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The Effect of Pond Soil Types and Stocking Weight of *Mugil capito* Fingerlings Reared in Poly-culture System on Production Performance

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ABSTRACT

The research is target to study the effects of pond soil types (sand and clay) and initial body weight of *Mugil capito* fingerlings on their growth performance, survival, production and profitability. It was used in the rearing poly-culture system of Nile tilapia (*Oreochromis niloticus*) with carp's species (common, silver and grass carps). Water quality results revealed that the T °C, salinity, pH ammonia and DO for SSP and CSP were in the appropriate limits Moreover, the water quality in CSP was better in quality and quantity of phytoplankton and zooplankton, were total numbers of phytoplankton community and zooplankton populations were higher in water samples collected from CSP stocked with *M.capito* SIW comparing with those collected from SSP, while the highest value recorded in CSP stocked with LIW. Fish performance parameters revealed that the final fish body weight, individual weight gain, average daily gain, specific growth rate, survival percentage and fish production were better in CSP than SSP. Moreover, results detected that the all growth parameter were the highest in CSP under stocking LIW of *M.capito* than SIW. The evaluation economic efficiency showed that CSP achieved the best revenue and the best growth and production performances. It can be concluded that, the all ponds are economically profitable and the revenue could cover the costs of production, but the LIW *M.capito* culture in CSP possessed the best economical profitability parameters than SIW fish culture in CSP and SSP.

INTRODUCTION

Egypt faces a rapid increase of population growth in recent years. This high population growth rates will exaggerate the problems associated with food sector allocation and specify of protein. Fish is an important and the cheapest source of animal protein. It provides approximately 16% of the animal protein consumed by the world population. Fish is particularly an important protein source in require where livestock is relatively scarce. Billions of people mostly in developing countries depend on fish as a primary source of animal protein (Omeru and Solomon 2016). Also, it relieves the strain on wild species to allow them to continue to be a significant source (Mutter 2011).

Therefore, aquaculture is considered to be the only possible solution to increase fish productions, which lead to reduce the gap between production and consumption of protein (FAO 2016). In Egypt the most fish farms practice poly-culture with tilapia (*Oreochromis niloticus* and *Oreochromis aureus*); mullets (*Mugil cephalus* and *Mugil capito*); seabass (*Dicentrachus labrax*) and seabream (*Sparus aurata*). In addition, mullet is one of the most popular fish group in Egypt, they are second only to tilapia (GAFRD 2015).

Furthermore, the *Mugil capito* is the second choice in the aquaculture of mullet, constitutes the majority of the aquaculture harvest of mullet in Egypt. The availability and abundance of the wild fry of this species as compared to those of *Mugil cephales* makes it the dominant aquaculture species (Sadek and Mires 2000; Saleh 2008).

Also, Mullet have number of biological characteristics make excellent for culture: 1) They can be cultured in sea, brackish and fresh water areas. 2) They feed on planktonic and suspended matter, this feed is low price. 3) They rate grow rapid and market demand (Sadek 2010; Essa *et al*. 2012 and El-Ebiary *et al.* 2015).

Water quality management has been considered one of the most important aspects of pond aquaculture for many years, but the condition of bottom pond and the exchange of substances between soil and water can be strongly affect and affected water quality. Soil quality is an important factor in fish pond productivity as it controls pond bottom stability. Therefore, the management must attention by quality of bottom pond (Siddique 2012).

The present research aim to considerable emphasis has been focused on how to reach the most appropriate conditions for the *Mugil capito* culture which possess the best fish performance through study the effects of pond soil type (sand and clay) and initial body weight of *Mugil capito* fingerlings on their growth performance, survival, production and profitability; reared under poly-culture system with Nile tilapia (*Oreochromis niloticus*) and carps species (common, silver and grass carps).

MATERIALS AND METHODS

1. Experimental Ponds and Fish:

The present study was performed for 7 month in earthen ponds at El-Max Research Station, National Institute of Oceanography and Fisheries, Alexandria, Egypt.

The experiment was conducted in two replications slightly brackish water (4.2 ppt.) earthen ponds with sand soil pond bottom (SSP) and clay soil pond bottom (CSP) of 2.30 acre (feddan) each stocked with small initial weight (SIW) and large initial weight (LIW) of *Mugil capito* fingerlings in CSP to study the effect of pond soil type, on the growth, production performance and survival percentage of *Mugil capito* fingerlings with mean initial weight of 2.87 g , reared in poly-culture system with Nile tilapia (*Oreochromis niloticus*) with initial weight 21.55 g and carps species (common carp

Cyprinus carpio, silver carp *Hypopthalmithys molitrix* and grass carp *Ctenopharyngodon idella*) with mean initial weights of 4.65, 0.87, 41.87g respectively.

