Topic Area

HUMAN NUTRITION AND HUMAN HEALTH IMPACTS OF AQUACULTURE

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BETTER MANAGEMENT PRACTICES FOR *MOLA*-PRAWN-CARP GHER FARMING INTEGRATED WITH POND DYKE CROPPING FOR INCREASED HOUSEHOLD NUTRITION AND EARNINGS OF RURAL FARMERS IN SOUTHWEST BANGLADESH

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Human Nutrition and Human Health Impacts of Aquaculture/Experiment/16HHI01NC

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Objectives

1. Evaluate the effects of different fertilizers on production of prawn, *Mola* and carps in gher/pond polyculture systems.
2. To assess the comparative efficiency of prawn - gher/pond muds, mulch, and inorganic fertilizer on production of summer and winter vegetables in integrated pond dyke systems.

Significance

Wide use of integrated farming practices, including but not restricted to the production of multiple finfish, holds significant promise for increasing dietary nutrition, productivity, and profitability of farming households in rural Bangladesh (Lightfoot et al., 1990). In Bangladesh, rice and fish comprise the main diet of low-income families, particularly during the production season for these crops (Roos et al., 2007). Although integration of freshwater prawn (*Macrobrachium rosenbergii*) farming in seasonal rice/paddy fields (*ghers*) has been successfully implemented and serves as a significant source of income to coastal families, farmers typically sell the prawns produced to fetch higher prices in overseas markets, meanwhile family members (particularly women and children) remain malnourished from lack of complete protein, vitamins, and other minerals in their diet. The present investigation proposes to address this problem by promoting the use of the *Mola* (*Amblypharyngodon mola*) fish and seasonal vegetables in integrated aquaculture-agricultural systems and by evaluating the impact of different fertilizers on the production of these nutrient-rich foods as well as prawn and carps.

Child malnutrition continues to be a major public health problem in rural Bangladesh. Up to 38% of all pre-school children have vitamin A deficiency leading to night blindness and up to 55% exhibit signs of iron-deficient anemia (Micronutrient Initiative/UNICEF, 2004; West, 2002). These effects may be alleviated, in part, through consumption of small indigenous fishes, such as *Mola*, which have significantly higher concentration of vitamin A (~1900 IU, Thilsted et al., 1997) and micronutrient content than other commonly consumed fishes (e.g., carp). The *Mola*, a small fish with soft bones, is particularly favored in the diets of many people; however, consumption in the Southwest region is limited to those captured in local rice fields, rivers, and canals. Early experiments suggest that *Mola* can be successfully cultivated in the presence of other finfish cultivars (e.g., carp; Alim et al., 2004; Wahab et al., 2003). These fish are self-recruiting species, existing naturally in perennial ponds and other freshwater sources. Once stocked, *Mola* can reproduce within the ghers or in drainage ponds and can be continuously harvested over the production cycle of carp or prawn allowing for home consumption. *Mola* feed primarily on phytoplankton and detritus, therefore no feed input is necessary. Additionally, their bacteria-enriched waste can be utilized to enhance prawn production. Similarly, carps also feed on natural pond productivity and hence can be grown without supplemental feeds. Moreover, combining species of different trophic levels can maximize nutrient utilization and decrease the potential for harmful phytoplankton blooms and poor water quality that leads to mortalities (Halver, 1984; Wahab et al., 2008).

In our previous Innovation Lab research, we found that *Mola* and Rohu carp (*Labeo rohita*) could be successfully incorporated into gher-pond freshwater prawn culture without effecting prawn yield. We actually found that prawn production was somewhat enhanced by presence of *Mola* and Rohu in polyculture. More importantly production of *Mola* and Rohu increased the consumption of these nutritional foods and provided additional income from sale at local markets by households who undertook the polyculture farming practice. The study suggested stocking two brood of *Mola*/m^2 in prawn-carp gher-farming systems was best for increasing production of the fish without affecting their growth or that of other fishes. Molasses (30kg) and yeast (400g/ha) was used to fertilize ponds and our observations suggest it may increase production of protein enriched biofloc on the pond bottom and better buffer changes in pH that may occur with other organic or even inorganic fertilizers (personal observations, D'Abramo et al., 2009; New et al., 2010). Farmers are interested in understanding if this would be the best method for increasing prawn and fish production compared with inorganic fertilizers, which are commonly used for enhancing plankton for fish production (Javed et al., 1993; Qin et al., 1995; Jasmine et al., 2011; for review see Egna and Boyd, 1997). Therefore, this experiment will evaluate which method of fertilization; yeast/molasses, inorganic fertilizer, or the combination of the two would best promote production of prawn, carp and *Mola* and yield the greatest return on investment.

