Effect of Planting Pattern on Shading and Phytoplankton Photosynthesis in Bangladesh Rice-Fish Farms

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Introduction

The concurrent culture of rice and fish is being promoted in Bangladesh and there is growing interest in low-cost methods for improving yields. Border planting (BP) for reducing shading at the water surface, which could increase aquatic primary productivity and thereby natural food for fish, has been suggested as a means for increasing fish yields (Halwart 1991).

Research in the Philippines on the effect of BP on fish yields did not show any significant advantage over regular planting (RP), but this was thought to be due to low initial fish size and a low recovery rate (Halwart 1991).

In the present study, a BP pattern recommended by the Bangladesh Agricultural Research Council (Mazid et al. 1992) was tested against RP to assess the effect, if any, on gross phytoplankton photosynthesis and shading. A wide planting (WP) pattern was also included in the trial, as an "extreme case", to assess the level of photosynthesis that might be obtained if some of the rice yield was sacrificed.

Materials and Methods

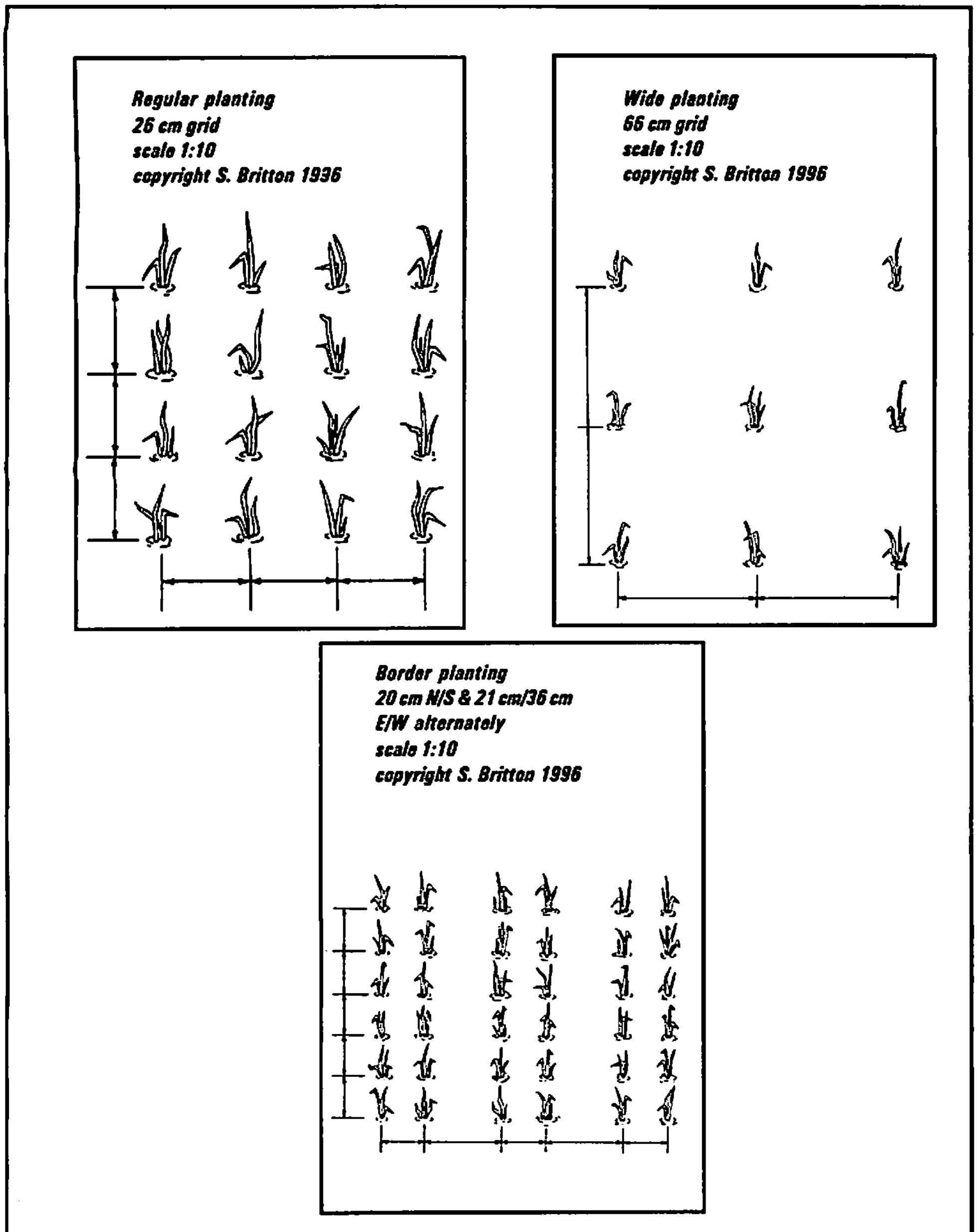
Experimental work was carried out at the Northwest Fisheries Extension Project (NFEP), Parbatipur, Bangladesh in the irrigated rice season of 1995, using 12 trial plots of 225 m^2 each. Three rice-planting treatments (Fig. 1), each with four replicates, using the rice variety BR16, were undertaken:

- RP, 26 cm between rows N to S and E to W;
- BP, 20 cm between rows N to S and alternately 21 cm and 36 cm between rows E to W; and
- WP, 66 cm between rows N to S and E to W.

Rice was transplanted on 27-28 February and harvested 106 days later. Common carp *(Cyprinus carpio)* fingerlings of 0.2 g mean weight were stocked at a density of 9 000 fish/ha, 28 days after transplanting (DAT), and harvested immediately after rice harvesting. Following practices of local farmers, fertilization for rice consisted of basal application of triple super phosphate (TSP), gypsum, potash and zinc at 110, 100, 100 and 20 kg/ha, respectively, and approximately 40 t/ha dried cattle manure. Top dressing of 220 kg/ha urea was applied in equal split doses, 37 and 55 DAT.

Gross phytoplankton photosynthetic rate (GPPR) was estimated by the oxygen determination method using light and dark bottles (Lind 1979). Water was collected from several points in the plot and incubated in 250 ml glass reagent bottles at the water surface for 24 hours. One pair of bottles was incubated at a random location within the plot, with the light bottle placed mid-distance between hills, or in the middle of the widest space between planted rows for BP. Another pair was placed in a 2 m^2 cleared area, as an unshaded control.

Photosynthetically active radiation (PAR) transects were taken in plots between 1000 and 1400 hours, using a cosine corrected quantum sensor (Delta-T QS) and microvolt integrator (Delta-T MV2) attached to a purpose-built bench. Estimates of PAR were taken for a 20-second period at regular intervals along a 1-1.5-m long bench, 0.25 m above the substrate. The



transects were oriented E to W, mid-distance between adjacent rice hills and, for BP, covered equal numbers of broad and narrow spaces. Non-shaded control readings were taken on the bank.

Chlorophyll *a* concentrations were determined spectrophotometrically (APHA 1992). Dissolved oxygen (DO), temperature, conductivity, pH, nitrate and phosphate were measured using a Phox Model 962 meter, thermometer, Ciba Corning M90 multi-probe kit and Hach DR/2000 spectrophotometer, respectively. Depth was calculated from five randomly located measurements. For five hills in each plot, the heights of 10 tillers and the total number of tillers, were recorded. Harvested rice was sun-dried and weighed unhusked. Weather data were obtained from an airport, 17 km away. A single set of comparative measurements were taken from two local rice-fish farms.

A repeated measures analysis involving a split-plot analysis of variance was completed on each of the parameters. The control values for PAR and GPPR were used as covariates when analyzing these parameters. Data on yields were subjected to single-classification ANOVA.

Results

The range of values recorded for selected parameters from rice fields while fish were present are given in Table 1.

Table 1. Range of values recorded for selected parameters from rice fields, while fish were present. Number of samplings in parentheses. (N.D. = not detectable)

Parameter	Range
Gross phytoplankton photosynthetic rate [mg C/m^3/hour] (6)	11-252
PAR [mmol/m^2/s^1] (2)	30-1 550
Chlorophyll *a* concentration [mg/m^3] (6)	1-132
Oxygen concentration [mg/l] (7)	1-2-20.3
Water temperature [°C] (9)	20-35
pH (2)	6.4-8.2
Conductivity [mS] (2)	320-740
Nitrate nitrogen [mg/l NO_3 - N] (2)	N.D.-0.3
Orthophosphate [mg/l PO_4] (2)	N.D.-0.2
Depth [cm] (4)	6 - 26

Differences between treatments in terms of GPPR and chlorophyll *a* were tested in the three sets of data collected between 57 and 92 DAT, when the rice was 60-100% of its maximum height. Taking control values into account, only WP values of GPPR were significantly greater than those of RP ($p<0.01$). Regular planting readings in-crop were on average 73% (s.d. 16) of control readings. Mean GPPR increased after each urea application, despite reductions in sunshine hours compared to the preceding sampling period.

