The Economic Performance Oftilapia Pond Culture Systems In Egypt

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Abstract

The aim of this study is to understand the economic performance characteristics of different pond culture systems for Nile tilapia (Oreochromis niloticus) in Egyptian fish farms. The study adopted a field survey approach covering sixty fish farms in the four main aquaculture governorates. Economic performance datawere obtained forthree culture systems; tilapia monoculture (tilapia only);tilapia plus mullet (tilapia and mullet); tilapia polyculture (tilapia, mullet and/or catfish/carps).The currentstudy discusses general characteristics and the financial performance of different tilapia culture strategies. Budget and sensitivity analysis for different culture systemswere estimated in this paper. A production function was employed to compare resource use efficiency between the studied systems.

The study revealed that on average,tilapia mono culture systemsproduced significantly higher yields (4.19 t/fed/yr) than tilapia plus mullet or tilapia polyculture systems(3.14 t/fed/yr and 3.27t/fed/yr), respectively.In terms of financial performance, tilapia plus mullet systemsshowed significantly higher returns to investment.Sensitivity analysis demonstrated that farms adopt tilapia plus systems wereable to tolerate financial shocks compared to the other two culture systems. Production function estimation showed that fish feed wasa common input resource which has the most significant effect on increasing fish yields in the three culture systems.The study concludes that farms using tilapia plus mullet systemsare more financially sustainablethan tilapia monoculture and tilapia polyculture systems. Furthermore, the three tilapia culture systems also operates in increasing return to scale and yield could be increased through increasing investment in input resources..

Keywords: **Economics, tilapia culture, pond, earth ponds, production function, sensitivity analysis, Egypt.**

1. Introduction

Egyptian aquaculture production grew from340,093 metric tons in 2000 to 1,017,738metric tonsin 2012. This is primarily due tothe growth in aquaculture production which increased its share of total production from 47% in 2000 to 74% in 2012 (GAFRD, 2013). Aquaculture production is strongly concentrated in low lying land around the northern lakes (Manzala, Brulous, Edko and Maryout) El-Gayar (2003). Eighty-five percent of aquaculture production comes from earthen ponds, with the rest produced in fish cages, rice fields and intensive farms (Macfadyen et al., 2012).

Nile tilapia (Oreochromis niloticus) is the main culture species in Egyptian fish farms and represented 75.5% of farmed fish production in 2012. Other species grown in fish ponds in the same year are; grey mullet (Mugil cephalus) and thinlip mullet (Liza ramada) represented12.7% of harvest, common carp (Cyprinus carpio), grass carp (Ctenopharyngodon idella), and silver carp (Hypophthalmichthys molitrix) represented6.6% of harvest, North African catfish (Clarias gariepinus) accountedfor 1.4% of harvest, and European seabass (Dicentrarchus labrax) and gilthead seabream (Sparus aurata) accountedfor 2.8% (GAFRD 2013).In their value chain study in four governorates in Egypt, Macfadyen et al. (2012) reported that tilapia representing 91% by volume (81% by value) and mullet representing 9% by volume (18% by value) of farmed fish production in the main farmed fish producers governorates in Egypt. The authors did not attempt to classify pond culture by species combination.

Early attempt to classify pond culture system by species combinations was done by (El-Naggar et al., 2006; 2008).Authors reported that tilapia plus mullet represent 73.3%, while tilapia monoculture and tilapia polyculture represent the same rate 13.3%. On the other hand,Hebicha et al. (2013) and Eltholth et al. (2015) studied economics of tilapia monoculture system in Fayoum and kafr el Sheikh, respectively.None of these studiesexamined in detail production cost and output for different species combination culture strategies.

The output of pond culture system is a function of all input variables and fixed cost used in production process (Dey et al., 2005; Asmah, 2008; Asamoah et al., 2012; Hebicha et al., 2013). In Efficient culture systems operators are able to identify optimal amount of inputs to be used for attaining maximum level of inputs (Sharma & Leung, 2003; El-Naggar et al., 2008; Asamoah et al., 2012; Hebichaet al., 2013). Cobb-Douglas production function form is widely used in production analysis to estimate technical efficiency of input use (Battese & Coelli, 1995; Asmah, 2008; Sharma & Leung, 2003; Dey et al., 2005; Asamoah et al., 2012; Hebicha et al., 2013).In Egypt, limited number of publications adopted the production function model to examine efficiency use of resources in fish pond culture in Behera (El-Naggar et al., 2008) and to tilapia culture ponds in Fayoum (Hebicha et al., 2013).

