TOPIC AREA:
PRODUCTION SYSTEM DESIGN & BEST MANAGEMENT ALTERNATIVES

❖❖

EXPERIMENTAL POND UNIT ASSESSMENT IN SOUTHERN NEPAL

Production System Design & Best Management Alternatives/Activity/09BMA14UM

FINAL INVESTIGATION REPORT

Madhav K. Shrestha
Institute of Agriculture and Animal Science
Tribhuvan University
Rampur, Chitwan, Nepal

James S. Diana
School of Natural Resources and Environment
University of Michigan
Ann Arbor, Michigan, USA

ABSTRACT

This pond characterization experiment had goals to evaluate ponds in Nepal for their physical, chemical, and biological characteristics during a grow-out; and to evaluate production characteristics of Nile tilapia (*Oreochromis niloticus*) in these ponds. Twelve earthen ponds were used with treatments including 4 control ponds receiving fertilization alone, 4 fully fed ponds with feed applied at 3% bw, and 4 combined ponds with both feed at 1.5% and fertilizer applied. All ponds were stocked a week after fertilization with sex-reversed Nile tilapia at 2 fish/m^2. Fertilizer was applied each week at 4 kg N and 1 kg P per hectare for fertilization treatments. Locally available feeds were used to feed twice daily in the morning and afternoon. Fish were stocked on 9 February 2013 and the experiment is ongoing. Fish growth in fertilized with half feeding ponds gave highest growth, followed by full feeding then fertilizer. Treatments that included fertilizer had higher pH, higher dissolved oxygen, lower Secchi disk, higher chlorophyll-a, higher total Kjeldahl nitrogen, higher total phosphorus, lower alkalinity, higher ammonium, higher soluble reactive phosphorus, and higher nitrite-N compared to only fed ponds. Fertilization with feeding produced the best growth conditions and best water quality consistently.

INTRODUCTION

A number of physical, chemical, and biological characteristics are important for the completion of quality experiments in ponds. The most obvious ones in physical characteristics include pond morphometry, pond depth, evaporation rate, seepage rate, and water temperature. The chemistry of pond water has dramatic effects on the pond ecosystem, as well as the organisms being cultured. It also is an indicator of management methods and their success. While a very large number of variables can be monitored, those most commonly related to production in a pond include dissolved oxygen, phosphorus, various forms of nitrogen, pH, alkalinity, and dissolved and suspended solids. Besides the biomass and production of the target organisms in a pond, other biological characteristics are important. Generally, the interest would be in the amount of phytoplankton production in ponds, either by estimating the rate of primary production or the phytoplankton standing crop. While bacteria and other microbes may be very important in pond culture, they are not regularly measured microbial processes in pond waters.

This pond characterization experiment has two goals: the first is to evaluate ponds in Nepal for their physical, chemical, and biological characteristics during a grow-out; and the second is to evaluate production characteristics of Nile tilapia (*Oreochromis niloticus*) in these ponds. The methods for pond characterization are well described in a number of publications, including Egna et al. (1987) and the *Standard Methods for the Examination of Water and Wastewater* (multiple versions of this are available; the most recent is APHA et al., 2012). The purpose of this experimental pond assessment is to describe a series of measurements at each experimental site for the AquaFish CRSP and to outline some of the reasons for these measurements.

Objectives:

1. Evaluate ponds in Southern Nepal for their physical, chemical, and biological characteristics during a grow-out.
2. Compare growth, production, and economics of production of tilapia in different treatments.

MATERIALS AND METHODS

Twelve earthen ponds of Institute of Agriculture and Animal Science (IAAS), Chitwan, Nepal, were used for this experiment. Treatment design consisted of 4 control ponds receiving fertilization alone, 4 fully fed ponds with feed applied at 3% bw, and 4 combined ponds with both feed and fertilizer applied, feeding at 1.5% bw. All ponds were drained, cleaned, and limed with 5 kg/ pond. After a week, ponds were filled and fertilized with urea and diammonium phosphate (DAP). All ponds were stocked with sex-reversed Nile tilapia at 2 fish/m^2 a week after fertilization. Fertilizer was also applied each week at 4 kg N and 1 kg P per hectare for fertilization treatments. Locally available feeds were used to feed twice daily in the morning and afternoon. Fish were stocked on 9 February 2013 and the experiment is ongoing. Ponds will be managed for 120 days and then harvested.