The advantage of integration of aquaculture with agriculture (Aquatic-Agriculture System -AAS) is that the nutrient rich pond muds and water derived from fish culture systems can be used for growing vegetables on pond dykes. It is an increasing trend for farmers to use inorganic fertilizer in Bangladesh and the country faces a large fertilizer deficit. Consequently, the share of imported urea has increased from 30% in 2005 – 2006 to 69% in 2010 – 2011 and the country is almost completely dependent on imports of triple super phosphate (TSP) and muriate of potash (MP) (Ahmed, 2011). By 2050, the country's inorganic fertilizer requirements will be higher and international fertilizer markets are becoming increasingly more volatile (Basak et al., 2015). Hence, use of pond muds may reduce the costs of crop production and can also improve the pond water quality by reducing the possibility of eutrophication. Pond muds from carp and tilapia production have proved to be potential fertilizer for the cultivation of seasonal vegetables in Northern Bangladesh (Wahab et al., 2001), but this had yet to be applied to the Southern regions of Bangladesh where prawns are grown on over 50,000 hectares and where seasonal water bodies (2.83 million hectares; flooded for 4-6 months) remain underutilized in Bangladesh (Kunda et al., 2008; DOF, 2012). Our recent Phase I project shows that pond mud yields higher production of two seasonal vegetables (gourd and spinach) over dyke soil alone. The better utilization of pond muds with mulching material like black polythene has the potential to further increase vegetable production and its benefit will be analyzed and compared with that of inorganic fertilizer in the proposed studies.

Among household members, women and children often suffer most from a lack of nutritious foods. One key element of this investigation, therefore will involve training of women and girls on nutrition and better management practices for producing foods. Their greatest contributions to farming are feeding and maintaining fish and growing vegetables (Belton et al., 2011; Apu, 2014). We will train women on how to conduct the studies, and provide them with best practices for improving production of fishes and crops, namely *Mola* and vegetables, that can improve household consumption of nutritious foods and provide additional income.

Quantified Anticipated Benefits

1. We will determine whether organic (yeast + molasses), inorganic, or a combination of the fertilizers provide better production yields and economic returns for farming *Mola*-prawn-carp in gher/pond polyculture systems.
2. Proper selection and more efficient approaches to vegetable production using pond muds, mulch or fertilizer will be established.
3. Better management practices for cultivating nutrient-rich *Mola* and vegetables for family consumption will increase the dietary nutrition available for low-income farming households, especially for women and children.
4. Forty to sixty women and girls will receive direct, on-site instruction on nutritional benefits of integrated farming designs and on best-management practices for production of nutrient rich fish and vegetables for consumption.

Research Design and Activity Plan

Location

This investigation consists of a series of two studies and training activities, which will be carried out on participating farms located in villages of Rangpur Union, Dumuria Upazila, Khulna District, Bangladesh and the surrounding region. Water quality, and both pond dyke soil and the pond mud of the proposed experiment will be analyzed at Khulna University and BAU, Mymensingh, Bangladesh, respectively.

Methods

Experiment 1. Evaluate the effects different fertilizers on production of prawn- Mola- carps in gher-pond polyculture farming systems.

Null Hypothesis 1: There is no difference in fish/shellfish yield or benefits of applying organic and inorganic or their combination on Mola-carp-prawn gher-pond polyculture.

