RELATIVE CONTRIBUTION OF SUPPLEMENTAL FEED AND INORGANIC FERTILIZERS IN SEMI-INTENSIVE TILAPIA PRODUCTION

Eighth Work Plan, Kenya Research 3 (8KR3)
Final Report

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ABSTRACT

A 20-week experiment was conducted at Sagana Fish Farm, Kenya, to characterize the productive capacity of ponds at this new CRSP research site and to determine least-cost combinations of rice bran and inorganic fertilizer. Twelve 800-m^2 ponds were stocked with juvenile (32 g each) *Oreochromis niloticus* at 20,000 ha^{-1} and *Clarias gariepinus* fingerlings (average weight 4.6 g) at 2,400 ha^{-1}. Ponds contained about half sex-reversed and half mixed-sex tilapia, with an estimated ratio of approximately 75% males to 25% females at stocking. Four treatments were applied in triplicate as follows: 1) Urea and DAP to provide 16 kg N ha^{-1} wk^{-1} and 4 kg P ha^{-1} wk^{-1}; 2) Urea and DAP applied to give 8 kg N and 2 kg P ha^{-1} wk^{-1}, plus rice bran fed at 60 kg ha^{-1} d^{-1}; 3) Rice bran fed at 120 kg ha^{-1} d^{-1}; and 4) Rice bran as in Treatment 3 and fertilizer as in Treatment 2. Net fish yield averaged 1,127, 1,582, 1,607, and 2,098 kg ha^{-1} for Treatments 1 through 4 respectively. Fish in ponds receiving rice bran (Treatments 2, 3, and 4) were still growing rapidly at harvest time, but the growth rate of fish in Treatment 1 was beginning to decrease near the end of the experiment. Treatment 1 was the most cost-effective, but Treatments 1, 2, and 4 all resulted in fairly similar net profits. Input costs for Treatments 1 and 2 will be of interest to fish farmers, although it is possible that fish raised using only fertilizer at the rates used in Treatment 1 may never reach market size at this stocking density. Fish had reduced growth towards the end of the culture period and resulting low final average weights, which were less than 100 g. If rice bran had cost 3.5 KSh or less per kilogram, profit for Treatment 3 would have surpassed that of Treatment 1. If rice bran had cost less than 5.8 KSh per kg, Treatment 2 would have been more profitable than Treatment 1.

INTRODUCTION

Aquaculture development in Kenya has been hampered by a lack of nutritionally complete feeds. The application of chemical fertilizers can enhance natural food production and indirectly provide protein to complement energy-rich rice bran (> 16 kcal digestible energy (DE) g^{-1} protein; National Research Council, 1993). A 20-week experiment was conducted at Sagana Fish Farm, Kenya, to characterize the productive capacity of ponds at this new CRSP research site and to determine least-cost combinations of rice bran and inorganic fertilizer. In addition to the work reported here, samples of fish tissue, fish feed, soil, and plankton from the experiment were provided to researchers at the University of Arkansas at Pine Bluff for a companion study entitled "Nutritional Contribution of Natural and Supplemental Foods for Nile Tilapia: Stable Carbon Isotope Analysis." (See pp. 29–31 of this report)

METHODS AND MATERIALS

This experiment was conducted in twelve newly renovated CRSP research ponds at Sagana Fish Farm, Kenya, beginning on 31 October 1997 and ending on 25 March 1998 (144 days). Lime was applied to all ponds at a rate of 5 t ha^{-1} prior to the experiment. The newest ponds received the lime treatment just prior to filling. Twelve 800-m^2 ponds were stocked with juvenile (32 g each) *Oreochromis niloticus* at 20,000 ha^{-1} and *Clarias gariepinus* fingerlings (average weight 4.6 g) at 2,400 ha^{-1}. Ponds contained half sex-reversed and half mixed-sex fish, with an estimated ratio of approximately 75% males to 25% females at stocking.

