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Effect of stocking densities of grey mulle (*Mugil cephalus*) reared on natural food in monoculture earthen ponds on growth performance and total production with economical evaluation

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ABSTRACT

Growth performance, total fish yield and economical evaluation of the grey mullet *Mugil cephalus* (L.) at different stocking densities were compared in monoculture system without any supplementary feeding. Four stocking densities at rate of 1050, 1400, 2100 and 4200 fish/feddan (0.42 ha) for treatments, T_1, T_2, T_3 and T_4 respectively, were carried out in eight freshwater earthen ponds. Ponds were fertilized with organic and inorganic fertilizers, (60 kg; chicken manure, 30 kg. super phosphate and 10.0kg urea per feddan biweekly). Results indicated that the main individual growth rate was highest for lower density and lowest for the higher density. Final body weight was 231.86, 182.82, 151.19 and 91.65 g /fish for T_1, T_2, T_3 and T_4 respectively, with significant difference ($p<0.05$).

Final body length, SGR (%), RGR (%), daily weight gain, survival rate, condition factor, economic evaluation and sensitivity analysis were discussed. Total fish production values at the end of experimental period (180 days) were 233.7, 236.8, 273.0 and 313.9 kg. / feddan (0.42 ha.) for T_1, T_2, T_3 and T_4 respectively.

It could be concluded that treatment (T_1) that received the lowest stocking density at the rate of 1050 grey mullet *Mugil cephalus* fingerlings per feddan (0.42 ha.), without any supplementary food, and cultured for 180 days in monoculture system, had the highest net return and rate of return, followed by T_2 and T_3, which can reduce the risk for the farmer in the event of unexpected fall in market price or production or increasing of costs.

Key words: Monoculture, grey mullet, *Mugil cephalus*, growth performance, earthen ponds, total production, economic evaluation and sensitivity analysis.

INTRODUCTION

Mullet are an extremely important fish which are cultured in many countries, particularly in the Mediterranean (Smith and Swart, 1998). They feed at the lowest trophic levels on plant detritus and algae (Oren, 1981).

Striped grey mullet is long considered to feed primarily on detritus, however recent researches has indicated that they obtain much of their food from plankton, (Cardona, *et al;* 1996).

Mullet are well suited for farming since they feed on algae, diatoms, small crustaceans, decayed organic matter and mud; hence there is a little need to feed (Swart, *et al;* 2001). Also, they were mainly detritivorous and shifted to zooplankton (Blanco, 2003).

Mugil cephalus is one of the most important mullet species for culture purposes. This due to high quality flesh, superior growth, large maximum size and wide salinity and temperature tolerance, (Smith and Swart, 1998).

As known, fertilization and supplementary feeding led to best growth rate of *M.cephalus* compared to supplementary feeding only (Abd-El-Tawab and Yones, 2001). It means that striped mullet could utilize both supplemental and / or natural food, (Abdel-Tawwab *et al*, 2005). But, the availability of natural feed increased the growth of *M. cephalus* by 20.7 % in absence of supplementary preferable feeding (Essa, *et al*, 1989).

The fry *Liza ramada, L. aurata, L. saliens, Chelon labrosus* and *Mugil cepahlus* in a lagoon in NE Spain fed mainly on zooplanktonic crustacean, such as cyclopaids, clnoids and cladocerans, but adult chironomids were also important. (Gisbert, *et al.,* 1995).

Flathead grey mullet enhanced phytoplankton development due to the removal of large cladocerans and not as consequence of nutrient release. Furthermore, they strongly modified the benthic community, probably due to direct predation, (Torras *et al*., 2000).

Jana *et al*; (2004) reported that a periphyton-supported aquaculture system can be used successfully for the culture of herbivorous brackish water fish species like *Mugill cephalus* in inland saline ground waters and thus could contribute to the development of sound and sustainable aquaculture technology.

Grey mullet obtain food from the benthos and plankton and they dramatically affect plankton and benthos composition. So, in the presence of grey mullet, rotifers density was low, cladocerance were completely absent and small phytoplankton were very dense (Cardona, *et al*., 1996).