The aim of this study is to examine economic performance of fish pond culture under different species combination in Egypt. In specific the current study aimed to:

- Compare operational characteristics of three tilapia culture strategies in earthen ponds.
- Compare production costs, yield and gross return for different systems
- Find out the difference in financial performance of the three culture systems
- Test sensitivity of various strategies for reduction of sales price and or increasing variable costs.
- Investigate efficiency use of inputs in the different culture systems

The three species combinations understudy are:

Tilapia only will refer to hereinafter (monoculture)

Tilapia & mullet will refer to hereinafter (tilapia plus mullet)

Tilapia, mullet & others will refer to hereinafter (polyculture)

2. Materials and methods

2.1.Data collection

The current study was based on collecting production and financial information from fish farms (grow fish in earth ponds) in four Egyptian governorates. The selected governorates collectively produced an estimated 75% of Egyptian farmed fish in 2011 (GAFRD, 2012). Also according to official statistics 90% of licensed farms are located within the study governorates (GAFRD, 2012). The official statistics was used as main source of information for statistics of farming area and production per governorates. The information was used to decide on the number of interviews to be carried out on a stratified basis to represent fish farming area in different governorates. This research was based on cross sectional input and output data among the 60 fish farmers representing the fish community in selected governorates. Number of farmer interviewed per governorates is as follows; Kafr el Sheikh 22, Behera 14, Sharkia 12 and Fayoum 12. A detailed questionnaire for fish farmer operators was drafted in English and then translated into Arabic. The questionnaire was revised, discussed and modified, then piloted with fish farm manager before being finalized and printed. The survey interviews were conducted in October 2011 as part of efforts of getting information on the production performance of fish farming operations in the study area. The data collected included: detail information of farm are used, cultured species data of production inputand output for one year through 2010. Production costs include variable cost, fixed costs and output data per the period under review. Variable costs include; fry or fingerlings cost, cost of feed, staff salary, other costs (maintenance, fertilizer, fuel, transport, wages, etc.). Fixed cost include; governmental charges, repair and maintenance, land rent depreciation and financial charges.In order to overcome difficulties in the coordination of interviews with target groups, local contacts in each of the governorates were used to arrange to meet at a central location. Individual interviews generally lasted more than one hour with each farmers/operators.

2.2.Data entry and analysis

Data from the questionnaires were entered into a Microsoft Excel spreadsheet file and checked for accuracy with the interviewers. The questionnaires generated data on individual farms which was allocated into three types of culture systems and allowed calculation of average farm performance in terms of the efficiency of resource usage, quantity of fish produced, net revenue per feddan, feed cost per kg, break-even prices, break-even production and rate of returns on operational costs (Green et al., 2002). Data on sales volumes and values and on operational and fixed costs allowed for the construction of costs and earnings models. The interviews included questions on the number of people employed (part-time and full-time) and wereconverted into Full-Time Equivalent (FTE) jobs. The financial performance of the three farm systems was compared by developing a costs and incomes table as described by Green et al. (2002) and Nasr-Allah et al. (2014). The main indicator of financial performance was net farm income (NFI) expressed as:

$NFI = GR - TC$

where;

NFI = Net Farm Income

$TC = (TVC + TFC) = P_x. X$

TC = Total Cost (EGP)

TVC = Total Variable Cost (EGP)

TFC = Total Fixed Cost (EGP)

P_x = Unit Price of Input

X = Quantity of Input

$GR = P_y. Y$

GR = Gross Return / farm

P_y = Unit Price of Output

Y = Quantity of Output

Calculation of depreciation costs of equipment was computed using the straight line method (Jolly & Clonts, 1993), where annual depreciation = (Cost – Salvage Value) / Useful life and the salvage value for all equipment was assumed to be zero (Asmah, 2008).

A production function model: used to determine the factors influencing the productivity of fish farming in the study area: The model as adopted by (Ahmed et al, 1996; Olayemi, 1998; El-Naggar et al, 2008) is specified below:

$Yi = f(xi;\beta i)$ implicit function (eqn1)

$Yi = \beta o + \beta 1X1 + \beta 2X2 + \beta 3X3 + \beta 4X4 + \beta 5X5 + \mu$ explicit function (eqn2)

Thus, it can be written as:

$LnYield = \beta o + \beta 1Sn + \beta 2Ss + \beta 3Fd + \beta 4Sa + \beta Fc + \mu$ exponential form (eqn3)

$LnYield = \beta o + \beta 1lnSn + \beta 2lnSs + \beta 3lnFd + \beta 4lnSa + \beta 5lnFc + \mu$ double log (eqn4)

Where:

$\beta o \ldots \beta 5$ = production function parameters to be estimated

Yield = Yield (t/fed)

Sn =stocking number (1000/fed)

Ss = average stocking size (g)

Fd =Quantity of fish feed (t/fed)

Sa = Salary of staff (EGP/fed)

Fc = Fixed cost (EGP/fed)

Ln= natural logarithm

μ= random error

However, the two functional forms (double log and exponential model) were estimated and the one that meets the econometric and statistical criteria (positive parameters, number of significant parameters, F-value and Adjusted R2 value) was chosen as the better fit.

