POND DYNAMICS/AQUACULTURE COLLABORATIVE RESEARCH SUPPORT PROGRAM
RESEARCH REPORTS
SUSTAINABLE AQUACULTURE FOR A SECURE FUTURE

Evaluation of Nile Tilapia Production Systems in Egypt

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Abstract

Experiments were conducted at the Central Laboratory for Aquacultural Research to 1.) evaluate and compare the performance of established PD/A CRSP pond management systems to Egyptian pond management systems and 2.) to assess the economic potential of different tilapia pond culture systems. Five management practices —*Traditional Egyptian, Enhanced Egyptian, Feed Only, Fertilization then Feed,* and *Chemical Fertilization*— were tested in twenty 0.1-ha earthen ponds. Young-of-year Nile tilapia (*Oreochromis niloticus)* were stocked 20,000/ha and fingerling African catfish were subsequently stocked 60 fish/ha to prey on tilapia offspring. Water quality variables were analyzed weekly for 17 weeks. The Free-Water Diel curve method was used to determine primary productivity on six occasions. Dissolved oxygen was measured with a polarographic dissolved oxygen meter at depths of 5 cm, 25 cm, 50 cm, and 75 cm. Economic potential and profitability were also evaluated using Enterprise Budget Analysis. *Fertilization then Feed*, *Traditional Egyptian*, and *Enhanced Egyptian* treatments, in decreasing order, were more economically viable and produced the greatest gross fish yields, net returns, and average rates of return on capital. These treatments had the highest values of production per man-hour per kilogram of feed and per Egyptian pound. In addition, the treatments achieved the highest margins between average prices and break-even prices to cover total variable costs of total costs. Production trial results and economic analyses demonstrated sufficient incentive for the expansion of intensified pond culture in Egypt.

Introduction

Fish, an important source of animal protein, is a component of the traditional Egyptian diet. Consumption of fish and fish products was estimated at 350,000 MT in 1989—100,000 MT were imported, 33,000 MT were produced through aquaculture, and the remainder was supplied by domestic capture fisheries. While aquaculture has been practiced in Egypt for thousands of years, systematic aquacultural research to increase fish pond yields in Egypt is relatively new. The Central Laboratory for Aquaculture Research (CLAR), Abbassa, Abou Hammad, Sharkia, inaugurated in the mid-1980s, was part of the General Authority for Fish Resources Development until November 1992 when it became part of the Agricultural Research Center (ARC). CLAR's mission, as a member of the ARC, is to conduct applied research to improve freshwater aquaculture production practices. In October 1992, the Egypt Pond Dynamics/Aquaculture Collaborative Research Support Program (PDIA CRSP) was initiated at CLAR as part of the Egyptian National Agricultural Research Project (NARP) Collaborative Research Component to complement previous and concurrent CLAR research efforts.

Traditional Egyptian aquaculture involves a polyculture of mixed-sex, young-of-year tilapia, common and silver carp, and mullet. Ponds are fertilized with

Table 1. Nutrient inputs and frequency of application by treatment for 0.1-ha ponds stocked with Nile tilapia (*O. niloticus*).

Treatment	Tilapia Stocked	Chicken Litter (dry matter)	Urea	Super-phosphate	Pelleted Feed (25% protein)
		(kg/ha)			
Traditional Egyptian	Mixed sex	715 (initial) 238 (monthly)	23.8 (2-wk intervals)	212.2 (2-wk intervals)	3% fish biomass daily
Enhanced Egyptian	Mixed sex	1,000 (weekly for first 60 days)	***	***	3% fish biomass daily beginning day 61
Feed Only	Monosex (males)	***	***	***	3% fish biomass daily
Fertilization then Feed	Monosex (males)	1,000 (weekly for first 60 days)	***	***	3% fish biomass daily beginning day 61
Chemical Fertilization (N:P of 4:1)	Monosex (males)	***	54.4 (weekly)	92.4 (weekly)	***

organic and chemical fertilizers, and fish are offered commercial rations. Pond aquaculture of tilapia is an important component of Egyptian aquaculture, yet management practices and fish yields are variable. Results of PD/A CRSP Global Experiment research in other countries has identified a number of tilapia pond management strategies that have produced high fish yields and positive economic returns. These pond management systems, however, were developed in tropical countries, whereas Egypt is a subtropical country with an arid climate.

