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# Effect of *Mugil cephalus* Size and Density at Initial Stocking on Growth Performance and Fish Marketable Size at Harvest

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## ABSTRACT

A study on cultivation of mullet (*Mugil cephalus*) in one feddan earthen ponds (4200 $m^2$ each) was done. Twelve rectangular earthen ponds were used representing six treatments, three different stocking densities ($SD_1$, $SD_2$ and $SD_3$ being 10000, 12000 and 14000fish/feddan respectively) within each of them two fish size ($FS_1$ and $FS_2$ , being 10.05 ± 0.12 and 20.03 ± 0.30 g, respectively). Two replicates were used for each treatment. The duration of the experiment was 12 month. The treatment of 12000 fish / feddan with 20 g/ fish showed the best results of marketable size, net yield (6562.58kg/feddan) and highest profit index (1.54 L.E). Based on the obtained results, it could be recommended that the best fish size and stocking density of mullet (*M.cephalus*) are 20 g/ fish and 12000 fish/feddan to get the optimal marketable fish size and economical return under pond farm management conditions.

**Keywords:** Stocking density, Fish size, Mullet (*M.cephalus*), Growth performance, Fish marketable size, Profit index.

## INTRODUCTION

In Egypt, grey mullet (*M.cephalus*) is one of the most popular and acceptable fish for human consumption. Information concerning the optimum stocking density of this species is still very limited. Bakeer, (2006) used three stocking densities (1, 2 and 3fish/$m^3$) and one fish size (10 g/fish) and reported that the best

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stocking density of grey mullet (*M. cephalus*) in monoculture system was 2 fish/$m^3$ under the experimental conditions in Wady – El Natron, Behira governorate.

Eid (2006) stocked grey mullet (*M. cephalus*) fingerlings with initial weight 2.1 g at a rate of 10000, 12000 and 14000 fish /feddan and were fed diet containing 30.1% crude protein and 435.59 k.cal /100g gross energy. He reported that weight gain, absolute growth rate and feed conversion were significantly decreased with increasing stoking density. The highest fish production was obtained with stocking density 10000/feddan with average body weight (180.3g) while the lowest fish production, was obtained with stocking density 14000 fish /feddan with average body weight (120.5g) . Survival was negatively correlated with stocking densities through the experimental period (210 days).

Rearing fish density is one of the most important factor influencing the result of controlled fish cultivation. This has been described for almost all cultivable fish species, and also for all types of production systems (El- Syed, 2002; Abramo *et al.*, 2006; Islam *et al*, 2006 Menghe *et al.*, 2006).

Mostafa. (2008) studied the effect of dietary protein level (25 and 30%) and stocking density (3 and 6 fish/ $m^3$) on growth performance of grey mullet (*M.cephalus*) fingerlings (10g/fish). He reported that the best stocking rate was 3fish/$m^3$.

In optimizing production from a system, a number of factors which are directly related to the stocking density must be considered, and some of these are the physico- chemical conditions of the water, the production system, the type and size of rearing tanks, water exchange rate, size of the fish and quantity of ration have been particularly emphasized (Frzebiatowski *et al*., 1981 and Herbrt *et al*, 2006).

Therefore, The aim of the present study was to determine the optimal stocking density and initial stocking fish size, of grey mullet (*M.cephalues*) to reach the marketable size throughout the evaluation of the effect of the treatments on growth traits, total



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production and economic efficiency.

## MATERIALS AND METHODS

This work was conducted in the region of Edku, El-Behera governorate, Egypt at a private fish farm. during season 2008 (for 360 days), to investigate the effect of grey mullet (*M.cephalus*) density (SD) and initial fish size (FS) on fish marketable size at harvest. Twelve rectangular earthen ponds (each of 4200m$^2$) were used and represented 6 treatments (three stocking rates in two fish sizes) as follow:

Treatment (1) 10g/fish at 10000 fish/feddan (FS1 × SD1)

Treatment (2) 10g/fish at 12000 fish/feddan (FS1 × SD2)

Treatment (3) 10g/fish at 14000 fish/feddan (FS1 × SD3)

Treatment (4) 20g/fish at 10000 fish/feddan (FS2 × SD1)

Treatment (5) 20g/fish at 12000 fish/feddan (FS2 × SD2)

Treatment (6) 20g/fish at 14000 fish/feddan (FS2 × SD3)

Experimental ponds were supplied with water from Idku drainage canal. The water level was maintain at approximately 1 m and loss of water due to evaporation and leakage was replaced whenever necessary.