Furthermore the experiment was conducted in CSP aimed to study the effect of stocking weight on the growth and production performance, survival, rate as well as profitability of *M. capito* with large mean initial weights 12.54 g, reared in the same previous poly-culture system. The stocking rate was 11,750 fries/ feddan with 76% *T. nilotica*, 17% *M. capito* and 7% Carps species.

All experimental fish were fed a commercial diet with 19.75% crude protein and 4357.2 kcal gross energy/kg diet (Table 1). Feed was distributed in the pelleted form of 3.0 mm (sinking pellets) at a rate of 3% of total biomass/day (6 days/week), two times daily (10.00 a.m. and 14.00 p.m.). A monthly fish sample was captured, weighted to adjust the feed quantity.

Table 1: The Composition and Chemical Analysis of the Commercial Diet is Used for Fish Feeding during the Experiment in Earthen Ponds.

Ingredients	**% composition**
Fish meal menhaden (64% CP)	5
Soya bean (44% CP)	25
Wheat bran meal (15% CP)	30
Rice bran meal (12%)	22
Yellow corn (8%)	10
Sesame meal (20%)	5
Di calcium phosphate	2.5
Vitamin premix*	0.15
Mineral premix**	0.15
Yeast	0.2
Chemical analysis	
Dry matter (DM %)% on DM basis:-	90.85
Crude proten	22.51
Ash	6.83
Ether Extract	6.22
Crude fiber	3.83
Nitrogen free extract	60.61
Gross energy kcal/kg	4356.7
P/E ration g/kcal	5.1

* Vitamin premix supplied the following in mg/kg premix:

Vitamin A, 6000000 1U; vitamin D_3, 6000000 IU; vitamin E, 5000 mg; vitamin K, 500 mg; vitamin B_1, 100 mg; vitamin B_2, 100 mg; vitamin B_{12}, 25 mg; vitamin C, 10000 mg; Niacin, 2000 mg; calcium pintotheniate, 5000 mg; Folic acid, 1000 mg and BHT, 20000 mg

** Mineral premix/kg: 60 g manganese, 55 g Zinc, 30 g Iron, 4 g copper, 1 g selenium, 1 g cobalt, 3 g Iodine and 850 g carbonate calcium.

2. Analytical methods

2.1. Water quality:

Physico-chemical parameters (temperature, dissolved oxygen, pH, and salinity) were determined daily at 8:00AM, while ammonia was monitored once a week according to (Boyd, 1996). The quantitative and qualitative evaluations of phytoplankton and zooplankton standing crops were determined also according to (Boyd and Tucker, 1998**)**.

2.2. Commercial diet analysis:

Commercial diet sample was analyzed for dry matter (DM), crude protein (CP) ether extract (EE), ash and energy contents according to (AOAC, 2000).

2.3. Growth and production performance parameters:

Body weight gain (BWG), average daily gain (ADG), specific growth rate (SGR), survival rate (%), condition factor (K) and total biomass at harvest were conducted according to (Lagler, 1956; Castel and Tiewes, 1980).

2.4. Economical evaluation:

The Input costs, returns and some evaluating performance parameters: percentage of operating, return on revenue, revenue on costs, and rate of return as a % of total inputs, were used to identify the current operating economics of culture *M. capito* in poly culture system experimental ponds, were determined according to (Scott *et. al*., 1993; Helal and Essa, 2005).

2.5. Statistical analysis:

Data of the experiments were statistically analyzed by using analysis of variance using the General Linear Model (GLM) (SAS software). Differences were considered significant at $P<0.05$. Comparisons between treatments means were conduct according to Least Significant Differences test (L.S.D).

RESULTS AND DISCUSSION

This experiment was conducted to evaluate the effects of pond bottom soil type [sand soil pond (SSP) and clay soil pond (CSP)], more over study the effect of SIW and LIW of stocking *M.capito* in CSP on growth and production performance. As well as economic feasibility study under poly-culture pond farm management conditions.

1. **Water quality criteria:**

The averages of water quality criteria in experimental ponds at El-Max Research Station are shown in Table 2. The results indicated that there were no significant differences in physicochemical water quality parameters in different pond bottom soil types (SSP and CSP). The results revealed that the T °C, salinity, pH ammonia and DO for SSP and CSP were in the appropriate limits for fish farming as reported by (Boyd, 1990 ; Wurts, 2003).