Economic considerations in selection of an appropriate aquacultural production system include its potential for economic returns, its economic efficiency, and the farmer's access to operating capital. Few reports of economic evaluation of aquacultural production systems exist in Egypt. Soliman and Gaber (1988) compared production level, production variability, economic efficiency, and technology level for two different fish culture systems. El Hendy (1990) evaluated technical and economic aspects of tilapia cage culture in Domyatt, Egypt. Reports of economic evaluation of tilapia pond culture practices in Egypt have been lacking. Thus, the PD/A CRSP conducted Year I Global Experiment research with the following objectives: 1.) to evaluate performance of established PD/A CRSP pond management systems under local climatic, edaphic, and water quality conditions, 2.) to compare these systems to Egyptian pond management systems, and 3.) to assess the economic potential of different tilapia pond culture systems.

Materials and Methods

The experiments were conducted in twenty 0.1-ha earthen ponds located at CLAR. Five pond management practices were tested using a completely randomized design (Table 1). Young-of-year Nile tilapia (*Oreochromis niloticus)*, averaging 1-3 g, were stocked 20,000 fish/ha in ponds on 1 July 1993. Fingerling African catfish *(Clarias gariepinus)* averaging 59 g were stocked 60 fish/ha on 13 September 1993 to prey on tilapia offspring. Ponds were harvested in late November, approximately 145 days after stocking. Tilapia were separated according to the following established market size classes: 1st class (1-5 fish/kg), 2nd class (6-12 fish/kg), 3rd class (13-25 fish/kg), and 4th class (26-40 fish/kg).

Chemical fertilizers were dissolved and dispersed over the pond surface. Chicken litter composed of bedding (rice or wheat chaff), manure, feathers, and waste feed was purchased from a local layer operation and applied on a dry matter (DM) basis. DM was measured weekly by calculating the weight loss of chicken litter samples weighed before and after drying for 24 h at 60° C. Water was added to ponds periodically to replace evaporation and seepage.

Water quality variables were analyzed weekly for 17 weeks according to Standard Methods (APHA, 1989). Primary productivity was determined on six occasions according to the Free-Water Diel Curve method (Hall and Moll, 1975). Dissolved oxygen was measured with a polarographic dissolved

Table 2. Summary of mean harvest data for 0.1-ha earthen ponds that received different nutrient inputs during 145-day production period.

Treatment	Gross Fish Yield[1]	Tilapia Yield (kg/ha per 145 days)			Tilapia Repro-duction	Catfish Yield
		Nile	*Other*[2]	*Total*		
Traditional Egyptian	4,074 a	2,877 a	346 a	3,223 a	634 a	201
Enhanced Egyptian	2,881 ab	2,674 a	81 a	2,755 ah	0 b	121
Feed Only	2,467ab	l,770ab	218a	1,989 ab	170 b	308
Fertilization then Feed	3,895 a	2,851 a	686 a	3,537 a	99 b	253
Chemical Fertilization	1,526 b	1,278 b	129 a	1,407 b	21 b	97

Means within columns followed by same letter (a,b.c) are not significantly different (P>0.05).
[1] Includes tilapia reproduction and extraneous fish harvested.
[2] Includes *O. aureus, S. galilae, T. zilli.*

oxygen meter at 4-h intervals for 24 hours beginning at 0600 h and ending at 0600 h the following day. Measure-ments were made at depths of 5 cm, 25 cm, 50 cm, and 75 cm. Community respiration was estimated as two times the decrease in dissolved oxygen that occurred between 1800 h of the first day and 0600 h of the following day. Dissolved oxygen measurements were not corrected for diffusion as wind data were not available.

Economic potential and profitability of an enterprise were evaluated through enterprise budget analysis (Kay, 1981; Boehlje and Eidman, 1984; Hatch and Hanson, 1991). Global Experiment data on pond stocking, management, and harvest were used in the economic analyses. Harvested tilapia were sold to the Cairo Fish Marketing Company. Data on labor and equipment requirements were obtained from available information on the production ponds at CLAR. Data on pond construction costs were obtained from the General Authority for Fish Resources Development, Ministry of Agriculture and Land Reclamation. Enterprise budgets were developed for each production system based on a 2.1-ha pond stocked with 20,000 tilapia/ha for a 145-day grow-out period. Charges for land were not included in the cost estimates; land was assumed to be owned and previously used for aquaculture.

Fish production and water quality data were analyzed by ANOVA followed by Student-Newman-Keuls post-hoc comparison. Means were declared significantly different at alpha level 0.05.