The main water quality variables under monitoring in experimental ponds and frequency of those measurements and their metrics are listed in Table 1. Methods for the measurement of each parameter are based on Egna et al. (1987) and APHA et al. (2012).

Table 1. *Physical, chemical, and biological characteristics measured during pond characterization.*

Variable	Daily Frequency	How often	Type of sample
Pond morphometry	-	Once	
Pond depth (cm)	Once	Daily	One
Evaporation (mm)	Once	3 times	One
Seepage (cm)	Once	3 times	One
Temperature (^oC)	Diel measures	3 times	3 depths
Dissolved oxygen (mg/L)	Diel measures	3 times	3 depths
pH	Diel	3 times	3 depths
Total Alkalinity (mg/L)	Diel	3 times	3 depths
Water depth (cm)	Once	Weekly	Whole pond
Temperature (^oC)	Once	Weekly	3 depths
Dissolved oxygen (mg/L)	Once	Weekly at dawn	Composite sample
pH	Once	Weekly	Composite sample
Total Alkalinity (mg/L)	Once	Weekly	Composite sample
Total phosphorus (mg/L)	Once	Weekly	Composite sample
Total Kjeldahl Nitrogen (mg/L)	once	Weekly	Composite sample
Total Ammonium-N	Once	Weekly	Composite sample
NO_3/NO_2 -N	Once	Weekly	Composite sample
Secchi disk depth (cm)	Once	Weekly	Whole pond
Chlorophyll-a (mg/m^3)	Once	Weekly	Composite sample

Data, including yield, growth rate, and survival, were estimated for fish from all treatments, and comparisons were made using ANOVA. Changes in water quality between treatments and over time were tested using ANOVA. In addition to chemical concentrations, diel measurements were used to determine stratification in the ponds and primary productions rates. These were also compared among treatments using ANOVA.

RESULTS

Fish Growth

Fish growth during 42 days in 3 different treatments are presented in Table 2. The first sampling indicated that fertilizer with half feeding (1.5%bw, T3) gave highest growth, followed by full feeding (3%bw, T2), and fertilizer (T1).

Table 2. *Growth of Nile tilapia in different treatments.*

Treatment	Mean stocking wt. (g)	Mean wt. at 42 days (g)
Fertilizer only (T1)	6.1 ± 0.06	31.2 ± 5.7
Full feeding (T2)	6.2 ± 0.06	38.7 ± 5.2
Fertilizer + half feeding (T3)	6.3 ± 0.04	45.5 ± 3.5

Water Quality

Mean physical, chemical, and biological parameters measured weekly in three different treatments are shown in Table 3. The value presented is the mean over four weeks. Fertilized ponds and ponds fertilized with half feeding had higher pH compared to full feeding ponds. Similarly, higher dissolved oxygen, lower Secchi disk, lower alkalinity, higher ammonium, higher soluble reactive phosphorus, and higher nitrite-N were observed in fertilized ponds followed by fertilized and fed ponds and compared to full feeding ponds. Total Kjeldahl nitrogen increased in full fed and fertilized with feed ponds compared to only fertilized ponds. Total phosphorus was higher in fertilized and fertilized and fed ponds compared to full fed ponds. Chlorophyll-a increased in fertilized and fed ponds compared to the fertilizer alone and only fed treatments. Evaporation measured during this period was 0.3 cm/day.

Table 3. *Weekly measured physical, chemical, and biological parameters of experimental pond water (Mean of 4 weeks ± SE).*