The data collected was entered into Microsoft spread sheet excel then transferred to SPSS (version 19) (SPSS, Inc., Chicago, Illinois, USA) for statistical analysis. Analysis of variance (ANOVA) was estimated according to the method of Steel and Torrie (1980) and Duncan's Post Hoc Multiple Comparisons Test were performed to evaluate the differences between means (Duncan, 1955). Differences were considered significant at a probability level of 0.05. Ordinary least squares methods used to estimate double-log form. The t-test used to test significance of individual estimated coefficients. The F-distribution was employed to test the overall significance of the model.

3. Results and discussion.

3.1. Operational characteristics of tilapia farms

As shown in table 1, the number of years of experience in fish farming ranged from 15.7 years in tilapia only farms to 20 years in tilapia polyculturefarms and 18.8 years in tilapia plus mullet farms. The average farm sizes in feddan were31, 28.6 and 25feddan for the monoculture, tilapia plus mullet and polyculture systems, respectively. Similarly, El-Naggar et al. (2008) reported that the average farm size in Behera governorate is 23.5 feddanand 73% of these farms adopting tilapia plus mullet culture system. Hebicha et al. (2013) reported that during their study of tilapia mono-culture systemin Fayoum the average farm size was 6.3 ha (15 fed).

Tilapia monoculture is characterized by significantly higher ($P<0.05$) stocking rate compared to tilapia with mullet or tilapia polyculture. This could be explained due to the higher tolerance of tilapias to low levels of dissolved oxygen (DO) which happen as at high carrying capacity due to increase stocking rate(El-Sayed, 2014). On the other hand, growing mullet in tilapia with mullet or tilapia polyculture make both systems more sensitive to low level of DO and as result of that fish farmer tend to reduce stocking density in these systems.

However, the study showed that tilapia fingerlings stocking size wasnoticeable bigger in tilapia polyculture systems 9.2 g/fish with no significance difference from other systems tilapia monoculture and tilapia plus mulletsystems 7.5 and 6.7 g/fish, respectively. Stocking biomass calculated as kg/feddan showed noticeable high level in polyculture systems compared to the other systems but with no significant difference ($P>0.05$). This could be attributed to the big size of catfish and carp at stocking of polyculture system. Tilapia harvest size was slightly higher in tilapia monoculture and tilapia with mullet compared to tilapia polyculture with no significant difference ($P>0.05$) among systems.Bigger initial stocking sizes of tilapia 10.14 g/fish and total initial stocking weight of tilapia 136.5 kg/fed were reported in tilapia monoculture strategies in Fayoum by Hebicha et al. (2013).

Table 1 Summary of operational characteristics of different tilapia pond culture systems.

	Tilapia monoculture	Tilapia plusmullet	Tilapia polyculture
Number of Farmers interviewed	18	31	11
Years in practices	15.7 ± 1.9^a	18.8 ± 1.3^a	20.0 ± 2.8^a
Average farm size (fed)	31.2 ± 9.5^a	28.6 ± 3.9^a	25.2 ± 3.8^a
Stocking number			
Tilapia (1000/fed)	16.17 ± 1.16^b	11.8 ± 0.45^a	10.4 ± 1.03^a
Grey mullet (1000/fed)		0.69±0.07	0.85±0.13
Thinlip mullet (1000/fed)		1.1±0.14	1.9±0.29
Carp (1000/fed)			0.09±0.06
Catfish (1000/fed)			0.37±0.13
Total stocking density (1000/fed)	16.17 ± 1.16^b	13.6 ± 0.5^a	13.6 ± 0.9^a
Stocking size			
Tilapia size (g)	7.5 ± 2^a	6.7 ± 1.5^a	9.2 ± 4.4^a
Grey mullet size (g)		7.6±1.6	18±5.7
Thinlip mullet size (g)		4.3±1.03	11.2±2.7
Common Carp size (g)			36±28
Catfish size (g)			168±22.6
Total stocking biomass (kg/fed)	121.3 ± 27^a	89 ± 18^a	198 ± 38^b
Growth duration (month)	7.7 ± 0.45^b	9.6 ± 0.45^a	8.5 ± 0.47^{ab}
Feed quantity (metric tons/fed)	7.03 ± 0.6^b	4.74 ± 0.4^a	4.95 ± 0.6^a
Tilapia harvest size (g)	269 ± 8.9^a	270 ± 8.3^a	239 ± 13.3^a
Grey mullet harvest size (g)		413±26.5	353±18.4
Thinlip mullet harvest size (g)		167.5±22.3	183±13.4
Common carp harvest size (g)			377±282
Catfish harvest size (g)			1291±181
Average annual yield (metric tons/fed)	4.19 ± 0.35^b	3.14 ± 0.14^a	3.27 ± 0.30^a
Biomass increase (kg/fed/day)	18.6 ± 1.5^b	11.5 ± 0.77^a	13 ± 1.2^a
Apparent food conversion ratio (AFCR)	1.72 ± 0.11^a	1.51 ± 0.08^a	1.55 ± 0.14^a
FTE per 100 metric tons	7 ± 1.1^a	9.6 ± 1.99^a	6.1 ± 1.07^a

- Means in the same rows with different superscripts are significantly different ($P< 0.05$).