A monthly fish sample of 150 fish / pond was weighted to adjust the feed quantity. Fish were fed on a commercial diet (25.6 % crude protein and 4900 k.cal gross energy/kg diet). The protein, carbohydrate and lipids source were fishmeal, yellow corn, wheat bran, wheat flour and corn oil, respectively, feed was distributed in the pelleted form of 2.0mm (floating pellets) at a rate of 3% of total biomass per day (5 days per week). The daily ration was offered at two portions at 10.00 a.m. and 2.00 p.m. The determined chemical composition of the diet used was 91.6% dry mater, 24.9% crude protein, 10.9% crude fat, 4.9% crude fibres and 9.4% ash.

Individual body weight to the nearest 0.1g was measure at the start of the experiment for samples of 150 fish / pond and repeated monthly. Fish samples were withdrawn from the experimented



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ponds by a seine net, and transferred to a tank containing water from the experimental ponds and returned back to ponds after measuring their weights. The experiment was started on 15 April and lasted for 48 weeks. Organic and chemical fertilizers were used in all experimental ponds to accelerate phytoplankton and zooplankton, at a rate of 200 kg cattle manure (treated by sun), 20 kg superphosphate and 10 kg ammonium sulphate biweekly.

Chemical analysis of the diet was performed according to the methods describeal by A.O.A.C. (2000).

***Parameters tested***

Daily weight gain (g/day); specific growth rate (SGR,%/d); feed conversion ratio (FCR) and survival rate were calculated according to the following equations:

Daily weight gain (g/day) = final fish wt (g) – initial fish wt (g) / time (day)

SGR = (Ln final w – Ln initial w) × 100 / Time (days)

FCR = feed intake (g) / Wt. gain(g)

Survival rate (%) = Nt ×100 / NI

Where : Nt = Number of fish at t days.

NI = number of fish initially stocked.

Water quality criteria (physical, chemical and biological characteristics) were tested for all ponds according to APHA (1985) and Boyd (1992). Also, growth performance and nutrients utilization of the experimental fish were followed after Jobling (1983).

The statistical analysis of date was carried out by applying the computer program of Harvey (1990). Differences among means were tested for significance according to Duncan's multiple range test (1955).

**RESULTS AND DISCUSSION**

***Water quality***

Water quality parameters are shown in Table (1). The averages of temperature ranged from 26.5 to 27C$^o$ during the experimented period. In general, water



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temperature was adequate for grey mullet growth during the experimental period. The overall mean temperature for all treatments during the experiment was 26.83C$^o$. this temperature is suitable for all chemical, physical and biological processes in ponds water as cited by Boyd (1979).

The overall average of Secchi disk reading was slightly lower for the lower stocking density (19cm) which mean there is blooming in the pond water due to lower density compared to the other treatments. The range of Secchi disk visibility was 19-28 cm for all experimental ponds and was within the acceptable limits (Boyd, 1979). which reported that water quality parameters of fish ponds ware in good conditions when Secchi disk visibility between 30-45 cm and when turbidity was in form of phytoplankton (Boyd, 1979).

Field observation during early morning revealed that dissolved oxygen (DO) was closely related to the best growth and survival of cultured fish. The average of DO concentration ranged between 6.8 and 7.3 mg/l. The previous results agree with NACA(1989) These values are beneficial to fish cultivation and indicate that water dissolved oxygen slightly decreased in ponds with higher density and fish size compared to the other ponds. This may be attributed to the increase in fish size and density of these ponds, which may lead to decrease the dissolved oxygen. In this connection, Anand and Mukherjee, (2000) demonstrated that high stocking ponds require more dissolved oxygen concentration in water bodies.