Results and Discussion

Fish Production

Mean gross yields of Nile tilapia ranged from 1,278-2,877 kg/ha per 145 days (Table 2). Unfortunately, screened pond water inlets did not completely exclude wild tilapia *(Oreochromis aureus, Sarotherodon galilae, Tilapia zilli)* or African catfish present in Egyptian waterways. Total tilapia yield, which includes stocked and wild tilapia, represented 79-96% of gross fish yield (Table 2). Significantly greater quantities of tilapia offspring were produced in the *Traditional Egyptian* treatment than in the other remaining treatments (Table 2). Tilapia offspring comprised more than 15% of the gross fish yield of the *Traditional Egyptian* treatment. African catfish stocked to prey on tilapia offspring were unable to exert complete control over stocked tilapia reproduction. African catfish comprised 4-13% of gross fish yield.

The *Traditional Egyptian* and *Fertilization then Feed* treatments exhibited a lack of significant differences in total tilapia yield indicating that the addition of commercial ration was not necessary during the first two months of culture. Natural productivity stimulated by pond fertilization was sufficient to permit rapid fish growth during the first two months of culture (Green, 1992). Pelleted fish ration, probably consumed inefficiently by tilapia during the initial 60 days of culture, acted more as an expensive pond fertilizer. Fertilizer applications beyond day 60 in the *Traditional Egyptian* treatment did not appear to affect

Table 3. Water quality variable means in 0.1-ha earthen ponds stocked with 20,000 Nile tilapia/ha for a 145-day grow-out period.

Treatment	Total Alkalinity ($mg/L\ CaCO_3$)	Ammonia ($mg/L\ NH_3$-N)	Nitrite ($mg/L\ NO_2$-N)	Nitrate ($mg/L\ NO_3$-N)	Total Phosphorus ($mg/L\ PO_4$-P)	Chlorophyll *a* (mg/m^3)	Net Primary Productivity ($g\ O_2/m^3/d$)	Gross Primary Productivity ($g\ O_2/m^3/d$)	Community Respiration ($g\ O_2/m^3/d$)
Traditional Egyptian	347.32 b	0.74 a	0.005 a	0.120 a	3.02 b	154.1 a	10.44 b	18.66 bc	16.44 bc
Enhanced Egyptian	374.28 bc	0.84 a	0.020 a	0.125 a	2.63 b	234.0 a	12.64 b	23.67 c	22.06 c
Fertilization then Feed	412.56 c	0.80 a	0.015 a	0.125 a	2.12 b	241.0 a	9.39 b	16.50 b	14.22 b
Feed Only	347.29 b	0.84 a	0.007 a	0.110 a	0.52 a	125.5 a	5.87 a	10.20 a	8.66 a
Chemical Fertilization	283.40 a	0.86 a	0.150 b	0.803 b	2.04 b	202.8 a	10.68 b	19.37 bc	17.39 bc

Means within columns followed by same letter (a,b,c) are not significantly different ($P>0.05$)

Table 4. Mean yield of tilapia (categorized by size class) from 0.1-ha ponds managed according to different nutrient input regimes during a 145-day grow-out period.

	Tilapia Yield by Size Class			
	1st Class	*2nd Class*	*3rd Class*	*4th Class*
Treatment	kg/ha per 145 days			
Traditional Egyptian	228 ab	1.658 a	1.130 a	203 a
Enhanced Egyptian	1.066a	1.413a	190b	87a
Feed Only	148ab	880a	646ab	315a
Fertilization then Feed	844 a	1.584 a	604 ab	506 a
Chemical Fertilization	4 b	516 a	721 ab	167 a

Means within columns followed by same letter (a,b,c) are not significantly different (P>0.05).

tilapia yield significantly when compared to the *Fertilization then Feed* treatment, which only applied feed. Thus, fertilizer application beyond day 60 in the *Traditional Egyptian* treatment probably was not necessary.