Source : This study

Tilapia monoculture showed significantly (P<0.05) higher annual yield (4.19 t/fed) compared to tilapia plus mullet and tilapia polyculture systems (3.14 and 3.27 t/fed, respectively).Similarly the daily increase in fish biomass per feddanper day was significantly higher (P<0.05) in tilapia monoculture 18.6 kg followed by tilapia polyculture 13 kg and then tilapia plus mullet systems11.5 kg. Lower yield reported either in tilapia monoculture 2.78 t/fedin Fayoum (Hebicha et al., 2013) and in tilapia plus mullet system 2.63 t/fed in Behera (El-Naggar et al., 2008).

Extruded floating fish feeds became widely produced in Egypt and are used in many farms (El-Sayed, 2014). As expected, the study showed that tilapia monoculture was less efficient in feed use compared to the other systems with no significant difference (P>0.05) between systems. The result shows that the highest apparent food conversion ratio (AFCR)was in tilapia monoculture 1.72 and the lowest werein tilapia plus mullet 1.51 while it was 1.55 in tilapia polyculture systems. Similar AFCR 1.62 reported by Nasr-Alla et al. (2012) during their study of Egyptian aquaculture value chain. On the other hand, higher AFCR 1.99 reported by Hebicha at el. (2013) in tilapia monoculture ponds in Fayoum.

Labor inputs (FTE per 100 metric tonsof production per year) were noticeable higher in tilapia plus mullet systems compared to the other two species combination, although there wasno statistically significantdifference among culture strategies (P>0.05). Against expectation labor inputs (FTE per 100 metric tons productions per year) in tilapia monoculture was lower than tilapia plus mullet but with no significant difference between them. Macfadyen et al. (2012) reported an average of 8.31 FTE per 100 metric tonsof fish produced from Egyptian fish pond culture systems.

3.2.Fish yield and sales revenue

Tilapia production varied significantly (P<0.05) between the three culture strategies (table 2). The results show that the highest tilapia yield was in monoculture systems, followed by tilapia plus mullet and polyculture (4.05, 2.68 and 2.38 t/fed, respectively). The contribution of tilapia to total yield was 97% in monoculture systems followed by 85% in tilapia plus mullet systems and 72% in polyculture systems. In the Egyptian value chain analysis Nasr-Alla et al. (2012) reported that tilapia represented 87% of fish yield followed by mullet which represented 9%. The highest production of tilapia grade 1 (first class tilapia) was in monoculture system, followed by tilapia plus mullet and then polyculture. The result indicated that tilapia grade 1 production and sales revenue in monoculture systems were significantly (P<0.05) higher than the other two systems. Similarly total tilapia sales revenue took the same order, where monoculture was the highest followed by tilapia plus mullet and then tilapia polyculture systems. The results show that gross sales revenue vary significantly (P<0.05) among the three systems. The obtained result indicate that sales revenue of tilapia was significantly (P<0.05)higherin tilapia monoculture, compared to tilapia plus mullet andtilapia polyculture (35.94, 23.35 and 18.08 thousand EGP/fed/year, respectively). Lower yield of tilapia monoculture reported by Eltholth et al. (2015) who stated that in tilapia yield in tilapia production ponds in Kafr el sheikh 3.2 t/fedand tilapia grade one (more than 300g/fish) accounts for only around 51% of yield. The authors also reported that tilapia grade two (200-300g/fish) and grade three (<200g/fish) accounts for 27 and 21% of yield, respectively.Similar result of gross revenue per fed is reported by Nasr-Alla et al. (2012) as they stated fish sales revenue EGP32,886/feddan. Lower gross revenue result reported by El-Naggar et al. (2008), who estimated sales revenue per fed at an average of EGP18,869/fed/year. Dey et al. (2005) reported higher yield 10.808 t/ha (4.54 t/fed) and 8.606 t/ha (3.61 t/fed) reported in semi-intensive carp polyculture system in China and Vietnam, respectively. They also stated that semi-intensive pond in Thailand produced lower yield 4.182 t/ha/yr (1.75 t/fed) while in intensive ponds in China yield reached 20.711 t/ha/yr (8.7 t/fed).

Table 2 Fish production and sales revenue in the three culture systems.

