Concurrent Rice-Fish Trials: Comparing Regular and Border Planting Patterns

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Background

In the past decade, interest in rice-fish culture has increased, particularly in Asian countries (MacKay et al. 1987; Li and Pan, in press). Rice yields in rice-fish culture are similar but fish production varies by several orders of magnitude (Li 1988). Therefore, efforts should concentrate on optimizing fish yields.

Varying the rice planting pattern is one approach. Border planting (BP) can be used to maintain rice yields by keeping an equal number of rice hills, while lessening shading of the water by the rice canopy. This could increase aquatic primary production and therefore natural food for the fish and provide more space for fish feeding. When food and space are limiting factors in the system, fish production is likely to increase.

Experimental Work

The experiment was conducted in the dry season of 1989 at the Freshwater Aquaculture Center (FAC) of the Central Luzon State University (CLSU) in Muñoz, Nueva Ecija, Philippines. Two planting patterns were used in a randomized complete block design with three replicates of each: Regular planting (RP) with 25 cm spacing within and between planted rows and BP with 17 cm spacing within and 25 cm between planted rows, leaving two rows vacant after each third planted row (3:2) (see photo). Each experimental rice-fish plot (300 m², 25 x 12 m) provided a central trench about 0.4 m deep. Water was supplied from wells and an irrigation canal. No pesticides were used other than 'Brestan' [Hoechst Far East Marketing Corporation] to control the golden snail (*Pomacea* sp.). Additionally, snails were handcollected in the first two weeks after transplanting. Fertilizers totalling 44 kg/ha urea (NPK 46-0-0) and 286 kg/ha complete fertilizer (NPK 14-14-14) were given in two split doses of the same amount and quality: 1) a basal application and 2) topdressing in the third week after transplanting.

Rice variety IR 64 of the International Rice Research Institute (IRRI) was transplanted to the plots. Common carp (*Cyprinus carpio*) and tilapia (*Tilapia zillii*), with initial weights of 2-4 g, were stocked at 5,000 fish/ha at a 1:1 ratio. Fish were harvested 78 days after stocking, counted and weighed, including fry/fingerlings for tilapia. Rice was harvested 83 days after transplanting, airdried and the yield determined at a moisture content of 14% for each plot.

Twelve-hour dissolved oxygen (DO) and temperature (T) profiles, at 3-5 cm water depth, were taken at two-hour intervals during weeks 2 and 11 after transplanting from 0600 to 1800 hours using a YSI DO/T meter. All other water samples were taken weekly. The sampling times: pH at 0600 to 1800 hours using a pH-meter; total ammonia (NH_3/NH_4^+) and total solids at 0800 hours followed the procedures described in Boyd (1979). Computed means were compared using Student's t-test ($P<0.05$).

Results

Fish harvest data are presented in Table 1. The recovery rates ranged from 48 to 66%, RP and 28 to 69%, BP. Net total fish yields were not significantly different: RP, 108.7 kg/ha and BP, 110.9 kg/ha. With BP, *C. carpio* grew significantly better than *T. zillii*, and gave better net yields: 59.9 compared to 10.3 kg/ha. Rice yields were 2.5-3.0 t/ha, not significantly different between treatments.

The DO and T profiles (Fig. 1) showed distinct diurnal cycles. DO fluctuated from about 1-13 mg/l and T from 19 to 34°C. In the week 11 profiles, DO concentrations with BP were significantly higher than with RP during most of the day.

Border planting in rice-fish culture to provide more space for fish and to allow more light to reach the water. (Photo by M. Halwart)

Table 1. Harvest data for *Cyprinus carpio* (CC) and *Tilapia zillii* (TZ) in concurrent rice-fish culture in Muñoz, Nueva Ecija, Philippines.[a]

	Recovery (%)		Individual growth (g)		Net yield (kg/ha)				
Treatment	CC	TZ	CC	TZ	CC	TZ	TZ fry/ fingerlings	Total TZ	Total CC + TZ
RP[b]									
Mean	66	48	35.5	28.5	56.6	28.0	24.1	52.1	108.7
S.D.	29	14	12.8	7.7	33.7	8.7	16.5	18.1	39.9
BP[b]									
Mean	69	28	35.9	23.0	59.9	10.3	40.7	51.0	110.9
S.D.	38	20	6.6	7.0	34.5	12.8	27.6	34.2	68.4

[a]Stocking size, 2-4 g; stocking density, 5,000 fish/ha (1:1 species ratio); growth period, 78 days; rice variety, IR 64; dry season 1989. Plot size = 300 m², N = 3.
[b]RP = Regular planting, BP = Border planting.