Four treatments were applied in triplicate as follows:

1) Urea and diammonium phosphate (DAP) to provide 16 kg N ha^{-1} wk^{-1} and 4 kg P ha^{-1} wk^{-1};
2) Urea and DAP to provide 8 kg N and 2 kg P ha^{-1} wk^{-1}, plus rice bran fed at 60 kg ha^{-1} d^{-1};

3) Rice bran fed at 120 kg ha^{-1} d^{-1}; and
4) Rice bran as in Treatment 3 and fertilizer as in Treatment 2.

Due to the relative newness of some ponds and a suspected high P adsorption capacity of newly exposed pond bottoms, the ponds were blocked according to the following criteria:

Block 1: New ponds, never before filled and receiving lime just prior to filling.
Block 2: Ponds that had been limed and were in production for less than a month; these were drained and refilled prior to this experiment.
Block 3: Ponds that had been limed, filled, and in production (receiving feeds and fertilizers) for more than a month before the start of this experiment.

Ponds were assigned randomly in a split block design, with one replicate of each treatment in each block.

Dissolved oxygen concentration, temperature, and pH were measured weekly in the morning and afternoon. Total alkalinity, chlorophyll *a*, Secchi disk visibility, and total ammonia nitrogen concentration were measured every two weeks. Total nitrogen, mineral nitrogen, total phosphorus, and soluble reactive phosphorus were analyzed monthly. Samples for water chemistry were taken on Mondays, fertilizing was done on Tuesdays, and dissolved oxygen and temperature readings were done on Thursdays.

Ponds were sampled monthly for fish growth and drained completely after 20 weeks. Tilapia were separated by sex, counted, and weighed at draining. Tilapia reproduction was weighed and subsamples were counted. *Clarias* were counted and weighed. Two fish of each species were taken from each pond for proximate analysis at the beginning, in the middle (day 65), and at the end of the experiment. The whole fish, including viscera, was used for proximate analysis.

Rice bran was sampled as each lot arrived and combined into three batches. Each of the batches was analyzed for protein, fiber, lipids, ash, and phosphorus. Proximate analyses of fish and feedstuff was done using the Kjeldahl method for protein, Soxhlet extraction for lipids, and muffle furnace for ash and phosphorus.

RESULTS AND DISCUSSION

Although the Treatments 1, 2, and 3 were intended to be iso-nitrogenous, the rice bran contained less protein than expected. Total nitrogen and phosphorus inputs are summarized in Table 1. The first few lots of rice bran (all in Batch 1) contained excessively high quantities of fiber, and large amounts of husks were observed in these lots. Proximate analyses of the batches are given in Table 2.

Some of the ponds in Blocks 1 and 2 still had residual lime on their bottoms after draining; however, there were no significant differences in fish production between blocks. Block assignments were therefore not taken into account in the statistical analyses of other results. At harvest, the average weights of tilapia were 89, 106, 106, and 131 g, and *Clarias* weights were 110, 217, 236, and 296 g for Treatments 1, 2, 3, and 4, respectively (Table 3). Male tilapia and *Clarias* showed significantly different average weights among treatments but differences among female tilapia were significant only for Treatments 1 and 4. Survival ranged from 67 to 88%; there were no significant differences by treatment. Males made up 65 to 71% of total tilapia numbers at draining.

Fish began spawning during the first month of the experiment. However, due to the presence of *Clarias*, few fingerlings survived to harvest.

Net fish yield averaged 1,127, 1,582, 1,607, and 2,098 kg ha^{-1} for Treatments 1, 2, 3, and 4, respectively (Table 3). Fish in Treatments 2, 3, and 4 were still growing rapidly at harvest time, but the growth rate of fish in Treatment 1 was beginning to decline near the end of the experiment (Figures 1 and 2).

Table 1. Weekly nitrogen and phosphorus inputs as chemical fertilizer or rice bran (feed) in 800-m^2 ponds for 20 weeks.