	Tilapia monoculture	Tilapia plusmullet	Tilapia polyculture
Tilapia grade 1 (metric tons/fed)	2.32±0.31[b]	1.36±0.14[a]	0.95±0.21[a]
Tilapia grade 2 (metric tons/fed)	1.27±0.32[b]	0.74±0.06[a]	0.77±0.15[a]
Tilapia grade 3 (metric tons/fed)	0.45±0.09[a]	0.57±0.08[a]	0.64±0.14[a]
Sub-total Tilapia (metric tons/fed)	4.05±0.35[b]	2.68±0.13[a]	2.38±0.25[a]
Grey mullet (metric tons/fed)	-	0.25±0.02	0.24±0.03
Thinlip mullet (metric tons/fed)	-	0.21±0.02	0.34±0.05
Carp (metric tons/fed)	-	-	0.03±0.02
Catfish (metric tons/fed)	-	-	0.27±0.08
Other fish (metric tons/fed)	0.14±0.05	0.001±0.0	-
Yield (metric tons/fed/year)	4.19±0.35[b]	3.14±0.14[a]	3.27±0.30[a]
Tilapia grade 1 sales (1000 EGP/fed)	22.54±2.8[b]	13.35±1.32[a]	8.23±2[a]
Tilapia grade 2 sales (1000 EGP/fed)	10.58±2.64[b]	6.16±0.46[a]	5.83±1.2[a]
Tilapia grade 3 (1000 EGP/fed)	2.81±0.17[a]	3.79±0.11[a]	3.92±0.17[a]
Total Tilapia (1000 EGP/fed)	35.94±2.94[b]	23.35±1.18[a]	18.08±2.14[a]
Grey mullet (1000 EGP/fed)	-	4.9±0.48	4.63±0.6
Thinlip mullet (1000 EGP/fed)	-	3.76±0.43	4.68±0.62
Carp (1000 EGP/fed)	-	-	0.44±0.09
Catfish (1000 EGP/fed)	-	-	1.45±0.62
Other fish (1000 EGP/fed)	1.03±0.45	0.16±0.16	-
Gross Revenue (1000 EGP/fed/year)	36.996±2.9[b]	32.2±1.44[ab]	29.28±2.4[a]

- Means in the same rows with different superscripts are significantly different (P<0.05).

Source: Survey data.

3.3.Production costs

Table 3 presents information on variable costs (VC) and fixed costs (FC) per feddan used in fish productionunder the three culture systems. Fish feed represents the highest portion of variable costs in the three systems. The obtained result shows that fish feed costs ranges between 76% in tilapia monoculture and 60% in tilapia polyculture practices. On the other hand fertilizers cost was noticeably higher in polyculture (4.8%) compared to tilapia plus mullet (1.8%) and tilapia monoculture systems (0.7%). Cost of fertilization showed opposite trend to feed costs in the three culture practices. As farmers adopting monoculture systems rely more on feeding and use less fertilizers compared to polyculture systems where producers increase fertilizers application rates to reduce feed costs. The result showed that the highest variable cost per feddanper year were in monoculture system EGP 26,010followed by polyculture EGP 20,649and then tilapia plus mulletEGP 22,792. Salary costs of farm staff ranged from 5.6% of VC in polyculture system to 9% in tilapia plus mullet systems. The result showed that salary cost was noticeably higher in tilapia plus mullet compared to polyculture or monoculture. The high level of variable cost in monoculturewas due to the significant high yieldoftilapia monoculture farms4.19 t/fed and higherAFCRs under this system resulting in the use of more fish feed and consequently leading to increasedvariable costs compared to the other culture systems.

Variable costs as % of total costs were similar in the three culture practices and ranged between 91.7- 93.6% of total costs. Similarly fixed costs represent 6.5 to 8.3% of total costs. The highest fixed costs were for land rent followed by depreciationof equipment and then repairs and maintenance. Similar results werereported by Macfadyen et al. (2012), who found that the variable cost of pond culture systems represented 92% of total costs. Also, Green et al. (2002) reported that variable costs represented 82% and fixed cost represented 18% of total cost for tilapia monoculture ponds. While in a study of tilapia hatcheries in Egypt, Nasr-Allah et al. (2014) reported that variable cost represented 80% and fixed costs represent 20% of total costs.

Table 3 Production costs in the three earthen pond culture systems.

	Tilapia monoculture		Tilapia plusmullet		Tilapia polyculture	
	Cost	% of total	Cost	% of total	Cost	% of total
1. Return						
Fish sales (EGP/fed)	36,996		32,188		29,286	
2. Variable costs (EGP/fed)						
Seed	1,935	7.4%	2,290	11.1%	3,829	16.8%
Feed	19,857	76.3%	13,595	65.8%	13,614	59.7%
Fertilizers	179	0.7%	382	1.8%	1,094	4.8%
Power	1,041	4.0%	855	4.1%	1,160	5.1%
Salaries	1,587	6.1%	1,853	9.0%	1,278	5.6%
Wages	486	1.9%	505	2.4%	343	1.5%
Transportation	70	0.3%	72	0.4%	181	0.8%
Sales commission	751	2.9%	928	4.5%	1,063	4.7%
Ice	36	0.1%	36	0.2%	128	0.6%
Other	68	0.3%	133	0.6%	101	0.4%
Total Variable costs	26,010	100%	20,649	100%	22,792	100%
3. Fixed costs (EGP/fed)						
Financial charges	35	1.8%	32	2.3%	34	1.6%
Governmental charges	21	1.1%	26	1.8%	24	1.2%
Repairs and maintenance	371	19.1%	201	14.1%	302	14.6%
Land rent	1,126	58.0%	796	55.9%	1,423	68.6%
Depreciation	388	20.0%	369	25.9%	290	14.0%
Total fixed costs	1,941		1,424		2,073	
4. Total costs (EGP/fed) (2+3)	27,951		22,074		24,865	

Source: Survey data.