Moreover, the water quality in CSP was better in phytoplankton and zooplannkton. Phytoplankton and zooplankton density results recorded that the number of species more productive in CSP than the SSP. This may be attributed to increasing organic matter in CSP. These results agree with (Boyd, 1996), who reported that, clay soil is suitable for aquaculture more than sandy soil because it is rich in nutrients (phosphorus, nitrogen, organic carbon etc.).

The phytoplankton community in CSP or SSP dominated with diatoms (Bacillariophyces), chlorophytes (Scenedesmus, Ankistrodesmus and Tetraedron). Dinophyceae appeared in small numbers. Also, the results revealed a clear difference where it reached 21, 724, 546 unit/L and 112, 275, 461 unit/L in CSP, while in SSP it reached 10, 421, 348 unit/L respectively as shown in (Table 2).

Table 2: Physicochemical and Biological Parameters Recorded in Water of the Experimental Earthen Ponds.

Item	Sand Soil Pond (SSP)	Clay soil ponds (CSP)	
		***M.capito* with SIW**	***M.capito* with LIW**
Temperature (°C)	21.56±1.04	22.56±1.04	22.06±1.04
Salinity (mg/l)	4.22±0.11	4.24±0.11	4.24±0.12
pH	8.32±0.06	8.43±0.06	8.36±0.08
Ammonia (mg/l)	0.04±0.01	0.07±0.01	0.04±0.01
DO (mg/l)	5.97±0.10	6.08±0.11	6.03±0.09
Total phytoplankton (unit/l)	10,421,348	21,724,546	112,275,461
Total zooplankton (org/m^3)	8864	29923	292461

In all experimental ponds, the zooplankton population was mainly dominated with Rotifera, Copepoda and Protozoa. Also, it showed also a clear difference where it reached 29923 and 29246 in CSP, while in SSP it reached 8864 organism/m^3 respectively (Table 2).

Furthermore, the results revealed that the total numbers of phytoplankton community and zooplankton populations were higher in water samples collected from CSP stocked with *M.capito* SIW comparing with those collected from SSP. The phytoplankton population was highest in water samples collected from *M.capito* ponds stocked with LIW. These results clearly indicated that numbers of plankton communities, mainly phytoplankton, in fish ponds were affected greatly by the initial fish body sizes

(Table 2). These results may be attributed to the feed consumption rate which was higher in large size fish especially for the filter feeders fish such as: *M.capito*, tilapia and silver carp. These results were agreed with the findings of (Bakeer *et al.*, 2008). Helal *et al.*, 2017 reported that high level of ammonia, nitrite, nitrate and BOD as a result of organic residues including uneaten feed containing high percentage of protein 30%, feaces and dead algae which settle to the pond bottom. The excessive organic matters are converted into nutrients; they enable proliferation of high algal level which causes high level of eutrophication.

2. Fish performance parameters:

The results in Table 3 indicated that there were significant differences ($P< 0.05$) in the growth and production performance parameters between *M.capito* reared in CSP and SSP under poly-culture condition with Nile tilapia and carps fish species.

Results revealed that the final fish body weight, individual weight gain, average daily gain, specific growth rate and survival percentage were 162.71 g, 150.17 g, 0.64 g/fish/day, 1.10 %/day and 42.95 % for *M.capito* stocked with LIW respectively and in SIW stocked was 109.36g, 106.49g, 0.45 g/ fish/day, 1.50%/day and 51.38% respectively. While, the result in SSP revealed that 98.22g, 95.35g, 0.40g/fish/day, 1.55%/day and 27.49%, respectively means that the all parameter were better in CSP than SSP. Moreover, results detected that the all growth parameter were the highest in CSP under stocking LIW of *M.capito* than SIW.

Furthermore, the results exposed that the positive vulnerable values of final fish body weight for Nile tilapia, silver and grass carps to grew better in CSP than in SSP which were 142.739, 735.86 and 327.40g in CSP stocked with LIW *M.capito* and 127.11, 989.08 and 362.36g in CSP stocked with SIW *M.capito* comparing the lowest value 100.34, 850.60 and 217.23g in SSP.

