farming by using leftover water from the shrimp rearing pond for rice farming gave benefit from better rice growth and better yield. Rice cultivation could benefit to the farmer 4,582 baht/rai. Typically, farmers with 1-5 rais could make use of integrated farming; fish or shrimp rearing together with rice cultivation or with other crops. The scheme supports the idea of sustainable agriculture which desirable among the farmers by enlarge.

Acknowledgements

This research was part of a project, The Sustainable Integrated Resource Management of Watershed Area Using Land-Water-Population Management (LWPM) Concept: A Case Study of Nam Phong Watershed and Nam Young Watershed. The project was managed by Environmental Research Institute, Chulalongkorn

University and was funded by the National Research Council of Thailand.

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