Treatment	Nitrogen Input (kg ha^{-1} wk^{-1})			Phosphorus Input (kg ha^{-1} wk^{-1})		
	As Fertilizer	*As Feed*	*Total N*	*As Fertilizer*	*As Feed*	*Total P*
1	16	0	16.0	4	0	4.00
2	8	6.6	14.6	2	3.51	5.51
3	0	13.2	13.2	0	7.02	7.02
4	8	13.2	21.2	2	7.02	9.02

Table 2. Proximate analyses of rice bran batches (RB1–RB3) at the beginning, middle, and end of the study period (mean values presented unless noted otherwise).

Sample	Date	Water (%)	Protein (%)	Fiber (%)	Fat (%)	Ash (%)	Carbohydrate (NFE) (%)
RB1	31-Oct-97	10.35	8.60	19.65	9.68	17.77	33.95
RB2	03-Jan-98	10.23	10.15	16.93	3.38	7.00	52.32
RB3	23-Mar-98	19.38	10.73	14.30	6.12	6.47	43.00
RB Mean		13.32	9.83	16.96	6.39	10.41	43.09

Table 3. Final average weights of original tilapia stock, number and total weight of uncontrolled reproduction, average weight of *Clarias*, and net total fish yield at harvest after 20 weeks by treatment.

Treatment	Original Tilapia Stock			Uncontrolled Tilapia Reproduction		*Clarias* (g)	Net Fish Yield (kg ha^{-1})
	Average Weight (g)			*Number*	*Total Weight* (kg)		
	Males	Females	Mixed				
1	98 [a]	61 [a]	89 [a]	1,218 [a]	14.2 [a]	110 [a]	1,127 [a]
2	121 [b]	70 [ab]	106 [b]	837 [a]	12.5 [a]	217 [b]	1,582 [ab]
3	125 [b]	72 [ab]	106 [b]	1,230 [a]	15.7 [a]	236 [b]	1,607 [ab]
4	155 [c]	77 [b]	131 [c]	640 [a]	12.4 [a]	296 [c]	2,098 [b]

[a,b,c] Values in a column followed by the same letter are not significantly different at the 95% level (Least Significant Difference; LSD).

Supply waters at Sagana typically have total alkalinity (TA) levels between 10 and 20 mg l^{-1} as $CaCO_3$. TA levels in all ponds were higher than this throughout the experiment. The average TAs of ponds receiving rice bran rose to 70 mg l^{-1} or above by day 46 and remained relatively steady throughout the remainder of the experiment, whereas those of ponds receiving only chemical fertilizer descended to levels between about 35 and 55 mg l^{-1} after the first month (Figure 3).

Ponds in Treatment 1 had the highest average chlorophyll *a* concentrations (Tables 4 and 5). After December (month 2) the ponds in Treatment 3 (rice bran only) developed good algal blooms; however, prior to the second month they had little phytoplankton, and dissolved oxygen concentrations were frequently less than 1 mg l^{-1} in the morning.

Ponds that received only inorganic fertilizer (Treatment 1) had significantly more suspended silt (inorganic matter) than other ponds (TSS - VSS in Tables 4 and 5), and suspended inorganic matter was linearly and negatively correlated with bran input rate (Figure 4). Nesting activities in monosex tilapia ponds can be a source of pond levee erosion. The high clay content of the pond soils at Sagana means they would be subject to erosion from activities such as nest building by male tilapia and from wind. Additions of organic matter such as chicken litter have been reported to reduce levels of suspended silt in ponds (Boyd, 1982; Teichert-Coddington et al., 1992).