Also, fish production were increased in CSP than in SSP management conditions, and as a result the overall total production in CSP poly-culture conditions were 1524.72 kg/feddan and 1258.4 kg/feddan at LIW and SIW respectively, while the corresponding result in SSP was only 836 kg/feddan as shown Table 3. While the fish production for common carp were 579.0, 457.44 and 540.07g respectively, it is clear that the difference between the three cultures systems were slightly differences.

Table 3: Growth and Production Performance Parameters of *M.capito* Reared in Poly-Culture System with Nile Tilapia as Well as Carps Species in CSP and SSP*

			Final fish body weight (g)	Individual av. total weight gain (g)	Average daily weight gain (g/fish/day)	Total biomass at harvest (kg/fed.)	Specific growth rate %/day	Survival rate (%)	Condition factor (K)
SSP		*M.capito*	98.22±0.14^{b}	95.35±1.26^{b}	0.40±0.01^{b}	54	1.55±0.01^{a}	27.49±2.53^{b}	0.86±0.00^{a}
		Nile tilapia	100.34±0.52^{b}	95.69±0.25^{b}	0.41±0.00^{b}	528.4	1.30±0.00^{b}	44.24±0.82^{b}	1.69±0.00^{a}
		Common carp	540.07±1.49^{a}	539.2±9.98^{a}	2.28±0.04^{a}	191.6	2.70±0.01^{a}	88.69±7.67^{a}	1.77±0.01^{a}
		Silver carp	850.60±1.08^{b}	808.73±2.29^{b}	3.43±0.01^{b}	36	1.30±0.00^{a}	84.65±9.08^{a}	1.33±0.00^{b}
		Grass carp	217.23±0.77^{b}	195.68±1.05^{b}	0.83±0.01^{b}	26	1.00±0.00^{b}	59.84±3.61^{a}	1.14±0.00^{b}
		Total (average)	**(361.29±146.53^{B})**	**(346.93±141.34^{B})**	**(1.47±0.60^{A})**	**836**	**(1.57±0.30^{A})**	**(60.98±11.69^{B})**	**(1.36± 0.17^{A})**
CSP	SIW	*M.capito*	109.36±0.13^{b}	106.49±0.74^{b}	0.45±0.00^{b}	112.4	1.50±0.01^{a}	51.38±3.06^{b}	0.96±0.00^{a}
		Nile tilapia	127.11±0.74^{a}	122.46±1.28^{a}	0.52±0.01^{a}	882	1.40±0.01^{a}	75.42±3.30^{a}	1.73±0.00^{a}
		Common carp	457.44±1.24^{b}	456.57±4.70^{b}	1.93±0.02^{b}	178.4	2.70±0.01^{b}	97.49±1.16^{a}	1.58±0.00^{a}
		Silver carp	989.08±2.28^{a}	947.21±1.46^{a}	4.01±0.01^{a}	38.4	1.30±0.01^{a}	77.64±1.03^{b}	1.37±0.00^{a}
		Grass carp	362.36±1.04^{a}	340.81±2.86^{a}	1.44±0.01^{a}	47.2	1.20±0.01^{a}	65.12±2.22^{a}	1.21±0.00^{a}
		Total (average)	**(409.07±159.73^{A})**	**(394.71±153.16^{A})**	**(1.67±0.65^{A})**	**1258.4**	**(1.62±0.27^{A})**	**(73.41±7.60^{A})**	**(1.37±0.14^{A})**
	LIW	*M. capito*	162.71±0.25^{a}	150.17±0.02^{a}	0.64±0.00^{a}	275.2	1.10±0.01^{b}	42.95±1.03^{b}	0.91±0.00^{a}
		Nile tilapia	142.73±0.80^{a}	138.08±3.03^{a}	0.59±0.01^{a}	957.92	1.50±0.01^{a}	84.56±0.77^{a}	1.72±0.00^{a}
		Common carp	579.00±2.64^{a}	578.13±3.30^{a}	2.45±0.01^{a}	217.6	2.80±0.01^{a}	93.95±2.40^{a}	1.73±0.00^{a}
		Silver carp	735.86±2.46^{b}	693.99±2.63^{b}	2.94±0.01^{b}	36	1.20±0.00^{b}	97.84±1.19^{a}	1.27±0.00^{b}
		Grass carp	327.40±0.70^{a}	305.85±4.89^{a}	1.30±0.02^{a}	38	1.20±0.01^{a}	58.03±0.86^{a}	1.25±0.00^{a}
		Total (average)	**(389.54±116.63^{A})**	**(373.24±112.80^{A})**	**(1.58±0.48^{A})**	**1524.72**	**(1.56±0.32^{A})**	**(75.47±10.69^{A})**	**(1.38±0.16^{A})**

*In the same column, different superscripts indicated significant differences ($p < 0.05$).