The application of 3.6 kg N/ha per day at a 4N:1P ratio in the *Chemical Fertilization* treatment yielded 9.7 kg tilapia/ha per day (net tilapia yield). A net tilapia yield of 10 kg/ha per day was obtained in ponds fertilized with 3.8 kg N/ha per day in Rwanda (Newman et al., 1994). In Thailand, net tilapia yields of 30.5 kg/ha per day (KnudHansen et al., 1992) and 21.5 kg/ha per day (Diana et al., 1994) were reported for ponds fertilized with 4 kg N/ha per day at a 4N:1P ratio. Ponds in Honduras fertilized with 3.6 kg N/ha per day resulted in a net tilapia yield of 11.5 kg/ha per day (Teichert-Coddington et al., 1993). Net tilapia yields from ponds fertilized with a high rate of chemical fertilizer appeared similar to net tilapia yields in Egypt, Honduras, and Rwanda, but appeared less similar to yields obtained in Thailand. The observed differences in tilapia yields may be attributed to higher mean water temperatures in Thailand.

The poor performance of fish in the *Feed Only* treatment most likely resulted from the inability of the young fish to consume the commercial fish feed pellet, rather than the quality of feed. Although feed for small fish should be of small particle size, the commercially available feed pellets in Egypt generally are 3-4 mm in diameter. The small quantity of feed initially offered to fish was of little value even as fertilizer to stimulate natural productivity, so fish growth was limited by food availability. This is supported by the lower observed mean chlorophyll *a* concentration and significantly lower net primary productivity in the *Feed Only* treatment (Table 3). Natural productivity resulting from heavy fertilization sufficiently maintains fast fish growth during the first two months of grow-out, as was observed in the *Fertilization then Feed* treatment. In fact, fish growth during the first two months did not differ between the *Fertilization then Feed* and the *Traditional Egyptian* treatments, even though fish were offered feed in the latter treatment. Once natural productivity can no longer maintain fast growth, the use of fish feed once again may permit the fast growth of fish, as was observed in the *Fertilization then Feed* treatment.

While PD/A CRSP pond management treatments did not produce significantly greater tilapia yields than the *Traditional Egyptian* treatment, an examination of tilapia size distribution revealed some differences among treatments (Table 4). A larger percentage of tilapia from the *Enhanced Egyptian* and *Fertilization then Feed* treatments were in the first and second size classes compared with the percentage of tilapia from the *Traditional Egyptian* treatment. The economic implications of this difference among treatments are important-fish of first-class-size are worth about 30% more than fish of second-class-size and about 130% more than fish of third-class-size. Tilapia offspring produced during grow-out compete with the initial stock for food and cause a lower yield of marketable fish with little economic value. Therefore, pond management strategy should attempt to achieve the efficient utilization of nutrient inputs and to minimize the potential for production of tilapia offspring during grow-out.

Table 5. Summary of economic returns in Egyptian pounds (L.E.; L.E. 3.395 = US $1, Dec 1994) and performance ratios for five Nile tilapia production systems in a 2.1-ha earthen pond for a 145-day grow-out period.

	Production Systems				
	Fertilization then Feed	*Traditional Egyptian*	*Enhanced Egyptian*	*Feed Only*	*Chemical Fertilization*
Net Returns (L.E.)	19.104	14.494	14.111	3.710	987
Total Production (kg)	7.616	6.757	5.694	4.159	2.973
Average Price (L.E.)	5.41	4.94	6.41	4.61	4.18
Total Variable Costs (L.E.)	18.100	14.900	18.370	11.461	7.430
AVC/kg Produced (L. E.)	2.38	2.21	3.23	2.76	2.50
Return/kg Above TVC (L.E.)	3.03	2.73	3.18	1.85	1.68
Value of Production/Man-h (L.E.)	104.05	56.50	94.76	55.90	56.31
Value of Production/L.E. of TVC (L.E.)	227.62	224.03	198.71	167.30	167.28
Value of Production/100 kg Feed (L.E.)	486.34	368.62	358.25	245.34	NA
Break-even Price to Cover TC (L.E.)	2.90	2.80	3.93	3.72	3.84
Break-even Yield to Cover TC (kg)	3.830	3.873	3.506	3.269	2.569
Margin between Average Price and ATC (L.E.)	2.51	2.14	2.48	0.89	0.34
Rate of Return to Capital (%)	29.97	22.94	22.52	6.66	2.42
CV (%)	26.91	20.35	35.18	42.40	18.94

The following defines the above abbreviations: AVC- average variable costs; TVC- total variable costs; TC- total costs; ATC- average total costs; CV- coefficients of variation.