Grey mullet could be cultivated in monoculture system or poly-culture system. So, it was found that when the striped mullet reared in monoculture and in lower density, they had greater growth and weight gain (Scorvo *et al*., 1995).

Eid, (2006) found that the optimum stocking density of grey mullet *M. cephalus* is about 10000 fish /feddan (0.42 ha.) in fertilized brackish water ponds with artificial feeding. But, Bakeer (2006) reported that the best stocking rate of grey mullet *Mugill cephalus* fingerlings during rearing period 32 weeks in brackish water ponds was 2 fish / m^3 under fertilization and artificial feeding.

In polyculture system, *Oreochromis niloticus* was stocked with *Mugil cephalus* at stocking density of 8000 fish / fed. (0.42 ha.), at different ratio (60:40, 70:30, 80:20 and 90:10). The best mixed species ratio was 70 % of

O.niloticus and 30% of M. cephalus for highest pond production in polyculture system (Abdel-Gawad, 2003).

In mixed cultivation of mullet *Mugil Liza* and white shrimp *Litopenaus schmitti*, the low density of mullet in ponds did not affect the main variables in the cultivation of shrimp contributing to improve economic and productive indicators (Artiles, *et al.,* 2001).

Magouz, *et al* ;(1999), reported that economic efficiency was superior in ponds fertilized with (10 kg urea + 25 kg MSP biweekly) for grey mullet *M. cephalus* cultivated in polyculture system with red tilapia.

Soliman, *et al*; (2000) found that the rearing of grey mullet *M. cephalus* in polyculture ponds with common carp, silver carp and tilapias in both of integrated and non-integrated systems, the data on return on sales, return on costs, return on equity pay-back period and break-even point showed that the integrated system was more profitable than non-integrated system.

Eid, (2006) cited that the stocking density 10000 fish /feddan (0.42 ha.), of grey mullet *M. cephalus* in monoculture with supplementary feeding, seemed to economic thus applied when it increased net production followed by stocking density 12000 fish/feddan, and stocking density 14000 fish/feddan.

Bakeer, (2006) reported that in grey mullet *M. cephalus* monoculture system, with supplementary feeding, the highest profitability was recorded for the lowest stocking density which had the rate of 1 fish/m^3.

The present study aimed to investigate the different stocking densities of grey mullet *Mugil cephalus* reared in earthen ponds without any supplementary feeding, and their effects on growth performance, total final yield, and economical potential, also, to evaluate the sensitivity analysis for different stocking densities estimating the risk to save the farmer in the case of applying the result of this study.

MATERIALS AND METHODS

This work was conducted in Central Laboratory for Aquaculture Research (CLAR) at Abbassa, Abo-Hammad, Sharkia governorate, Egypt. Eight earthen ponds 0.1 ha. (each) with one meter water depth, were used. Ponds were supplied by gravity with fresh water from Ismailia canal. The experiment was run during summer 2004 for 180 days (from 7 May to 3 November).

Ponds were fertilized with organic and chemical fertilizers at the rate of 60 kg, chicken manure, 30 kg mono-super phosphate $Ca(H_2PO_4)_2$ and 10 kg ; urea (46.5 % N) per feddan (0.42 ha) biweekly to accelerate phytoplankton and zooplankton (Magouz,*et al;*1999 and Abdel-Gawad, 2003). The fertilization was started one week before fish stocking and stopped tow weeks before fish harvesting.

Ponds were stocked in monoculture system with grey mullet *Mugil cephalus* fingerlings at four densities. The rate of densities was1050, 1400, 2100

and 4200 fish / feddan (0.42 ha) for treatments T_1, T_2, T_3 and T_4 respectively. Each treatment was replicated at the same conditions.
Initial body weight of grey mullet fingerlings was 12.10 ± 0.07 g/fish and initial body length of 6.51 ±0.05 cm /fish for all treatments.
Water sample were taken daily in the early morning and the physical properties, temperature, oxygen, pH and (secchi disk) of pond water determine according to (APHA,. 1985), and the measuring of water parameter values were represented in Table (1).