The average value of pH ranged from 7.6 to 8.0 in all treatments. Generally, the pH levels were suitable for well being of mullet fish. Boyd and Lickpoppler (1979) demonstrated that water with pH value of about 6.5 is considered the best for fish production.

Average of salinity was about 12 ppt. This value showed no variation and lays in the desirable range for mullet cultured in ponds (Oren, 1981).



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**Table (1):** ***Mean values of different water quality criteria in the experimental earthen ponds.***

| Parameters | Treatments | | | | | |
|---|---|---|---|---|---|---|
| | 10000 fish/ fed. (SD1) | | 12000 fish/fed. (SD2) | | 14000 fish/fed. (SD3) | |
| | 10g./fish (FS1) | 20g./fish (FS2) | 10g./fish (FS1) | 20g./fish (FS2) | 10g./fish (FS1) | 20g/fish (FS2) |
| Temperature($C^o$) | 26.5 | 27 | 27 | 27 | 26.5 | 27 |
| Secchi disk (cm) | 19 | 19 | 25 | 25 | 28 | 28 |
| Dissolved Oxygen (mg/l) | 7.1 | 7.0 | 7.3 | 7.2 | 6.8 | 6.8 |
| pH value | 7.8 | 7.6 | 7.9 | 7.9 | 7.8 | 8.0 |
| Salinity(ppt) | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 |
| $NH_3$ (mg/l) | 0.11 | 0.11 | 0.12 | 0.12 | 0.13 | 0.14 |
| O.P (mg/l) | 0.44 | 0.39 | 0.26 | 0.25 | 0.14 | 0.13 |

The average value of unionized ammonia ($NH_3$) did not exceed o.14 mg/l at different treatments. Averages of phosphorus had ranged between 0.13 and 0.44 mg/l in all ponds. Generally, these values showed no nutrients limitation in grey mullet



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experimental ponds. similar trend was observed by Abdelhamid (2003).

### *Phyto – and Zooplankton standing crop*

As shown in Table (2), the average total numbers of phytoplankton and zooplankton organisms per litter were higher in water samples collected from ponds with lower density and fish size, comparing with those collected from ponds of higher density and fish size. This may be due to the high consumption rate of these organisms by high total fish biomass. In general, numbers of plankton communities in fish ponds were affected greatly by the experimental treatments, densities and fish sizes. These results are in agreement with the finding of Eid (2006) and Abdel Gawad and salem (2007).

### *Fish growth performance*

Table (3) shows the effects of fish size and density and their interactions on the different body measurements studied. Regardless of stocking density, the increasing of fish size (from 10 to 20 g) increased the body weight from 485.16 to 620.20g, body length from 25.30 to 27.10cm. These results indicate that final body weight and length of grey mullet (*M. cephalus*) increased significantly ($P<0.05$) with the increase in fish size at stocking from 10 to 20g. These results were similar to those reported by Eid (2006), Bakeer (2006) and Abdel Gawad and Salem (2007).

It could be concluded that big fish size (20g/fish) used in this study gave the best growth performance in the form of body weight and body length.

These growth parameters were increased significantly with increasing fish size from 10 to 20g, but concerning the three stocking densities used in this study, these growth parameters were lower with high stocking density than with low stocking density and the differences due to fish sizes and stocking densities were significant (Table 3).