Net Returns and Costs

Net returns to land and management were greatest for the *Fertilization then Feed* treatment followed by, in decreasing order, *Traditional Egyptian, Enhanced Egyptian, Feed Only,* and *Chemical Fertilization* treatments (Table 5). Net returns to land and management of treatments that combined fertilization and feeding *(Fertilization then Feed, Enhanced Egyptian,* and *Traditional Egyptian)* were, on average, 16.1 times greater than the net returns for the extensive treatment *(Chemical Fertilization).* There was a positive relationship between net returns and gross fish yield. Since total fixed costs were similar for all production systems, the difference in net returns can be explained by fish yield, price received per unit of production, and total variable costs.

Tilapia are marketed according to size class in Egypt; market price per kilogram increases with fish size. Average prices were calculated according to the percentage of fish classes produced (Table 5). There was a positive relationship between intensification of production treatments and average price received for fish. A high average indicated that the fish harvest was predominantly composed of large fish.

Total variable costs (TVC) were higher for the semi-intensive treatments, which utilize supplemental feed, than for the extensive treatments, which use fertilizer. The *Enhanced Egyptian* treatment had the highest variable cost and the *Chemical Fertilization* treatment had the lowest variable cost (Table 5). The high variable costs of semi-intensive treatments primarily resulted from the cost of feed. Previous studies have shown that although there is a positive relationship between level of intensification and variable costs, the average cost for semi-intensive treatments may be lower than average cost for extensive treatments (Shang, 1981; Tucker et al., 1979). The average variable cost in Egyptian pounds (L.E.; L.E. 3.395 =US $1, December 1994) per kilogram produced for each treatment is shown in Table 5. For the semi-intensive treatments the average variable cost per kilogram produced ranged from L.E. 2.21 for the *Traditional Egyptian* treatment to L.E. 3.23 for the *Enhanced Egyptian* treatment. The average variable cost per kilogram produced was estimated to be L.E. 2.50 for the extensive treatment *(Chemical Fertilization).* These results indicated that not all intensified treatments had lower average variable cost than the extensive treatment. In the case of uniform stocking rate, however, intensification should positively affect the final size of individual fish and increase fish production. Thus, considering the average price per kilogram, semi-intensive treatments had higher average return per kilogram above total variable cost than the extensive treatment (Table 5).

Total variable costs and the breakdowns of the variable cost component expressed as a percentage of total variable costs for each production system are given in Tables 6 and 7. Results of previous research indicated that feed and fertilizer were the most important cost items for intensive aquaculture (Shang, 1981; Hatch et al., 1987). For semi-intensive treatments, feed costs ranged from 39% of TVC for the *Fertilization then Feed* treatment to 54% of TVC for the *Feed Only* treatment. Fertilizer costs ranged from 20% of TVC for the *Traditional Egyptian* treatment to 31% of TVC for the *Fertilization then Feed* treatment. Feed and fertilizer combined comprised 54-75% of TVC of production. Cost of fingerlings and fertilizers was 56% and 32% respectively of TVC for the extensive treatment (*Chemical Fertilization*).

Performance Ratios

Performance ratios are summarized in Table 5. Value of production per man-hour ranged from L.E. 104 for the *Fertilization then Feed* treatment to L.E. 56 for the *Feed Only* and *Chemical Fertilization* treatments. The *Fertilization then Feed* treatment had the highest value of production per L.E. of total variable costs followed by, in decreasing order, the *Traditional Egyptian, Enhanced Egyptian, Feed Only,* and *Chemical Fertili-zation* treatments. The value of production per 100 kg of feed ranged from L.E. 245 for the *Feed Only* treat-ment to L.E. 468 for the *Fertilization then Feed* treat-ment. Break-even prices and break-even yields to cover total costs also are shown in Table 5. The *Traditional Egyptian* treatment had the lowest break-even price to cover total costs followed by, in increa-sing order, the *Fertilization then Feed, Feed Only, Chemical Fertilization,* and *Enhanced Egyptian* treatments. The *Fertilization then Feed* treatment, however, had the highest margin between break-even price to cover total costs and average price followed by, in decrea-sing order, the *Enhanced Egyptian, Traditional Egyptian, Feed Only,* and *Chemical Fertilization* treatments.

Rate of return to capital was calculated as a measure of profitability for each system (Table 5). Land was valued at L.E. 32,640 for a 2.1-ha pond, other investments were estimated at L.E. 34,204, and return to management was assumed to be zero. The *Fertilization then Feed* treatment had the highest rate of return to capital (29.97%), followed by the *Traditional Egyptian* treatment (22.94%), the *Enhanced Egyptian* treatment (22.52%), the *Feed Only* treatment (6.66%) and the *Chemical Fertilization* treatment (2.42%).