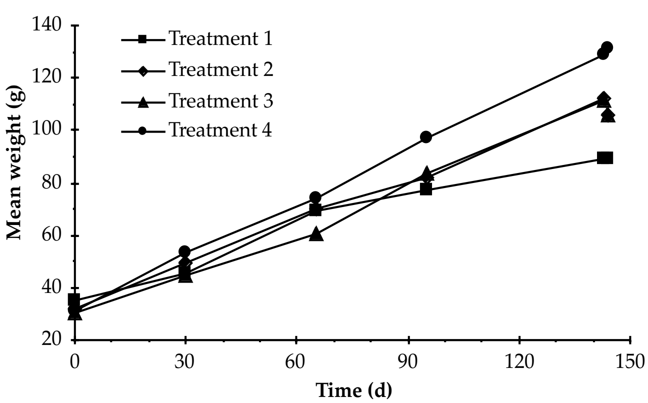

Figure 1. Tilapia growth for Treatments 1 through 4 during the 144-day experiment to evaluate the relative contributions of supplemental feed and inorganic fertilizer in semi-intensive tilapia production.

Soluble reactive phosphorus concentrations were never higher than 0.05 mg l^{-1} in any pond and were not greater than 0.03 mg l^{-1} in ponds receiving rice bran (Figure 5). Total ammonia nitrogen never surpassed 0.5 mg l^{-1} except on the final sampling date in Treatment 1 (Figure 6). Nitrate and nitrite were low throughout the experiment as well; average nitrite concentrations never surpassed 0.1 mg l^{-1} NO_2-N, and average nitrate concentrations always remained below 0.25 mg l^{-1} NO_3-N (Table 5). "Black cotton" soils, such as the ones in which the Sagana ponds are built have notoriously high phosphorus-adsorption rates. Assuming a clay content of 80% (ponds at Sagana are reported

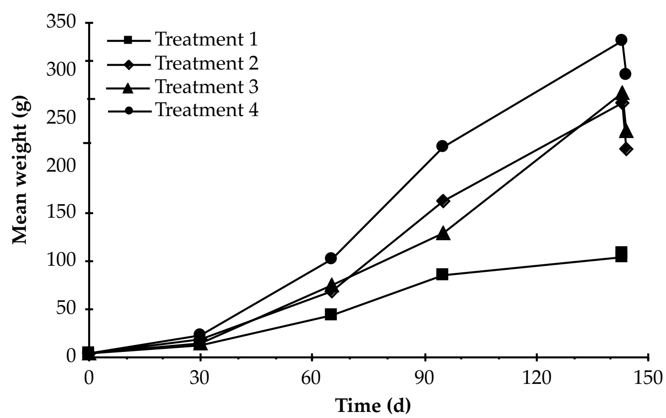

Figure 2. *Clarias* growth for Treatments 1 through 4 during the 144-day experiment to evaluate the relative contributions of supplemental feed and inorganic fertilizer in semi-intensive tilapia production.

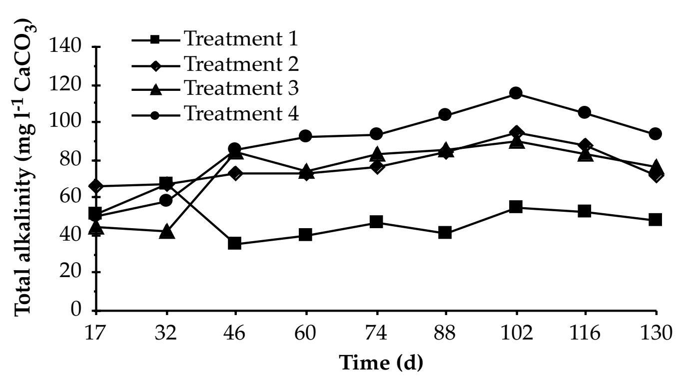

Figure 3. Average total alkalinity levels for ponds in Treatments 1 through 4 from day 17 through day 130 of the experiment.

Table 4. Treatment averages for water quality parameter observations. Each parameter was measured at least five times during the experiment. All values are in mg l^{-1} except for chlorophyll *a* (uncorrected and corrected), which is in mg m^{-3}, and total alkalinity, which is in mg l^{-1} as $CaCO_3$.