Parameter	**Fertilized pond (T1)**	**Full feeding pond (T2)**	**Fertilized + half feeding pond (T3)**
Water depth (cm)	79 ± 3.4	78 ± 3.2	82 ± 2.7
Water temperature (^oC)	20.8 ± 0.1	21.4 ± 0.1	21.0 ± 0.1
pH	8.4	7.8	8.2
Dissolved oxygen (mg/L)	9.2 ± 0.8	6.0 ± 0.8	7.6 ± 1.8
Secchi disk (cm)	30.3 ± 4.0	48.1 ± 2.8	37.5± 3.4
Total Alkalinity (mg/L $CaCO_3$)	110 ± 4	124 ± 15	117 ± 9
Total Ammonium-N (mg/L)	0.68 ± 0.03	0.40 ± 0.02	0.58 ± 0.02
Soluble reactive phosphorus (mg/L)	0.33 ± 0.04	0.15± 0.02	0.28 ± 0.02
Nitrite-N (mg/L)	0.04 ± 0.01	0.00 ± 0.00	0.03 ± 0.01
Total Kjeldahl nitrogen (mg/L)	2.66 ± 0.07	2.92 ± 0.12	3.01 ± 0.33
Total phosphorus (mg/L)	1.32 ± 0.20	0.94 ± 0.29	1.12 ± 0.19
Chlorophyll-a (mg/L)	95.6 ± 11.5	26.1 ± 4.8	119.7 ± 33.0

Mean diel water temperature and dissolved oxygen pattern are presented in Tables 4 and 5. These data indicate typical patterns of stratification in the afternoon and mixing in early morning.

Table 4. *Mean diel water temperature (^oC) measured in 3 depths.*

Treatment	Depth	6 am	10 am	2 pm	6 pm	10 pm	2 am	6 am
T1	15 cm	19.6	24.9	28.9	26.9	24.0	22.4	20.6
	30 cm	19.7	24.5	27.9	26.2	24.0	22.3	20.7
	60 cm	19.7	24.3	26.0	23.9	24.0	22.4	20.7
T2	15 cm	20.4	25.3	29.4	26.9	24.6	23.3	21.5
	30 cm	20.4	25.2	27.7	26.8	24.9	23.6	21.6
	60 cm	20.4	25.0	26.0	25.6	24.8	23.3	21.6
T3	15 cm	19.7	25.5	29.3	26.9	23.8	22.3	21.2
	30 cm	20.0	25.0	27.3	26.1	24.0	22.5	21.3
	60 cm	19.9	24.6	24.5	23.9	22.5	22.0	21.3

Table 5. *Mean diel water dissolved oxygen (mg/L) measured in 3 depths.*

Treatment	Depth	6 pm	10 pm	2 am	6 am	10 am	2 pm	6 pm
T1	15 cm	22.7	9.1	10.9	9.6	11.3	17.4	19.6
	30 cm	7.1	8.9	3.1	8.4	9.0	8.6	11.7
	60 cm	6.5	9.3	2.8	6.7	6.0	5.3	9.3
T2	15 cm	13.5	8.7	7.9	7.6	8.9	13.3	12.5
	30 cm	11.8	9.0	7.6	7.6	7.7	10.5	11.6
	60 cm	8.2	7.3	5.3	7.1	7.7	10.3	8.8
T3	15 cm	21.4	12.9	8.8	9.3	11.2	12.6	16.0
	30 cm	10.4	7.0	7.6	8.5	6.5	11.7	15.4
	60 cm	3.2	5.0	3.5	8.4	3.6	7.2	9.0

DISCUSSION

The experimental ponds were constructed in lowland with high ground water level. Water level increases during the rainy season and decreases in dry season. Results presented are preliminary of four weeks. Stocked fish were sampled only once. Fish growth during this period was highest in fertilized and fed ponds, followed by fed ponds, then only fertilized ponds. Water quality was best in fertilized ponds, followed by fertilized and fed ponds, and then fed ponds. At this point, it appears that ponds with fertilizer and feed had the highest growth and intermediate water quality compared to the other treatments, and most likely the highest economic returns because the inputs were reduced considerably while growth and yield were probably highest.

As this experiment is ongoing, analysis of the data is incomplete. After the completion of the experiment, statistical analysis will be performed.

REFERENCES

American Public Health Association (APHA), the American Water Works Association (AWWA) and the Water Environment Federation (WEF). 2012. Standard Methods for the Examination of Water and Wastewater, 22nd edition. APHA, Washington, D.C.

Egna, H.S., N. Brown, and M. Leslie (editors). 1987. Pond Dynamics/Aquaculture Collaborative Research Data Reports, Volume 1, General Reference: Site Descriptions, Materials and Methods for the Global Experiment. PD/A CRSP, Oregon State University, Corvallis, Oregon, 84 pp.