Table (1) Average of physical and chemical properties of pond water during experimental period (180days) through intervals (30 days) (mean ± SE)*

Items	Intervals						
	Initial	**After 30 days**	**After 60days**	**After 90days**	**After 120days**	**After 150days**	**After 180days**
Temperature (C^0)	25.8 ±0.4	27.3 ±0.45	28.4 ±0.5	29.8 ±0.3	28.9 ±0.31	26.1 ±0.02	24.4 ±0.15
Seccki Disk (cm)	15.5 ±0.28	15.3 ±0.3	15.2 ±0.4	14.9 ±0.35	14.7 ±0.23	14.3 ±0.21	13.9 ±0.35
PH values Unit)	8.3 ±0.1	8.4 ±0.11	8.9 ±0.15	8.7 ±0.2	9.0 ±0.14	9.2 ±0.09	9.1 ±0.08
D. Oxygen (mg/L)	5.8 ±0.2	5.7 ±0.25	5.3 ±0.27	4.8 ±0.35	4.6 ±0.32	4.3 ±0.4	4.9 ±0.38
Hardness (mg/L)	240 ±4.4	220 ±7.8	545 ±8.6	590 ±66	470 ±8.2	350 ±5.8	275 ±6.3
Alkalinity (mg/l)	263 ±35	270 ±25	250 ±35	220 ±15	300 ±40	370 ±25	170 ±30
NO3 (mg/L)	0.28 ±0.03	0.27 ±0.05	0.50 ±0.04	0.67 ±0.06	0.61 ±0.04	0.52 ±0.03	0.34 ±0.02

The time of dissolved oxygen test is 9:00

The chemical properties (total hardness and total alkalinity) of ponds water also determined according to (Boyd, 1992), every two weeks through the entire experimental period.

Live body weight and total length of random samples of (100-400 fish/feddan according to the rate of density) were taken monthly. The fish were netted from the water of pond, weighed to the nearest gram and length was measured to nearest 1mm.At the end of experimental period, ponds were drained from the water and the fish were harvested by seining. Total fish production for each treatment was weighed and graduated.

Parameters of relative growth rate (RGR %), specific growth rate (SGR %), daily weight gains (DWG) and condition factor (K), was calculated according to the following equation:

* Daily weight gain (DWG) was calculated as:

$(W_2-W_1) / t$, where W_2 is the interval time in days.

*Total gain g / fish: Average of final weight (g) – Average of initial fish weight (g).

* Condition factor (K) = weight (g)/ (length cm) ^{3} .100

* Relative growth rate (RGR %) was calculated as: $(W_2-W_1/W_1)-100$

*Specific growth rate (SGR %) was calculated as: $(\text{Ln } W_2- \text{Ln } W_1 / t).100$.

Economical evaluation:-

The evaluation of economic potential and profitability of an enterprise, estimated costs and returns associated with the enterprise are calculated (Shang, 1981).

No charge for land was included in the cost estimates, land was assumed to be owned and previously used for aquaculture.

Statistical Analysis:

All statistical evaluations were run using the programs (SAS, 1987). Deference among means was tested at 5% probability level using Duncan's new multiple ranges test (Duncan, 1955).

RESULTS AND DISCUSSION

Body weight (W) and body length (L):

Average body weight and average body length of grey mullet *Mugil cephalus* during experimental period intervals (one interval = 30 days) are represented in Table (2).The average of initial body weight was 12.1± 0.07 g/fish with insignificant differences ($p<0.05$).This indicates that all used *M. cephalus* fingerlings were of the same weight.

Results of Table (2) revealed that the different stocking density released significant effects on grey mullet *M. cephalus* body weight during the experiment period. The difference among groups in body weight were significant ($P<0.05$).That can be noticed at the first interval (after 30 days of the experiment started); the body weight was 31.46, 27.11, 24.83 and 19.35 g/fish for T_1, T_2, T_3 and T_4 respectively. The same trend can be observed at all intervals. The final body weight was 231.86±0.58, 182.82±0.37, 151.19±0.44 and 91.65±0.47 g/fish for T_1, T_2, T_3 and T_4 respectively. These results indicate that final body weight of *M.cephalus* increased significantly ($p<0.05$) with the decreasing of stocking density. The results are in agreement with those reported by (Abdel-Hakim, *et al*; 2006; Bakeer, 2006; and Eid, 2006) who found that the growth of grey mullet was influenced by the different stocking density fertilization and supplementary feeding.