Treatment	Chl *a* [1] (uncorr)	Chl *a* [2] (corr)	TSS[3]	VSS[4]	TSS - VSS[5]	Total N	TAN	NO_2-N	NO_3-N	Total P	SRP[6]	TA[7]
1	334	205	165 [c]	49	115 [c]	4.33	0.42 [b]	0.04	0.17 [b]	0.36	0.022 [c]	48
2	184	115	132 [b]	58	74 [b]	3.50	0.20 [a]	0.02	0.06 [a]	0.32	0.010 [ab]	75
3	93	61	79 [a]	44	35 [a]	3.08	0.22 [a]	0.01	0.09 [a]	0.30	0.007 [a]	70
4	187	128	96 [a]	59	37 [a]	4.39	0.20 [a]	0.02	0.07 [a]	0.41	0.018 [bc]	84

[a,b,c] Values in a column followed by different letters are significantly different at $P < 0.05$.
[1] Chlorophyll *a* (uncorrected)
[2] Chlorophyll *a* (corrected)
[3] Total suspended solids
[4] Volatile suspended solids
[5] Total suspended solids minus volatile suspended solids—a measure of suspended inorganic matter
[6] Soluble reactive phosphate
[7] Total alkalinity

Table 5. Averages of water quality parameters, by pond, for the experiment. Each parameter was measured at least five times during the experiment. All values are in mg l^{-1} except for chlorophyll *a* (uncorrected and corrected), which is in mg m^{-3}, and total alkalinity, which is in mg l^{-1} as $CaCO_3$.

Pond	Treatment	Chl *a* [1] (uncorr)	Chl *a* [2] (corr)	TSS[3]	VSS[4]	TSS - VSS[5]	Total N	TAN	NO_2-N	NO_3-N	Total P	SRP[6]	TA[7]
D05	1	206	131	162	50	111	4.32	0.51	0.06	0.23	0.37	0.02	43
D06	1	608	348	185	57	128	5.17	0.33	0.03	0.15	0.42	0.02	40
E05	1	187	136	147	41	106	3.50	0.42	0.02	0.14	0.28	0.02	60
D07	2	140	91	123	54	70	3.90	0.24	0.03	0.07	0.31	0.01	74
E07	2	186	129	127	52	75	2.78	0.16	0.01	0.06	0.33	0.01	91
E09	2	226	123	145	67	78	3.81	0.20	0.01	0.05	0.32	0.01	61
D08	3	90	55	77	42	35	2.74	0.21	0.01	0.08	0.26	0.00	55
E03	3	109	86	65	42	23	2.73	0.23	0.01	0.11	0.34	0.01	73
E04	3	79	41	95	48	47	3.75	0.22	0.01	0.07	0.29	0.01	83
D04	4	159	111	83	55	28	4.74	0.25	0.03	0.08	0.32	0.01	67
E06	4	168	114	97	55	42	3.78	0.20	0.01	0.07	0.43	0.02	99
E08	4	234	158	108	68	41	4.52	0.16	0.01	0.05	0.47	0.03	87

[1] Chlorophyll *a* (uncorrected)
[2] Chlorophyll *a* (corrected)
[3] Total suspended solids
[4] Volatile suspended solids
[5] Total suspended solids minus volatile suspended solids—a measure of suspended inorganic matter
[6] Soluble reactive phosphate
[7] Total alkalinity