3.4.Financial performance

The financial performance of the three culture strategies issummarized in Table 4. However, total costs varied significantly (P<0.05) between culture practices.Both variable and fixed costs did not vary significantly between culture systems (P>0.05). The highest income above VC were in tilapia plus mullet followed by monoculture and the lowest werepolyculture systems (11,539, 10,985 and 6,494EGP/fed, respectively) with no statistical significance difference (P>0.05). Average operational profits as percentage of sales were significantly higher (P<0.05) in tilapia plus mullet 35.8%, followed by monoculture 29.7% and the lowest was polyculture 22.2%.Obtained results agree with Macfadyen et al.(2012) resultswho stated that on average profit above operation cost reached 29% in Egyptian fish farms. El-Naggar el al. (2008) reported lower return on operation cost (19%) in fish farms in Behera governorates of Egypt.

Income above total costs followed the same pattern as income above variable costs with no significant difference between systems. Feed cost per kilogram of fish yield (EGP/kg) was the highest in monoculture followed by tilapia plus mullet and then polyculture (4.945, 4.37 and 4.198EGP/kg, respectively) with no significance difference (P>0.05) between culture systems.Lower feed cost per kg fish (EGP 3.87/kg) reported by El-Naggar et al.(2008) in Behera farms where most of producers adopting tilapia plus mullet culture strategies.

The break-even price to cover both variable and fixed costs followed the same pattern and didnot vary significantly between systems(P>0.05). On the other hand break-even yields to cover total costs varied significantly between systems (P<0.05). The highest break-even yield to cover TC was in tilapia monoculture, followed by polyculture and then tilapia plus mullet (3.183, 2.796 and 2.208 t/fed, respectively). The result shows that highest safety margin is in tilapia plus mullet and the lowest is in polyculture with significance difference between culture systems (P<0.05). Similar result of break-even yield to cover TC in Behera was 2.174 t/fed reported by (El-Naggar et al., 2008).

Table 4 Financial performance of the different tilapia culture systems.

	Tilapia monoculture	Tilapia plusmullet	Tilapia polyculture
Gross return (1000 EGP/fed)	36.996±2.9[b]	32.188±1.4[ab]	29.286±2.2[a]
Variable costs (1000 EGP/fed)	26.010±1.9[a]	20.649±1.2[a]	22.792±2.5[a]
Income above VC (1000 EGP/fed)	10.985±2.3[a]	11.539±1.3[a]	6.494±1.3[a]
Operational profit as % of sales	29.7±3.84[ab]	35.8±3.8[b]	22.2±4.0[a]
Fixed costs (1000EGP/fed)	1.941±0.3[a]	1.424±0.2[a]	2.073±0.5[a]
Total costs (1000EGP/fed)	27.951±1.9[b]	22.074±1.2[a]	24.865±2.7[ab]
Income above TC (1000 EGP/fed)	9.044±2.2[a]	10.114±1.3[a]	4.421±1.3[a]
Feed cost (EGP/Kg)	4.945±0.4[a]	4.37±0.2[a]	4.198±0.4[a]
Break-even price to cover VC (EGP/Kg)	6.498±0.4[a]	6.67±0.3[a]	6.958±0.4[a]
Break-even price to cover TC (EGP/Kg)	7.073±0.4[a]	7.188±0.3[a]	7.648±0.3[a]
Break -Even yield to cover TC (t/fed)	3.183±0.2[b]	2.208±0.2[a]	2.796±0.3[ab]
Safety Margin (%)	24.4±4.3[ab]	31.4±3.09[b]	15.1±3.93[a]

- Means in the same rows with different superscripts are significantly different (P<0.05).
Source: calculated from table (2) and table (3).

3.5.Sensitivity analysis

Egyptian fish farmers are facing problems due to increasing production input costs (feed, fuel and seed) and declining sales prices (Macfadyen et al., 2012; Nasr-Alla et al., 2012). Sensitivity analysis was performed to measure the financial performance of the three systems in case of further increasing in operating costs or decreasing fish sales prices. Table 5 shows in detail result of sensitivity analysis for the three culture system against increasing production cost by 10 or 20% combined with reduction of selling price by 10 or 20%.

The result of sensitivity analysis showed that all three pond culture systems would still generate positive net returns even if variable costs increased by 20% at current selling prices. Also the three systems still generated positive income when selling prices reduced up to 20% if production costs remained at current levels.

Moreover, the three culture strategies can generate positive income when operation costs increased by 10% and selling price decreasedby 10%. But, when fish sales prices were 20% less than current levels and operating costs were increased by 20%, only the tilapia plus mullet systems could still generate profits, while the monoculture and polyculture systems showed negative net farm income.