Most of the farming households practicing traditional prawn culture in gher systems minimize the use supplementary feeds for prawn/fish culture because of high investment costs (50-60% of the total cost), hence, application of the fertilizers is a critical component to increasing production of prawns and fishes. Here we will assess 3 different fertilizer applications in prawn-*Mola*-carp polyculture on the farms of 20 households such that each treatment group will be replicated 5 times. One treatment will apply molasses (30 kg/ha) and powdered yeast (0.4 kg/ha) that was used in our previous work demonstrating *Mola* and carps could be successfully integrated into prawn culture. A second will incorporate inorganic fertilizers using levels recommend for extensive or semi-intensive culture of fishes (4N:1P; 28 kg N/ha using Urea; 7 kg P/ha using triple super phosphate; see Egna and Boyd, 1997), and a third will incorporate both types of fertilizers at 50% of the application amount used in the other groups. A fourth treatment will have no fertilizer applied as a reference group. The design is as follows:

Parameter	T1	T2	T3	T4
Prawn (*M. rosenbergii*)	$2/m^2$	$2/m^2$	$2/m^2$	$2/m^2$
Rohu *(L. rohita*)	$0.1/ m^2$	$0.1/m^2$	$0.1/m^2$	$0.1/m^2$
Mola (*A. mola*)	$2/m^2$	$2/m^2$	$2/m^2$	$2/m^2$
Fertilization application	0	Molasses + Yeast	Inorganic Fertilizer	50 % of T2 + 50% of T3
Replication	5	5	5	5

Nursery pond preparation for prawn will be done according to standard practices followed by farmers. Prior to gher drying, bottom mud will be excavated and ponds will be limed and filled. Juvenile prawn (*Macrobrachium rosenbergii*) will be stocked at a density of $2/m^2$, Rohu at $0.1/m^2$, and brood *Mola* at $2/m^2$. Fertilizers will be applied to ponds (average of ~50 decimal or 2000 m^2; 1.0-1.5 m depth) fortnightly. Prawn will be fed with a commercial feed using a feeding tray at 10% body weight (bw)/day for 10 days, 7% bw/day for 10 days, 5% bw/day for 10 days and 4-2% bw/day for rest of the culture period. Feeding frequency will be twice daily in the early morning and evening. Fish and prawn will be grown out for six months. After 60 - 70 days *Mola* begin to self-recruit and hence can be harvested for home consumption. Partial harvesting of larger *Mola* will be encouraged beginning at day 75 and periodically throughout the remainder of the experiment. Number and weights of partially harvested *Mola* will be recorded.

Water quality parameters, including temperature, secchi disc (transparency), DO, and pH will be measured on the spot weekly, and total alkalinity, nitrate-nitrogen (NO_3-N), nitrite nitrogen (NO_2-N), ammonia-nitrogen (NH_3-N), and phosphate-p (PO_4-P) will be measured fortnightly.

During the six-month grow-out period, performance data (weights/lengths) for all species will be collected by monthly sub-sampling, followed by total yield assessment at the end of experiment. Significant differences ($p < 0.05$) in water quality, total production yields (biomass), and prawn, *Mola* and carp production yields/growth will be determined by analysis of variance (ANOVA) using SPSS.

Experiment 2. To assess the comparative efficiency of prawn- gher/pond muds, mulch, and inorganic fertilizer on production of summer and winter vegetables in integrated pond dyke systems.
Null Hypothesis 2: There is no difference in yield or benefits of summer or winter vegetable production between the different pond muds from the fish polyculture treatments or different soil treatments.

Two activities will be conducted under this trial, one on summer and the other on winter vegetable cultivation on pond dykes. Pond muds derived from the different polyculture gher pond systems in Experiment 1 (T2-T4) will be evaluated for their effects on production of fruit vegetable crops over both winter (Okra or gourd) and summer (tomato) seasons. This will allow a determination on whether vegetable growth might be enhanced by a particular pond fertilization treatment (organic versus inorganic fertilizers or both combined) using both summer and winter vegetables. The effects of pond mud will be compared in the absence and presence of mulch (black polythene) and with mulch and inorganic fertilizer. Black polythene is generally effective in preserving soil moisture and it will help to reduce the cost of irrigation, labor cost of weeding as well as to reduce the effect of soil salinity in experimental plots and can be incorporated at relatively little cost. The third group will have additional application of inorganic fertilizer at half the recommended level used for crop production in soils whether on pond dykes or not (FRG, 2012). Use of inorganic fertilizer represents a growing practice of horticulture on Bangladesh homesteads but the treatment can represent a significant cost, so here we will evaluate if its addition provides any further benefits relative to its extra cost. The experimental design is as follows:

Vegetable	Pond Treatment Experiment **1**	Soil Treatment 1	Soil Treatment 2	Soil Treatment 3
Summer Fruit: Okra or gourd	Pond T1	Pond mud	Pond mud + mulch	Pond Mud + mulch + inorganic fertilizer
	Pond T2	Pond mud	Pond mud + mulch	Pond Mud + mulch + inorganic fertilizer
	Pond T3	Pond mud	Pond mud + mulch	Pond Mud + mulch + inorganic fertilizer
Winter Fruit: Tomato	Pond T1	Pond mud	Pond mud + mulch	Pond Mud + mulch + inorganic fertilizer
	Pond T2	Pond mud	Pond mud + mulch	Pond Mud + mulch + inorganic fertilizer
	Pond T3	Pond mud	Pond mud + mulch	Pond Mud + mulch + inorganic fertilizer
Replicate Plots	3	3	3	3

Three replications will be done for each of the summer and winter activities, where total number of plots will be 3 replicates x 3 pond treatments x 3 soil treatments = 18. Plot size of the dyke will be 2 m x 2 m. The inorganic fertilizer will be applied according to the fertilizer recommendation guide (FRG, 2012).

Plant growth (plant height, leaf number, branching number) and flowering time, fruit yield parameters (tomato, gourd or okra), yield per plot and converted to per hectare and some nutrient quality parameters of vegetables will be collected in each season. Vegetables consumed by household will be recorded. A marginal cost-benefit analysis evaluating return on investment among the three soil treatments will be done based on total production yield, input costs and value of crops. Differences among variables measured will be analyzed by 3-way ANOVA in SSPS.

A major element of this investigation is to empower women and girls on best practices for producing crops, namely fishes and vegetables, for household consumption or sale that require relatively little additional cash investment and that can enhance nutrition and income. It is well established that a key role for women and girls in household farming is to maintain fish or seafood crops and establish homestead gardens (Belton et al., 2011). Gardens on pond dykes are less susceptible to flooding and muds provide a good source of nutrients for vegetable production at minimal costs. Thus, the technologies developed from our previous project and here for *Mola* and dyke cropping our excellent opportunities to work with women to increase household consumption of nutritious foods. We will work directly with women and girls in participating households in undertaking the studies. They will be trained by the PIs on all aspects of the experiment: the purpose and goals of the work, methodology, tracking inputs, cost accounting, consumption, marketing opportunities etc. They will be provided record keeping books to monitor feeding and fertilization inputs, their costs and sales, and consumption. This will be complemented by training sessions on nutrition, *e.g.* caloric intake, importance of balanced diets, and value of *Mola* and vegetables to the diet. Their food consumption will be monitored through a simple survey prior to and after the studies and relative to that of reference non-participating households (60 women and girl members total). Collectively the work will provide critical training on nutrition and best management practices for producing household foods in integrated AAS that can enhance the nutrition of women and children including an estimated 60 individuals from participating and non-participating households.

<u>Trainings and Deliverables</u>

1. The findings from these experiments will be reported through the Technical Reports of the AquaFish Innovation Lab (FIR).
2. The results will also be reported in workshops (Investigation 5) and/or relevant conference presentations.

3. Approximately 60 women and girls will receive direct training on nutrition and best management practices for producing fish and vegetables for home consumption that can benefits to their wellbeing.
4. The management practices for improved gher-prawn/*Mola*/carp or gher-pond/dyke cropping found in the proposed studies will be disseminated to the wider farming community through workshops outlined in Investigation 5.

Schedule

June 2016 to March 2017: Experiment 1:
September 2016 to September 2017: Experiment 2
June 2016 to December 2017: Training
January 2018 to February 2018: Final Investigation Report