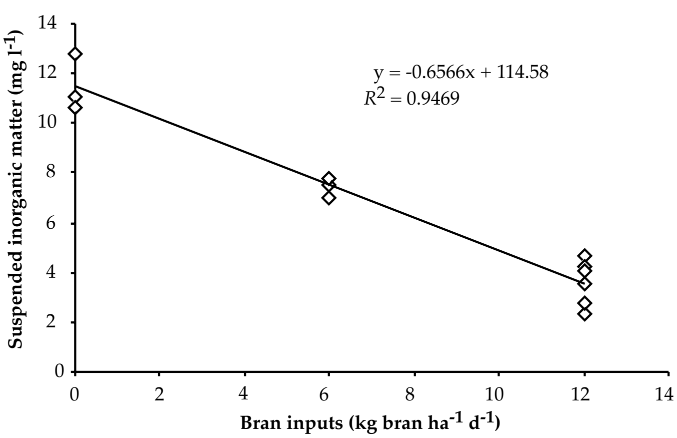

Figure 4. The relationship between bran input level (kg bran ha^{-1} d^{-1}) and suspended inorganic matter (mg l^{-1}) in the ponds.

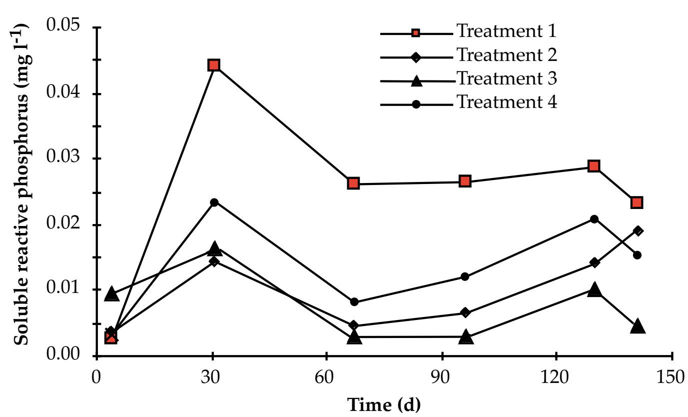

Figure 5. Average soluble reactive phosphorus concentrations for Treatments 1 through 4 during the experiment.

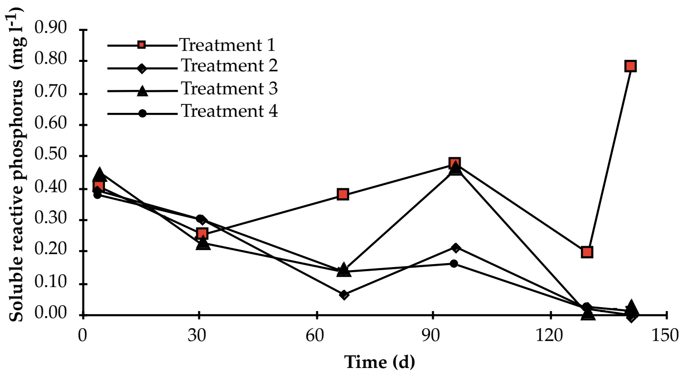

Figure 6. Average total ammonia nitrogen (TAN) concentrations for Treatments 1 through 4 during the experiment.

to have as much as 90% clay soils), a phosphorus adsorption capacity of 350 kg ha^{-1} was estimated using the formula proposed by Shrestha and Lin (1996). Only 80 kg ha^{-1} was added to most ponds over the 20 weeks, so the phosphorus adsorption capacity was far from satisfied, and little difference was observed among blocks of ponds.

Nitrogen efficiency (kg net fish yield per kg N applied) averaged 3.52, 5.42, 6.09, and 4.95 for Treatments 1, 2, 3, and 4, respectively. The N:P ratio of the inputs was lowest for Treatment 3.

At Rwasave Fish Station, Rwanda, an experiment was conducted in which fish were fed rice bran at 5 g fish^{-1} d^{-1} in ponds stocked at a density of 2 male tilapia m^{-2}. A mean net yield of 2,620 kg ha^{-1} and a feed conversion ratio (FCR) of 7.6 were obtained after 192 days. No chemical fertilizers were applied, but small additions of chicken manure and grass were used as fertilizer (Verheust et al., 1992). The FCRs obtained in Treatments 3 and 4 of this experiment, in which rice bran was applied at 6 g tilapia^{-1} d^{-1}, are much higher (10.5 and 8 for Treatments 3 and 4, respectively) because the fish started out at a smaller size (32 g in this experiment versus 80 g in the Rwanda experiment) and they could not consume all the bran. Also, the ponds were harvested before market size was reached, thereby not allowing recovery from the overfeeding at the beginning of the experiment. A study that combined inorganic fertilization and feeding rice bran to tilapia (reaching a maximum application of 46 kg ha^{-1} d^{-1}) obtained a mean net yield of 1,160 kg ha^{-1} after 159 days (Perschbacher and Lochmann, 1995). This is somewhat less than the net yield in Treatment 2 of this experiment (1,582 kg ha^{-1}).