Sensitivity analysis results agree with the results reported by Green et al. (2002), who foundthat a 20% reduction in fish selling prices combined with increasing cost by two standard errors, for traditional Egyptian pond farming would lead to negative net returns. On the other hand, Egyptian tilapia hatcheries are able to make positive net return when production costs increase 20% and seed selling price decline by 20% (Nasr-Allah et al., 2014). This result indicates that tilapia hatcheries are able to tolerate financial shook more than pond culture systems in Egypt. The current analysis concludes that among pond culture practices in Egypt, the tilapia plus mullet culture strategy is able to tolerate financial shock more than monoculture and polyculture earthen pond culture practices.

Table 5 Sensitivity analysis of changes in sale prices and variable costson net farm income(EGP/year) under different culture systems.

		Changes in operating costs		
	Changes in sales prices	**0**	**+10%**	**+20%**
Tilapia monoculture	0	10,986	8,385	5,784
Tilapia plusmullet	0	11,539	9,474	7,409
Tilapia polyculture	0	6,494	4,215	1,936
Tilapia monoculture	-10%	7,816	5,215	2,614
Tilapia plusmullet	-10%	8,925	6,860	4,795
Tilapia polyculture	-10%	3,776	1,497	-782
Tilapia monoculture	-20%	4,057	1,456	-1,145
Tilapia plusmullet	-20%	5,639	3,574	1,509
Tilapia polyculture	-20%	824	-1,455	-3,734

Source : calculated from table (3) and table (4).

3.6.Production Function Model

The results of exponential production function models for the three production systems are presented in detail in table 6. Production function estimate showedthat fourparameters effecting on fish yield positively on yield in the three culture systems. The analysis revealed that stocking densityand quantity of fish feed per feddanare significant factors contributing to increase fish yield in monoculture systems. In tilapia plus mullet systemsstocking density, quantity of feed per feddan and fixed costs are significant factors contributed to increased fish yield. In polyculture systems,stocking density and quantity of feed per fed contributed significantly to increased fish yield at 5% significant level. Quantity of fish feed per feddan contributed significantly to increase fish yield in the three culture systems at 5% significant levels.Similar result reported by El-Naggar et al. (2008) who found that increasing stocking rate contributed significantly to increased earthen pond farms income in Behera governorates in Egypt. Dey et al. (2005) reported that increasing feed cost lead to significant increase in yield in semi-intensive fish farms in China (growing tilapia and carp). Also, they reported that in selected Asian countries (China, India, Thailand and Vietnam) increasing stocking density lead to significant increase in fish yield.

Current study result indicate that a unit increase in quantity of fish feeds per fedwill lead to an increase in fish yields per fed in the monoculture, tilapia plus mullet and tilapia polyculture systems at rate of 0.734, 0.461 and 0.361 percent, respectively. Also, the result indicates that a unit increase in stocking density will lead to positive increase in yield in the three culture systems. These findings give an insight into thoughts of farm operators in the three different systems to what are the factors which contribute to increasing fish yield. Fish feed is an indispensable variable resource in Egyptian fish farming pond culture systems. More so, parameter estimated like stocking number found to be positive indicating a positive increase with a unit increase in the factor in the three culture systems, though significant at only 10% in monoculture system. Meanwhile, the adjusted R2 of about 90 percent implies that 90 percent of the total variation in dependent variable (endogenous variable) is being explained by the explanatory variables in polyculture system. Similarly, the F-value of 24.156 being significant at 1% is also an indication that the model has a good fit to justify the factors influencing the fish farming operations in the study area. On the other hand in monoculture and tilapia plus mullet systems adjusted R2 is only 52 and 33% and F-value are5.4and 4.3 and being significant at 1% as indication that variables in this models affect significantly on yield but they are not the only variables affecting on yield.

Obtained result agree with Hebicha et al. (2013) findings, who reported that in tilapia pond in Fayoum increasing quantity of feed lead to significant positive increase in yield. Furthermore, they reported that increasing Initial stocking weight lead to positive increase in yield but significant only at 10%. Similar result reported Asamoah et al. (2012) reported that increasing feed use lead to positive increase in fish yield with no significant effect. They also found that increasing stocking rate lead to significant increase in fish yield.Also, Ahmed et al. (1996) found that stocking density is significantly influenced tilapia output in small water bodies in Bangladesh.

Return to scale: The sum of output elasticity in the C-D production model is (ε=0.92) in monoculture and (ε=0.84)in tilapia and mullet. This indicates that on average those farmers have diminishing return to scale. This could be simplified as 1% decrease of all factors input, yield output will decrease by 0.92% in monoculture or 0.84% in tilapia plus mullet and producers still making profit. Similar diminishing return reported in tilapia monoculture in Fayoum by Hebicha et al. (2013) and in milkfish culture in Taiwan milkfish culture in Taiwan by Chiang et al. (2004).