Sensitivity Analysis

Variation in yield, as indicated by coefficients of variation, was less in the extensive treatment *(Chemical Fertilization)* than in the semi-intensive treatments (Table 5). Similar results have been reported by other researchers (Tucker et al., 1979). Actual prices received from the Cairo Fish Marketing Company were used to estimate total returns. These prices, however, were slightly higher than local prices. Therefore, the impacts of price reduction and output level reduction were estimated (Table 8).

At a 10% or 15% price reduction, all production systems except the *Chemical Fertilization* treatment had positive net returns (Table 4). Twenty percent decreases in price level resulted in negative net returns for the *Chemical Fertilization* and *Feed Only* treatments. One or two standard error decreases in production level with no reduction in sales price resulted in negative net returns for the *Feed Only* and *Chemical Fertilization* treatments. Results of the combined changes in price and production level showed the following: 1) decreases in production level by one standard error and in price by 10%, 15% or 20% resulted in negative net returns for the *Feed Only* and *Chemical Fertilization* treatments, and 2) decreases in production level by two standard errors and in price by 10%, 15% or 20% resulted in negative net returns for the *Feed Only*, *Chemical Fertilization* and *Enhanced Egyptian* treatments.

Conclusions

Results of these production trials and economic analyses demonstrated sufficient incentive for the expansion of intensified pond culture of tilapia in Egypt. The analyses indicated that the *Fertilization then Feed, Traditional Egyptian,* and *Enhanced Egyptian* treatments, in decreasing order, were more econom-ically viable than the *Feed Only* and *Chemical Fertili-zation* treatments. *Fertilization then*

Table 6. Estimated budgets in Egyptian pounds (L.E.; L.E. 3.395 = US $1, Dec 1994) for Nile tilapia pond management systems in 2.1-ha earthen ponds for a 145-day grow-out period.

			Fertilization then Feed			**Feed Only**			**Chemical Fertilization**		
Item	*Unit*	*Cost per Unit (L.E.)*	*Quantity*	*Value or Cost (L.E.)*	*% of Total*	*Quantity*	*Value or Cost (L.E.)*	*% of Total*	*Quantity*	*Value or Cost (L.E.)*	*% of Total*
GROSS RETURNS											
1st Class tilapia	Kg	7.85	1,843	14,467	35.11	307	2,410	12.57	7	55	0.44
2nd Class tilapia	kg	6.00	3,413	20,478	49.70	1,832	10,992	57.33	1,099	6,594	53.10
3rd Class tilapia	kg	3.40	1,290	4,386	10.65	1.355	4,607	24.03	1,516	5,154	41.51
4th Class tilapia	kg	1.75	1,070	1,873	4.54	665	1,164	6.07	351	614	4.95
Total Returns				41,204	100.00		19,173	100.00		12,417	100.00
VARIABLE COSTS											
Fingerlings	Thousand	100	42	4,200	23.20	42	4,200	36.64	42	4,200	56.53
Feed	Metric ton	800	8.797	7,038	38.88	7.814	6,251	54.54			
Superphosphate	50-kg bag	1 8							73.75	1,328	17.87
Urea	50-kg bag	25							43.34	1,084	14.58
Chicken Litter	m3	55.5	101.38	5,627	31.09						
Labor			396	298	1.64	343	261	2.28	221	183	2.46
Equipment Repair				75	0.41		75	0.65		75	1.00
Pond Maintenance				350	1.93		350	3.05		350	4.71
Interest on Operating Capital				513	2.83		325	2.83		211	2.83
Total Variable Costs				18,101	100.00		11,462	100.00		7,431	100.00
Income Above Variable Costs				23,103			7,711			4,986	
FIXED COSTS											
Depreciation Pond Equipment				1,949	48.70		1,949	48.70		1,949	48.70
Interest on Investment				2,052	51.30		2,052	51.30		2,052	51.30
Total Fixed Costs				4,001	100.00		4,001	100.00		4,001	100.00
Net Returns to Land and Management				19,102			3,710			985	

Table 7. Estimated budgets in Egyptian pounds (L.E.; L.E. 3.395 = US $1, Dec 1994) for Nile tilapia pond management systems in 2.1-ha earthen ponds for a 145-day grow-out period.