Table (2) Average of body weight (W) in g/fish and body length (L) in cm/fish of *M. cephalus* during experimental period through intervals (30 days) (mean ± SE)* at culture period 180 days.

Intervals	**Average body Weight (W) g**				Average of Body Length (L) cm			
	T1	T2	T3	T4	T1	T2	T3	T4
Initial	12.10 a ± 0.07	12.10 a ± 0.07	12.10 a ± 0.07	12.10 a ± 0.07	6.51 a ± 0. 05	6.51 a ± 0. 05	6.51 a ± 0. 05	6.51 a ± 0. 05
After 30 days	31.46 a ±0.18	27.11 b ±0.26	24.83 c ±0.18	19.35 d ±0.11	9.42 a ± 0. 10	9.08 b ± 0.11	9.02 b ± 0.11	8.50 c ± 0.15
After 60 days	60.22 a ±0.21	49.19 b ±.26	43.51 c ±0.41	30.42 d ±0.29	12.69 a ±0.104	11.7 ab ±0.20	11.52 b ±0.15	10.47 c ±0.1
After 90 days	95.80 a ±0.19	77.14 b ±0.27	66.52 c ±0.24	43.74 d ±0.34	14.69 a ±0.17	14.07 b ±0.18	13.87 b ±0.17	12.61 c ±0.19
After 120 days	136.63a ±0.25	109.30b ±0.25	92.40 c ±0.36	58.68 d ±0.39	17.29 a ±0.17	16.7 ab ±0.19	16.20 b ±0.19	14.83 c ±0.27
After 150 days	182.19 a ±0.47	144.8 b ±0.40	120.79 c ±0.47	74.70 d ±0.32	19.77 a ±0.23	19.1 ab ±0.22	18.79 b ±0.26	17.38 c ±0.18
After 180 days	231.86a ±0.58	182.8 b ±0.37	151.19 c ±0.44	91.65 d ±0.47	22.12 a ±0.45	21.48 b ±0.30	92.4 b ±0.35	20.32 c ±0.42

Values are means ± S.E of two replicates

Means in the same raw having the same superscript are not significantly different ($p<0.05$)

On the other hand the results of average of body length of *M. cephalus* through intervals which are represented in Table (2), was 6.5±0.05 for all treatments. That indicates that all *M.cephalus* fingerling had the same length when they were stocked at the start of experiment.

As represented in Table (2) results revealed that the stocking density of grey mullet effects on its length from the first interval (after 30 days of the experiment starting) to the end of the experiment. The averages of body length of grey mullet at the first interval were 9.42 ± 0.10, 9.08 ± 0.11, 9.02 ± 0.11 and 8.50 ± 0.15 cm./fish for T_1, T_2, T_3 and T_4 respectively. Result revealed that the value of T_1 was significantly ($P<0.05$) higher than those of T_2 T_3 and T_4, but, T_2 and T_3 were significantly higher than that of $T_{4.}$ The same trend was observed at the final interval where the average values of grey mullet length were 22.12 ± 0.45, 21.48 ± 0.30, 21.28 ± 0.36 and 20.32 ± 0.42 cm/fish for T_1, T_2, T_3 and T_4 respectively. These result are in agreement with those reported by (Esaa, 1996) he found that the mean individual growth rate and body length of *M.cephalus* were highest for the lower stocking density and lowest for the higher stocking density.

The Specific Growth Rate (SGR %):

The effects of stocking density on SGR (%) are represented in Table (3). The results revealed a significant ($P<0.05$) difference among treatments. They were at the first Interval (after30 days) 3.19, 2.69, 2.40 and 1.57 for T_1, T_2, T_3 and T_4 respectively. The result of SGR% kept the same trend through all experimental intervals .They were 0.80, 0.78 , 0.75 and 0.69 % at the final interval (after 180 days) for T_1, T_2 ,T_3 and T_4 respectively.

Table (3) Average of growth parameters of grey mullet (*M. cephalus*) during experimental period (180 days).