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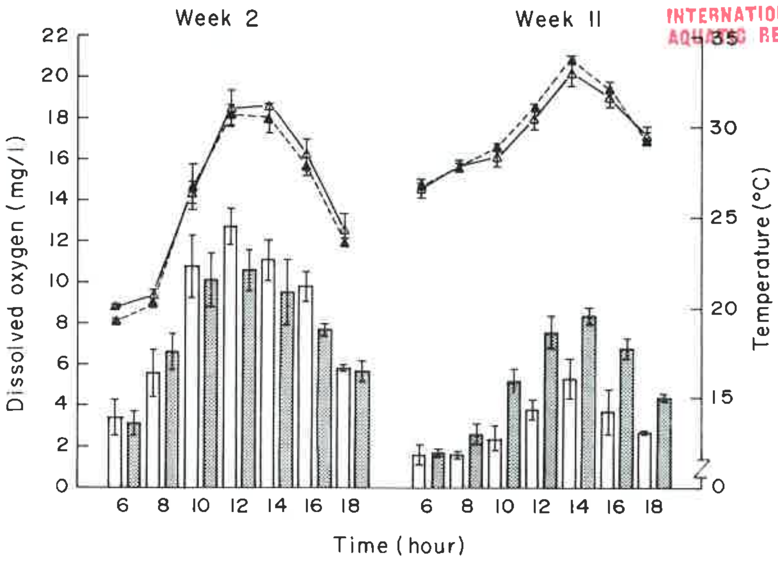

Fig. 1. Twelve-hour profiles for dissolved oxygen (histograms) and temperature (curves) in rice-fish plots with water 3-5 cm deep, taken during weeks 2 and 11 after rice transplanting. The two treatments compared were regular planting of rice (RP) (unshaded, open triangles) and border planting (BP) (shaded, closed triangles). The plotted values are means with standard deviation bars, N = 3.

Temperature fluctuations (about 13°C in the week 2 profile and about 7°C in week 11), total ammonia, pH (6.4-8.2) and total solids did not differ significantly between treatments. Total ammonia varied from 0.5 to 1.0 mg/l, except in week 3 when it rose to 4.6 mg/l in both treatments, returning to the previous range by week 4. No mortalities were attributable to this ammonia peak. Total solids increased from about 300 mg/l in week 3 to about 500-700 mg/l towards the end of rice cultivation.

Discussion

An irrigated ricefield is an aquatic ecosystem dominated by rice plants. Newly transplanted seedlings cover only a small portion of the field. As the rice plants ripen, however, there can be dense shading by the rice canopy. As a result, primary production and DO concentration in the floodwater decrease (Heckman 1979). The week 11 graphs in Fig. 1 illustrate that, in a regularly planted ricefield, DO concentration barely reaches 5 mg/l - a critical value below which retarded fish growth occurs (Boyd 1982).

The pH remained within the range considered optimal for fish production: 6.0-9.0 (Boyd 1982). The total ammonia peak, coincident with topdressing, corresponds at pH 8.0 and 32°C to about 0.4 mg/l of un-ionized ammonia: close to the toxic, short-term exposure range of 0.6-2.0 mg/l NH_3 (EIFAC 1973). Such ammonia peaks could cause mortalities and growth suppression. Therefore, topdressing in concurrent rice-fish culture needs caution.

The superior growth of *C. carpio* was perhaps because of a better benthic food supply throughout the rice cultivation period. *T. zillii* is predominantly macroherbivorous and weed availability peaks in the first third of rice cultivation. Also, the early reproduction of *T. zillii* uses resources that would otherwise be available for more weight gain by the stocked fish.

How did the planting pattern affect fish production? From the results of this study it has to be stated that BP shows no advantage compared to RP. Two factors are likely to be responsible for this result: initial fish size and recovery rate. The advantages of BP will not translate in higher fish production if the number of fish is small, because there is no competition for food and space. Unfortunately the small stocking size in this study reflects the lack of large fingerlings at peak times of needs. Low fish recovery is often observed in the locality and attributed to bird predation and fish escapes through cracks in the dikes.

Research on rice-fish culture should take these constraints into account. Possible approaches, e.g., include the pond refuge layout (dela Cruz 1990) which provides large fingerlings available for stocking all year-round. Additionally, biomass would be a more useful parameter for stocking rather than the number of fish.

The many interactions between fish and the ricefield environment are still not well understood. However, decisions on choice of species or crop rotation should be based precisely on this knowledge. Therefore, further research in rice-fish culture should focus on basic questions such as quantity and quality of fish food organisms under different farming systems.

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Editor's note: This paper is valuable as it provides summary data on water quality on concurrent rice-fish culture and highlights some of its constraints. However, the failure here of border planting (BP) to produce more fish than regular planting (RP) contrasts with the widening use of BP, particularly in Indonesia, based precisely on this rationale of increased fish/normal rice production. NTAS readers are invited to send in their views and contributions on this important topic through letters or short papers.