Fish of both species contained significantly higher lipid levels when fed rice bran (Treatments 2, 3, and 4) than when in the fertilizer-only Treatment 1 (Tables 6a and 6b).

Using the results of Treatment 1 (fertilizer only) as the baseline, partial enterprise budget analysis demonstrates that none of the other treatments resulted in greater returns to operating costs. However, in comparing Treatment 4 with Treatment 3, applying fertilizer in addition to the high bran application was definitely beneficial in the economic sense (Table 7).

CONCLUSIONS

Treatment 1 (fertilizer only) was the most cost-effective, but the net profits from Treatments 1, 2, and 4 were similar (Table 8). Input costs for Treatments 1 and 2 will definitely be of interest

Table 6a. Proximate analyses for tilapia at stocking and towards the end of the study period. Figures given are means ± SD for each treatment.

Treatment	Date	Water (%)	Protein (%)	Fiber (%)	Fat (%)	Ash (%)
All	31-Oct-97	74.7	14.7	1.29	3.74	3.75
1	1-Mar-98	78.6 ± 2.77 a	15.1 ± 3.45 a	0.7 ± 0.72 a	0.9 ± 0.72 a	3.8 ± 1.03 a
2	1-Mar-98	73.8 ± 3.41 a	14.6 ± 1.03 a	0.5 ± 0.16 a	7.2 ± 0.73 b	3.2 ± 0.19 a
3	1-Mar-98	71.2 ± 2.66 a	15.8 ± 1.26 a	0.3 ± 0.22 a	8.4 ± 1.04 b	3.3 ± 0.67 a
4	1-Mar-98	73.7 ± 1.55 a	16.7 ± 0.75 a	1.0 ± 0.56 a	9.2 ± 2.01 b	3.0 ± 0.72a

a,b Values in a column followed by the same letter are not significantly different at the 95% level (LSD).

Table 6b. Proximate analyses for *Clarias* at stocking and towards the end of the study period. Figures given are means ± SD for each treatment.

Treatment	Date	Water (%)	Protein (%)	Fiber (%)	Fat (%)	Ash (%)
All	31-Oct-97	68.13	12.42	1.07	0.62	2.94
1	1-Mar-98	79.1 ± 0.20 b	16.4 ± 0.78 a	0.2 ± 0.14 a	0.8 ± 0.62 a	3.1 ± 0.42 a
2	1-Mar-98	75.0 ± 2.18 a	17.9 ± 0.85 a	0.5 ± 0.24 a	4.9 ± 0.40 b	2.5 ± 0.14 a
3	1-Mar-98	75.0 ± 2.38 a	16.7 ± 0.93 a	0.6 ± 0.94 a	5.0 ± 0.48 b	2.9 ± 0.22 a
4	1-Mar-98	74.0 ± 1.90 a	17.8 ± 1.78 a	1.1 ± 0.36 a	5.0 ± 1.28 b	3.0 ± 0.47 a

a,b Values in a column followed by the same letter are not significantly different at the 95% level (LSD).

Table 7. Partial budget analysis in Kenya shillings (KSh) relative to Treatment 1 (fertilizer only). Cost of capital is calculated based on 12% interest (per annum interest is about 24%) of total increased operating costs. Figures are on a per-pond (800 m^2) basis. At the time the experiment ended, the exchange rate was approximately 60 KSh to US$1.