ITEMS	**T1**	**T2**	**T3**	**T4**
SGR% of first interval (after 30 days):	3.19 a ±0.01	2.69 b ±0.02	2.40 c ±0.01	1.57 d ±0.01
SGR% of final interval (after 180 days):	0.80 a ±0.002	0.78 b ±0.007	0.75 c ±0.005	0.69 d ±0.006
RGR% of first interval (after 30 days):	160.09 a ±0.41	124.0 b ±1.03	105.21 c ±0.44	59.95 d ±0.29
RGR% of final interval (after 180 days):	27.27 a ±0.06	26.28 b ±0.25	25.19 c ±0.17	22.69 d ±0.22
The average of Condition factor (K) through the experimental period:	3.16 a ±0.67	2.39 b ±0.07	2.72 b ±0.08	2.46 c ±0.09
The average of total weight gain through the experimental period (g / fish / interval):	36.63 a ±1.22	28.45 b ±0.65	23.18 c ±0.05	13.26 d ±0.28
The average of Daily weight Gain (DWG) through the experimental period (g/fish):	1.22 a ±0.03	0.95 b ±0.22	0.77 c ±0.2	0.44 d ±0.01

Data indicates that the lowest density of *M.cephalus* showed the highest SGR (%) records compare with those of the highest densities. These results are in agreement with those recorded by (El-Sayed, 2002), who reported that fish survival percentage, weight gain and specific growth rate (SGR %) of *M.cephalus* negatively correlated with stocking density.

The Relative Growth Rate (RGR %):

The results of RGR (%) of *M. cephalus* in the present study are illustrated in Table (3). Values of RGR (%) at the first interval (after 30 days) were 160.9, 124.0, 105.21 and 59.95 69 for T_1, T_2, T_3 and T_4 respectively. They had a significant ($P<0.05$) difference among treatments. At the final interval (after 180 days), the values of RGR% were 27.27, 26.28, 25.19 and 22.69 for T_1, T_2, T_3 and T_4 respectively with significant difference ($P<0.05$. These results are in agreement with those of (Scorvo, *et al*; 1995) and (Sampaio, *et al*; 2001), who reported that grey mullet *M.cephalus* reared in monoculture and in lower density, had greater growth and weight gain.

Condition Factor (K):

Average of condition factor (K) values of *M.cephalus* as represented in Table (3) increased significantly ($p<0.05$) with decreasing the stocking density. Results of average condition factor (K) per experimental intervals were 3.16, 2.93, 2.72 and 2.64 for T_1, T_2, T_3 and T_4 respectively. It can be observed that T_1 had the highest value of condition factor (K) compared with the others values of T_2, T_3 and T_4 ($p<0.05$). But the values of T_2 and T_3 had a higher value than T_4 ($p<0.05$). The results showed that the average of (K) values of *M.cephalus* increased significantly ($p<0.05$) with increasing the stocking density compared with lower stocking density.

Total Weight Gain and Daily Weight Gain (DWG):-

The average of total weight gain through the experimental period (g/fish/ interval} and the average of daily weight gain (DWG) of *M.cephalus* through the experimental period (g/fish) were recorded in Table (3). The results of average of body weight gain per the interval (30 days) were 36.63, 28.45, and 23.18 and 13.26 g/fish for T_1, T_2, T_3 and T_4 respectively. The differences among groups were significant ($p<0.05$).

Daily weight gain results of *M. cephalus* in gram /fish /day, were 1.22, 0.95, 0.77 and 0.44 g/fish for T_1, T_2, T_3 and T_4 respectively, through the experimental period (180 days),and the differences among groups were significantly ($p<0.05$). Results indicated that DWG of *M.cephalus* decreased as the stocking density increased .These are in agreement with the results of (Zied, *et al*; 2005), who found that harvesting body weight, total gain, daily weight gain and specific growth rate of *M. cephalus* and *Oreochromis niloticus* were affected by stocking density rates.