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**Table (2).** ***Average numbers of phytoplankton and Zooplankton in the ponds water of mullet reared at different densities and fish sizes.***

| Organisms | Treatments | | | | | |
|---|---|---|---|---|---|---|
| | 1000 fish/ fed. (SD1) | | 12000 fish/fed. (SD2) | | 14000 fish/fed. (SD3) | |
| | 10g/fish (FS1) | 20g/fish (FS2) | 10g/fish (FS1) | 20g/fish (FS2) | 10g/fish (FS1) | 20g/fish (FS2) |
| **Phytoplankton (thousand unit/l)** | | | | | | |
| Blue green algae | 480 | 485 | 425 | 420 | 389 | 380 |
| Green algae | 690 | 681 | 650 | 555 | 430 | 410 |
| Diatoms | 235 | 210 | 200 | 189 | 150 | 148 |
| Euglena | 620 | 600 | 510 | 500 | 340 | 310 |
| Total biomass (unit/l) | 2025 | 1976 | 1695 | 1664 | 1309 | 1248 |
| % of the smallest value | 162.25 | 158.33 | 135.81 | 133.33 | 104.88 | 100 |
| **Zooplankton (organism/l)** | | | | | | |
| Rotifera | 1190 | 1212 | 1011 | 1223 | 980 | 1000 |
| Copepoda | 810 | 891 | 790 | 870 | 680 | 711 |
| Cladocera | 612 | 673 | 509 | 658 | 614 | 622 |
| Crustacea | 1735 | 1520 | 1100 | 1115 | 950 | 810 |
| Biomass (Org./l) | 4347 | 4296 | 3410 | 3866 | 3224 | 3143 |
| % of the smallest value. | 138.30 | 136.68 | 108.49 | 123.00 | 102.57 | 100 |



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**Table (3):** ***Means and standard errors for the effects of initial stocking density and fish size on the body measurements of mullet at harvest.***

| Treatments | NO | Body weight (gm) | Body length (cm) | Condition Factor (k) |
|---|---|---|---|---|
| **Stocking density (SD)** | | | | |
| SD1 (10000 fish/fed) | 300 | $654^{a} \pm 1.43$ | $27.12^{a} \pm 0.07$ | $3.23^{C} \pm 0.09$ |
| SD2 (12000 fish/fed) | 300 | $613^{b} \pm 1.43$ | $26.00^{b} \pm 0.07$ | $3.48^{b} \pm 0.09$ |
| SD3 (14000 fish/fed) | 300 | $498^{c} \pm 1.43$ | $24.15^{c} \pm 0.07$ | $3.53^{a} \pm 0.09$ |
| **Fish size (FS)** | | | | |
| Low (10g) | 450 | $485^{b} \pm 1.12$ | $25.30^{b} \pm 0.08$ | $2.99^{b} \pm 0.09$ |
| High (20g) | 450 | $620.60^{a} \pm 1.12$ | $27.10^{a} \pm 0.08$ | $3.11^{a} \pm 0.09$ |
| **SD × FS** | | | | |
| SD1 × FS1 | 150 | $518.60^{d} \pm 1.36$ | $25.10^{b} \pm 1.12$ | $3.27^{c} \pm 0.03$ |
| SD2 × FS1 | 150 | $510.36^{d} \pm 1.36$ | $25.00^{b} \pm 1.12$ | $3.26^{c} \pm 0.03$ |
| SD3 × FS1 | 150 | $470.12^{e} \pm 1.36$ | $24.00^{c} \pm 1.12$ | $3.40^{b} \pm 0.03$ |
| SD1 × FS2 | 150 | $688.53^{a} \pm 1.36$ | $27.12^{a} \pm 1.12$ | $3.45^{b} \pm 0.03$ |
| SD2 × FS2 | 150 | $648.60^{b} \pm 1.36$ | $27.10^{a} \pm 1.12$ | $3.25^{c} \pm 0.03$ |
| SD3 × FS2 | 150 | $630.14^{c} \pm 1.36$ | $26.00^{b} \pm 1.12$ | $3.58^{a} \pm 0.03$ |
| Overall mean | 900 | 577.75 ± 0.72 | 25.72 ± 0.05 | 3.36 ± 0.01 |

***Means with the same letter in each collum are not significantly different (P>0.05).***



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Regardless of fish size, body weight and length were negatively correlated with the stocking density of fish (Table 3), However, net total fish yield at harvest increased with increasing the stocking density (Table 4). These results indicated that final body weights and lengths of grey mullet (*M.cephalus*) increased significantly ($P<0.05$) with each increase in size from 10 to 20g at stocking but significantly decreased by increasing the density from 10000, 12000 to 14000 fish/Fed.