Return to scale: The sums of output elasticities in the C-D production models for the three culture systems are (ε=1.47; 1.18 and 1.45) for monoculture, tilapia plus mullet and polyculture systems, respectively.This indicates that on average those farmers have increasing return to scale. This could be simplified as 1% increase of all input factors, yield output will increase by 1.47% in monoculture or 1.18% in tilapia plus mullet and 1.45% in polyculture systems (increasing return to scale). And those producers have high potential for increasing their yield through increasing use of production inputs factors. Similarly, Asamoah et al. (2012) reported that large scale farmers growing tilapia plus catfish or snakehead exhibited increasing return to scale and sum of elasticity was (ε=1.2). On the other hand, diminishing return reported with tilapia monoculture ponds in Fayoum by Hebicha et al. (2013) and in milkfish culture in Taiwan by Chiang et al. (2004).

Table 6 Cobb-Douglas production function estimation for the three culture systems.

	Tilapia monoculture		Tilapia plusmullet		Tilapia polyculture	
	Coefficient	S.E.	Coefficient	S.E.	Coefficient	S.E.
Const.	2.329	2.239	3.051	2.537	0.312	1.016
Sn	0.503*	0.266	0.594**	0.288	0.807***	0.201
Ss	0.123	0.083	1.20	0.089	-0.003	0.075
Fd	0.734**	0.311	0.461**	0.202	0.361**	0.156
Sa	0.134	0.167	-0.201	0.125	0.076	0.192
Fc	-0.023	0.135	0.210*	0.123	0.039	0.078
Return to scale	1.47		1.18		1.45	
Sum square resid.	2.393		5.496		0.239	
S.E. of Regression	0.399		0.443		0.148	
R-Square	0.644		0.435		0.938	
Adjusted R-squared	0.525		0.335		0.899	
F Value	5.418		4.318		24.156	
P-value (F)	0.005		0.005		0.000	

*** Indicates significance at 10% level: **indicates significance at 5% level: ***indicates significance at 1% level.**

Sn: denotes to stocking number (1000/fed)
Ss: denotes to average stocking size (g)
Fd: denotes to quantity of feed (metric tons/fed)
Sa: denotes to salary of staff (EGP/fed)
Fc: denotes to fixed cost (EGP/fed)

Source: calculated from table (3) and table (4).

Conclusion

Although, tilapia plus mullet culture systems produces significantly lower yield and gross return compared to tilapia monoculture systems, the first practicewas able to generate significantly higher safety margin and able to tolerate increasing production cost or decline sales prices. Farmers adopting tilapia plus mullet strategies use resources such as fish feed more efficiently which contributes to reduce operating costs and also benefitting from the high sales price of mullet, leading to higher net returns for farmers.

Furthermore, the study demonstrate thatthe three pond culture strategies exhibited increasing return to scale meaning that yield will increase at higher proportion with increasing operational inputs (stocking rate,using more feed and increased investment in fixed costs). This means that fish producers still able to increase fish yield through increase operational and fixed investment.

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تقييم الأداء الاقتصادي لممارسات استزراع البلطي في أحواض ترابية في مصر

أحمد محمد نصر الله

الملخص

تهدف الدراسة الحالية اى فهم الاداء الاقتصادى لممارسات استزراع البلطى النيلى المختلفة فى احواض ترابية فى مصر. اعتمدت الدراسة على اجراء بحث ميدانى لعدد ستين مزرعة فى اربع محافظات مختلفة. وتم تجميع البينات الاقتصادية لممارسات الاستزراع المختلفة وهى (بلطى منفرد – بلطى مع بورى – بلطى وبورى واسماك اخرى) . تناقش الدراسة الحالية السمات العامة والاداء المالى لممارسات استزراع البلطى تحت الدراسة. وتم ايضا عمل تحليل ميزانية وتحليل حساسية لممارسات التربية المختلفة.

أظهرت الدراسة ان متوسط انتاج البلطى المنفرد (٤,١٩ طن للفدان/ سنة) اعلى معنويا من انتاج البلطى مع البورى (٣,١٤ طن/للفدان/ سنة) او البلطى فى النظام المختلط (٣,٢٧ طن/للفدان/ سنة). واظهرت ممارسات استزراع البلطى مع البورى عائد اعلى على الاستثمار، وكذلك اظهر تحليل الحساسية ان ممارسات استزراع البلطى مع البورى قادرة على تحمل نقص الايراد وزيادة التكاليف افضل من الممارسات الاخرى. واظهرت نتيجة تقدير دالة الانتاج ان زيادة الاستثمار فى علف الاسماك ومعدلات الاستزراع تؤدى الى زيادة معنوية فى الانتاج لجميع ممارسات الاستزراع .

وخلصت الدراسة الى ان استزراع البلطى مع البورى افضل اقتصاديا للمربى من استزراع البلطى المنفرد او الخليط مع البورى واسماك اخرى. وكذلك أظهر تقدير دالة الانتاج زيادة الانتاج بنسبة اعلى من زيادة مدخلات الانتاج لممارسات استزراع البلطى تحت الدراسة وبالتالى يمكن تعظيم الانتاج لمزارع البلطى بزيادة الاستثمار فى مدخلات الانتاج مثل الاعلاف والزريعة والتكاليف الاستثمارية.