	Treatment		
	2	3	4
A. CHANGE IN COSTS			
Feed	+3,828	+7,656	+7,656
Labor	+190	+162	+190
Cost of Capital	+482	+938	+942
Fertilizer	-968	-1,937	-968
Net Change in Costs	+3,532	+6,819	+7,820
B. ADDITIONAL REVENUE FROM FISH	2,930	2,673	6,604
C. NET CHANGE (A - B)	-602	-4,146	-1,216

to fish farmers. Treatment 1 resulted in the highest profit (Table 8); however, it is possible that fish raised using only fertilizer at the rates in Treatment 1 may never reach market size at this stocking density, as evidenced by their reduced growth towards the end of the experiment (Figures 1 and 2).

In order to further increase production over that obtained using Treatment 2, applying additional fertilizer may be a better solution than increasing bran inputs. Diana et al. (1996) found that adding supplemental feed (floating pellets, 30% crude protein) after fish reached 150 g resulted in greater annual profit than either fertilization only or feeding right from the start. In this experiment, the bran can be considered to function partly as a feed and partly as an organic fertilizer.

Bran prices vary in Kenya. Rice bran can be purchased for as little as 3 KSh kg^{-1} (by special arrangement with government-owned rice mills), but 6 KSh kg^{-1} is more common for farmers buying retail. At the price of 6 KSh kg^{-1}, rice bran should be applied sparingly and not as a fertilizer. It is rumored that some unscrupulous retailers mix husks (obtained free) with bran. Proximate analyses indicate that some of this bran may have obtained early in the experiment. Wheat bran is available in greater quantities than rice bran and retails for 5 to 7 KSh kg^{-1}. One batch was tested and resulted in 14.64% protein, 2.9% lipids, and 12.52% fiber. Wheat bran may present a better alternative for farmers and should be tested in future PD/A CRSP experiments. It is now being used at Sagana Fish Farm. Maize bran (8% protein) and maize germ (16% protein) are also available in even greater quantities than wheat bran, but prices are higher per unit protein. If rice bran had cost 3.5 KSh kg^{-1} or less, then profit for Treatment 3 would have surpassed the profit of Treatment 1. If rice bran had cost less than 5.8 KSh kg^{-1}, then Treatment 2 would have been more profitable than Treatment 1. Since this experiment was conducted, rice bran prices in the Sagana area have dropped to just over 2 KSh kg^{-1}, making it much more attractive as a component in pond management regimes.

ANTICIPATED BENEFITS

This experiment has provided data on the comparative value of inorganic fertilizers and low-cost supplemental feeds as pond inputs for semi-intensive tilapia production at Sagana, thus providing the basis for the development of more efficient production strategies for pond systems in Kenya and similar areas of Africa. In addition, determining pond productivity using high nutrient input levels at Sagana provides data for comparison of the Africa site with other CRSP sites in Southeast Asia, Central America, and South America.

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Table 8. Summary of costs and harvest revenues per pond, not counting fingerling costs of 7,200 KSh $pond^{-1}$ for all treatments. The price of adult fish is assumed to be 90 KSh kg^{-1}. No value is attributed to fingerlings harvested.

Treatment	Fertilizer (KSh)	Feed (KSh)	Input Labor (KSh)	Adults Harvested (kg)	Revenue (KSh)	Net Profit (KSh)
1	1,937	0	1,220	133	11,970	8,813
2	969	3,828	1,410	166	14,900	8,693
3	0	7,656	1,382	163	14,643	5,605
4	969	7,656	1,410	206	18,574	8,539

Cite as: [Author(s), 2000. Title.] In: K. McElwee, D. Burke, M. Niles, X. Cummings, and H. Egna (Editors), Seventeenth Annual Technical Report. Pond Dynamics/Aquaculture CRSP, Oregon State University, Corvallis, Oregon, [pp. ___.]