Survival Rate (%):

Results represented in Table (4) illustrated the effect of different stocking densities of *M.cephalus* on its survival rates, final biomass, weight gain and final total production per feddan (0.42 ha). The results of survival rates were 96%, 92.5%, 88% and 81.5% for T_1, T_2, T_3 and T_4 respectively. These results indicated that stocking density of *M.cephalus* had affect on their survival rates. Also, the results are in accordance with those of (Abdel-Ghany, *et al*; 1995), who reported that, the survival of the grey mullet *M. cephalus* exceeded 97 % and it did not appear to be affected by quantity or quality of food. Also, they in agreement with findings of (El-Sayed; 2002, and Eid, 2006), who found that fish survival percentage, weight gain and specific growth rate (SGR %) negatively correlated with stocking density.

Table (4) Final body weight, number of livability, survival %, final weight gain, costumed fertilizers and total production per feddan (0.42 ha) of *M. cephalus* cultured at different stocking density in monoculture system for 180 days.

ITEMS	T1	T2	T3	T4
Average area of pond (ha.):	0.1	0.1	0.1	0.1
Culture period (days):	180	180	180	180
No. of stocked fish at start of experiment. (Fish/feddan):	1050	1400	2100	4200
Average initial body weight (g/fish):	12.10	12.10	12.10	12.10
Initial biomass. (Kg/feddan):	12.71	16.94	25.41	50.82
Final biomass (total production) (Kg/feddan):	233.7	236.8	273.0	313.9
No., of fish mortality (Fish/feddan)	42	105	294	775
No., of survival fish (Fish/feddan)	1008	1295	1806	3425
Survival rate (%)	96	92.5	88	81.5
Average final body weight (g/fish)	231.86	182.82	151.19	91.65
Final body weight gain (g/fish	219.76	170.72	139.09	79.55
Average initial body length (cm)	6.51	6.51	6.51	6.51
Average final body length (cm)	22.12	21.48	21.28	20.32
Total weight gain/ feddan (kg/feddan)	221.0	220.3	247.6	263.1
Costumed chicken manure (m3/feddan)	2.5	2.5	2.5	2.5
Costumed chicken manure (Kg/feddan)	360	360	360	360
Costumed chicken manure (Kg/feddan)	120	120	120	120

Total Production:

As represented in Table (4), the average of initial biomass of *M.cephalus* per feddan (0.42ha) was 6.41, 8.54, 12.81 and 26.62 Kg/fedaan for T_1, T_2, T_3 and T_4 respectively. Final biomass values of *M.cephalus* (total production) were 233.7, 236.8, 273.0 and 313.9 Kg/feddan (0.42ha) for T_1, T_2, T_3 and T_4 respectively. These results indicate that decreasing of *M.cephalus* stocking density decreased its final biomass.

On the other hand, the final body weight per fish was the biggest for T_1 (231.86 g/fish), comparing with the other treatments which was 182.82, 151.19 and 91.65 g/fish for T_2, T_3 and T_4 respectively. So, the price of big fish is higher than the small one. Theses results are in agreement with (Eid, 2006, and Bakeer, 2006).

Economical evaluation:-

Results in Table (5) indicate that the highest net return was 1860.38 L.E per feddan (0.42 ha) for T_1 followed by T_2 that was 1247.78 L.E and 1074.38 L.E for T_3 while the T_4 had negative net return which was (-175.62 L.E).

Table (5): The effect of different stocking densities on economic efficiency of growing grey mullet calculated in monoculture system ponds, area of feddan (0.42ha).

ITEMS	T1	T2	T3	T4
Operating costs:				
1- Variable costs:				
a- Fingerlings	525.00	700.00	1050	2100.00
b- Fertilizers				
I-Chicken manure :	150.00	150.00	150.00	150.00
II-Super phosphate	173.00	173.00	173.00	173.00
III- Urea :	54.00	54.00	54.00	54.00
c- Transportation:	50.00	50.00	50.00	50.00
d- Labor	300.00	300.00	300.00	300.00
Total variable costs :	1252.00	1427.00	1777	2827
2- Fixed costs:				
a-Depreciation (material and other)	200.00	200.00	200.00	200.00
b- Taxes	100.00	100.00	100.00	100.00
c- interest*	93.12	103.62	124.62	187.62
Total fixed cost :	393.12	403.62	424.62	487.62
3- *Total operating costs* (1 + 2):	1645.12	1830.62	2201.62	3314.62
4- Return** (fish sales in L.E /fed.)	3505.50	3078.40	3276.0	3139.00
5-Net return in L.E / fed. (4-3):	1860.38	1247.78	1074.38	-175.62
Rate of return % (5/3) x100:	113.08	68.16	48.80	----

* 12% of total operating costs × (180/360 days).