These results indicate that, production performance parameters increased with the increase of fish size at stocking These results agreement with trends was observed for grey mullet (*M. cephalus*) by (Eid, 2006; Bakeer *et al*., 2008). These results might be due to the feed efficiency was increased in large juvenile than small juvenile fish (Sund *et al*., 1998). Also, ammonia excretion of smaller size fish was higher than that of the large size fish (Liu *et al*., 2009). These results may be attributed to CSP are richer in phytoplankton and zooplankton than SSP as shown in (table 1) both in density and number of species which constituted the major natural food for *M.capito*, Nile tilapia, silver and grass carps.

According to Kumar *et al*., (2005) they reported that *M.capito*, Nile tilapia and silver carp have been primarily described as filter feeders, fed on phytoplankton and zooplankton such as diatoms, Scenedesmus, Ankistrodesmus, rotifers, protozoa, copepoda as well as animals and plants detritus. Therefore, fish cultured in CSP recorded higher condition factor value than those in SSP (Table 3) which mean the suitability of the environment to fish growth and survival percentage. Boyd (1996) reported that, clay soil is suitable for aquaculture more than sandy soil due to rich in nutrients (phosphorus, nitrogen, organic carbon etc.).

It can be concluded that *M.capito* grows in poly-culture system with *T. nilotica* and carps species significantly better when fish stocked with LIW (12.54g) than when stocked with SIW (2.87g). The same trends were observed also by (Eid, 2006; Bakeer *et al*. 2008) for grey mullet (*Mugil cephalus*) and Vargasmachuca *et al.* (2007) reported that the average final body weight and the mean weekly weight gain of spotted rose snapper (*Lutjanus guttatus*) were significantly higher ($P<0.05$) in sub-adults (mean initial body weight 110 g) compared to small juvenile (24.5 g) and juvenile (55.4 g).

3. Economic efficiency and evaluation:

Table 4 showed that the most important features of the economic analysis and evaluation of income and costs for *M.capito* fingerlings, reared in poly-culture system in SSP and under different stocking weight in CSP management conditions. The results showed that CSP achieved the best revenue (14018.7 LE/fed. And 10273.6 LE/fed.) and net income were (6644.22 LE/fed. and 3934.96 LE/fed.) in LIW and SIW respectively in CSP compared to that in SSP were (6609.4 LE/fed. and 318.92 LE/fed.) for revenue and net income respectively. The results achieved the CSP was the best growth and production performances.

The economic evaluation parameters in Table 4 showed also that**,** the ponds were all economically profitable and revenue could cover the costs of production, but CSP possessed the best economical profitability parameters than SSP. Moreover a LIW achieved the best performance for growth and production compared with SIW fish in CSP and SSP. Silphman (2004) reported that, pond soil is considered a key factor in aquaculture production and profitability, clay and sandy loam soils gave the highest production than sandy soil.

Table 4: The Most Important Features of the Economic Analysis and Evaluation for *M.capito* Reared in Poly-Culture System With Nile Tilapia as Well as Carps Species in CSP and SSP.

Item	**SSP**	**CSP**	
		SIW	**LIW**
a) Features of the economic analysis			
Size of pond (fed.)	2.5	2.5	2.5
Average fish production (kg/fed.)	836	1258.4	1524.7
Average operational costs (LE/fed.)	6290.48	6338.64	7374.48
Average revenue (LE/fed.)	6609.4	10273.6	14018.7
Average net income (LE/fed.)	318.92	3934.96	6644.22
b) Economic evaluation parameters			
Operating ratio (%)*	95.17	61.7	52.6
Return on sales (%)	4.83	38.3	47.4
Return on costs (%)	105.07	162.08	190.1
Rate of return as a % of total inputs	5.07	62.08	90.1

***** Increases the value of this criterion indicates declining of its economic efficiency.

From the results of the economic criteria for evaluating the performance and effectiveness of the fish ponds, it can be concluded that, the all ponds are economically profitable and the revenue could cover the costs of production, but the LIW *M.capito* culture in CSP possessed the best economical profitability parameters than SIW fish culture in CSP and SSP. This may be attributed to; size grading used in the culture of many fish species in an attempt to improve growth, survival, production and profitability (Kamstra, 1993; Bilal *et al*, 2002).

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