			Traditional Egyptian			Enhanced Egyptian		
Item	*Unit*	*Price or Cost per Unit (L.E.)*	*Quantity*	*Value or Cost (LE.)*	*% of Total*	*Quantity*	*Value or Cost (L.E.)*	*% of Total*
GROSS RETURNS								
1st Class tilapia	kg	7.85	467	3,666	10.98	2,212	17,364	47.60
2nd Class tilapia	kg	6.00	3,477	20,862	62.47	2,914	17,484	47.92
3rd Class tilapia	kg	3.40	2,390	8,126	24.33	388	1,319	3.62
4th Class tilapia	kg	1.75	423	740	2.22	180	315	0.86
Total Returns				33,394	100.00		36,482	100.00
VARIABLE COSTS								
Fingerlings	thousand	80	42	3,360	22.55	42	3,360	18.29
Feed	metric ton	800	9.055	7,244	48.62	10.187	8,150	44.36
Superphosphate	50-kg bag	18	89.04	1,603	10.76			
Urea	50-kg bag	25	10.00	250	1.68			
Chicken Litter	m^3	55.5	21.23	1,178	7.91	101	5,627	30.63
Labor			591	417	2.80	385	288	1.57
Equipment Repair				75	0.50		75	0.41
Pond Maintenance				350	2.35		350	1.91
Interest on Operating Capital				422	2.83		521	2.84
Total Variable Costs				14,899	100.00		18,371	100.00
Income Above Variable Costs				18,495			18,111	
FIXED COSTS								
Depreciation Pond Equipment				1,949	48.70		1,949	48.70
Interest on Investment				2,052	51.30		2,052	51.30
Total Fixed Costs				4,001	100.00		4,001	100.00
Net Returns to Land and Management				14,495			14,111	

Table 8. Sensitivity of net returns to changes in production level and sales price for five Nile tilapia pond management systems. Net returns (Egyptian Pounds. L.E.; L.E. 3.395 = US $1, Dec 1994) are based on 145-day grow-out period in a 2.1-ha production pond.

Production System	Change in Sale Price (%)	Net Returns (L.E.)		
		Production Level Estimates		
		Mean	Mean - 1 S.E.	Mean - 2 S.E.
Fertilization then Feed	0	18.104	13.564	8.020
Traditional Egyptian	0	14.494	11.120	7.719
Enhanced Egyptian	0	14.111	7.697	1.280
Feed Only	0	3.710	(356)	(4.421)
Chemical Fertilization	0	987	(188)	(1.365)
Fertilization then Feed	- 10	14.983	9.997	5.008
Traditional Egyptian	- 10	11.154	6.617	5.057
Enhanced Egyptian	- 10	10.463	4.690	(1.085)
Feed Only	- 10	1.793	(1.867)	(5.525)
Chemical Fertilization	- 10	(255)	(1.312)	(2.371)
Fertilization then Feed	- 15	12.923	8.214	3.502
Traditional Egyptian	- 15	9.485	6.512	3.726
Enhanced Egyptian	- 15	8.639	3.187	(2.268)
Feed Only	- 15	835	(2.622)	(6.077)
Chemical Fertilization	- 15	(875)	(1.874)	(2.875)
Fertilization then Feed	- 20	10.863	6.431	1.996
Traditional Egyptian	- 20	7.815	5.116	2.395
Enhanced Egyptian	- 20	6.815	1.684	(3.450)
Feed Only	- 20	(124)	(3.377)	(6.629)
Chemical Fertilization	- 20	(1.496)	(2.437)	(3.378)

Feed, Traditional Egyptian, and *Enhanced Egyptian* treatments, in decreasing order, produced the greatest gross fish yield, net returns, and average rates of return on capital. These treatments also had the highest values of production per man-hour, per kilogram of feed, and per L.E. of variable cost. In addition these treat-ments achieved the highest margins between average prices and break-even prices to cover either total variable costs or total costs. Only following 46%, 43%, and 39% reductions in average price respect-ively were net returns negative for the *Fertilization then Feed, Traditional Egyptian,* and *Enhanced Egyptian* treatments. This indicated that there would be reduced risks to farmers in the event of unexpected decreases in market price. Moreover, the above treatments had the highest net returns when fish yields were estimated at one or two standard errors below the mean. *Traditional Egyptian* and *Fertilization then Feed* treatments maintained positive net returns to land and management even in the extreme case scenario of the combined effects of production failure and a 20% decline in market price.

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