Taking control values into account, values of PAR, measured twice from 54 to 97 DAT, were only significantly greater than RP in WP ($p<0.05$). For RP, PAR in-crop was on average 59% (s.d. 23) of that on the bank.

Net fish yields with a mean of 69 kg/ha and 0-60% recovery were very variable (s.d. 80) and did not differ significantly between treatments. However, there was significant positive correlation with minimum depth ($r = +0.65$, $p<0.05$). Rice yields from the WP treatment with a mean of 2.0 t/ha (s.e. 0.3) were significantly lower ($p<0.01$) than those of the other two with a mean of 3.4 t/ha (s.e. 0.4).

Dissolved oxygen and water temperature fluctuated diurnally. Depth, conductivity, pH, and mean tiller height did not differ significantly between treatments. At harvest, mean tiller height was 70 cm (s.d. 3). There were significantly more tillers per hill in WP ($p<0.001$), because an error possibly led to about double the specified number being planted.

The two farmers' fields were shallower (4-6 cm) and contained a taller variety of rice (mean tiller height 85 cm). Within-crop GPPR and PAR were <30% of control readings.

Discussion

Border planting showed no advantage compared to RP, possibly because the rice variety used was short and thus produced relatively little shading. Low readings of PAR and GPPR from farmers' fields, where a taller rice variety was growing, reinforce this observation. Additionally, the BP pattern had relatively narrow spaces between planted rows, which may have made it ineffective in reducing shading. Wide planting did show a benefit for phytoplankton photosynthesis, but this may not generate an increase in fish yield sufficient to justify the negative impact on rice production. A BP pattern with wider spaces between planted rows, such as that used by Halwart (1991), might be effective in increasing aquatic productivity while maintaining the number of rice hills.

Even in RP close to harvest, shading was not much. This may explain why GPPR levels throughout the experiment were comparable to those recorded by Jana and De (1983) at the same time of year in four fishponds in neighboring West Bengal in India (37.6-280 mg C/m^3/hour). The low phosphate and nitrate levels and increases in GPPR after urea application suggest that nutrient availability may have been an important limiting factor to phytoplankton growth.

Ideally in this experiment there should have been less variation in water depth between plots, but in practice it is difficult to maintain water levels because of differing land levels. The positive correlation with net fish yield, a phenomenon also noted by Middendorp (1992), suggests that water depth might be an important factor in determining fish yield. However, in the present study, the correlation was probably mainly due to high mortality caused by very low water levels in some plots. Depth of water should not be less than 10 cm and the inclusion of a refuge area in rice-fish farms is recommended.

The method used for measuring mean tiller height was time consuming and equivalent information could have been obtained by simply measuring the tallest tiller in each hill. Dissolved oxygen in incubation bottles was measured by oxygen meter to allow a large number of GPPR readings to be taken. However the probe could not be inserted into the reagent bottles and pouring was necessary, which altered DO concentrations. As the change was predictable, data were adjusted accordingly, but use of compatible apparatus would be more accurate. Whitton et al. (1988) reported problems in obtaining reliable values for PAR measurements with similar instruments. However, in this study, since the same equipment was used throughout and comparisons were made between readings taken within a short duration, relative values should be reliable.

Further research using a different BP pattern and taller rice varieties was undertaken, the results of which will be published shortly.

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Breeding and Propagation of Tilapia (*Oreochromis niloticus*) in a Floating Hatchery, Gabon

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Background

The grow-out of tilapia species in floating cages is practised in tropical countries world-wide and is well documented. Typically, production units are stocked with fingerlings usually obtained from land-based hatcheries. Few producers attempt to carry out the entire culture cycle, from breeding to nursery stages and grow-out, in floating cages.

It has been suggested that breeding tilapia in cages may be an economic and practical way of improving fish production in freshwater lakes and reservoirs, and coastal lagoons, especially in African countries. The aim of this study was therefore to improve fish production in the freshwater lakes of the Lambaréné area, and in the numerous coastal lagoons of Gabon, to compensate for the current overexploitation of natural stocks, or the alternative of introducing other species, and to reduce the drift of the fishing population away from the lakes.

The target of increased fish production needed to reverse the economic and social trends in the region was estimated at 400 t/year in the short term, increasing to about 1 000 t/year in the long term to stabilize the local fisheries sector. Some or all of this target could be achieved through aquaculture practices with species for which breeding techniques are well-established and reliable, and where suitable supplementary feed is available. In addition, in view of the large numbers of fingerlings required to meet the quantified goals, it would be an advantage to carry out all aquaculture activities in one place to reduce risks of transporting fingerlings over