** Return = the total production x the price of one kg of fish per group.

- The economical evaluation of results was carried out according to market prices in 2006 in L.E
- The price of one fingerling was 0.5 L.E
- The price of 1 m^3 of chicken manure was 50.00 L.E
- The price of 1 ton of super phosphate was 480.00 L.E and of Urea was 450.00 L.E
- Labor: 2 workers for a fed. (Each had salary 200 L.E monthly).
- The price of one kg of fish for first group (T_1) was15 LE, for second group (T_2) was 13 LE, for third group (T_3) was 12 LE, and for fourth group (T_4) was 10 LE.
- Transportation was 50 L.E approximately.

To measure the profitability for each stocking density, the rate of return was calculated. As shown in Table (5), T_1 had the highest rate of return (113.08 %) followed by T_2 (68.16%) and T_3 (48.80%), while T_4 was avoided from the calculating.

Conducting sensitivity analysis for the four treatments was calculated with the following assumptions (Barrania *et al*; 1996):

1) Increasing costs by 10% and 15 %.
2) Decreasing in fish prices by 10%.
3) Decreasing in fish production by 10 and 20%.

So, Tables (6, 7, and 8) showed that T_1, T_2 and T_3 maintained positive net return. This indicated reducing of the risk to farmers in the events of unexpected fall in market price and production or the increase of costs.

Table (6): Represent sensitivity analysis for treatment (T_1)

ITEMS	1*	2*	3*	4*	5*
Total cost L.E	1809.63	1891.89	1645.12	1645.12	1645.12
Production kg	233.70	233.70	210.33	186.96	233.70
Price L.E.	15.0	15.0	15.0	15.0	15.0
Total return L.E.	3505.5	3505.50	3154.95	2804.40	3154.95
Net return L.E.	1695.87	1613.61	1509.83	1159.83	1159.28
Rate of return %	93.71	85.29	91.78	70.47	91.78

1* - represent increasing costs by 10%, 2* - represent increasing costs by 15%

3*- represent decreasing production by 10%, 4*- represent decreasing production by 20%

5*- represent decreasing price by 10 %

Table (7): Represent sensitivity analysis for treatment (T_2)

ITEMS	1	2	3	4	5
Total costs L.E	2013.68	2105.21	1830.62	1830.62	1830.62
Production KG	236.80	236.80	213.12	189.44	236.80
Price of 1 kg L.E	13.00	13.00	13.00	13.00	11.70
Total return L.E	3078.40	3078.40	2770.56	2462.72	2770.56
Net return L.E	1064.72	973.19	939.94	632.10	939.94
Rate of return %	52.87	46.23	51.35	34.53	51.35

Table (8): Represent sensitivity analysis for treatment (T_3)

ITEMS	1	2	3	4	5
Total costs L.E	2421.78	2531.86	2201.62	2201.62	2201.62
Production KG	273.00	273.00	245.70	218.40	273.00
Price of 1 kg L.E	12.00	12.00	12.00	12.00	10.80
Total return L.E	3276.00	3276.00	2948.40	2620.8	2948.40
Net return L.E	854.22	744.14	746.78	419.18	746.78
Rate of return %	35.27	29.39	33.92	19.04	33.92

CONCLUSION

According to obtained results, economic evaluation and sensitivity analysis, it could be concluded that the first treatment ($T_{1)}$ that received the lowest stocking density at the rate of 1050 *Mugil cephalus* fingerlings per feddan (0.42 ha.), without any supplementary food, and cultured for 180 days in monoculture system, had the highest net return and rate of return followed by T_2 and $T_{3,}$ which can reduce risk for the farmer in the event of unexpected fall in market price or production or increasing of costs.

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