These result are in agreement with Eid (2006), Abdel Gawad and salem (2007) who found that final mean weight and length of grey mullet decreased with increasing stocking rate but the net yield was increased. With regard to the interaction between the fish size and stocking density, result revealed that the treatment ($SD_2 \times DS_2$) produced the heaviest and longest fish compared to the other treatments (Table 4). The significance of variations due to the effect of interaction between fish size and stocking density on body weight and length showed that these two factors are dependently on each other and also each of them had its own significant effect. As shown in Table (4), SGR values were 1.09; 0.93; 1.08; 0.96; 1.05 and 0.95 %/d for the treatments $SD_1$x $FS_1$; $SD_1$x $FS_2$; $SD_2$x $FS_1$; $SD_2$x $FS_2$; $SD_3$x $FS_1$; $SD_3$x $FS_2$; respectively.

Data in Table (4) indicated that small fish (10g) showed the highest SGR records compared with the large fish. On the other hand, daily weight gains recorded values indicating that large fish (20g) at stocking showed the high weight gain records compared with those of the small fish (10g). These results are in agreement with the findings of Mahmoud *et al*. (2003) and Bakeer *et al* (2007) who studied the effect of stocking rate on the growth performance of fish and the interaction between fish size at stocking and growth parameters.

The FCR values increased (generally) as fish size increases. However, (El-Sayed (2002) and Bakeer *et al* (2007) reported that FCR decreased with each increase in fish size and this means that FCR improved significantly.



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**Table (4)*: Effect of stoking density and fish size at initial stocking on growth performance of grey mullet (M.cephalus) at harvest.***

| Parameters | Treatments | | | | | |
|---|---|---|---|---|---|---|
| | 10000 fish/ fed. (SD1) | | 12000 fish/fed. (SD2) | | 14000 fish/fed. (SD3) | |
| | 10g./fish (FS1) | 20g./fish (FS2) | 10g./fish (FS1) | 20g./fish (FS2) | 10g./fish (FS1) | 20g./fish (FS2) |
| Average initial body weight(g) | 10.11b ± 1.12 | 20.32a ± 1.18 | 10.31b ±1.12 | 20.33a ± 1.18 | 10.42b ± 1.12 | 20.14a ±1.18 |
| Average final body weight (g) | 518.60b ± 1.36 | 588.53b ±1.36 | 510.36b ±1.36 | 648.60a ± 1.36 | 470.12c ±1.36 | 630.14a ±1.36 |
| Average weight gain (g) | 508.49b ±1.25 | 568.21b ±1.25 | 500.05b ±1.25 | 628.27a ±1.25 | 459.70c ±1.25 | 610.00a ±1.25 |
| Daily weight gain,( g,/day). | 1.41d | 1.85[a] | 1.38d | 1.74[b] | 1.27e | 1.69c |
| Specific growth rate (SGR) %/d | 1.09[a] | 0.93[d] | 1.08[a] | 0.96[c] | 1.05[b] | 0.95[c] |
| Average feed intake (g) | 803.41c | 909.136[b] | 810.08[c] | 973.81[b] | 878.02b | 1281.00[a] |
| Feed conversion ratio (FCR) | 1.58b | 1.60[c] | 1.62[b] | 1.55[b] | 1.91[a] | 2.10[a] |
| Survival% | 95.00a | 92.00[a] | 88.00[b] | 87.00[b] | 83.00[c] | 80.00[c] |
| No. of fish per fed | 9500 | 9200 | 10560 | 10440 | 11620 | 11200 |
| Gross yield(kg) per fed | 4926.7 | 6414.47 | 5389.40 | 6771.38 | 5462.79 | 7057.68 |
| Net yield (kg) per fed | 4831.7 | 6230.47 | 5283.8 | 6562.58 | 5346.59 | 6833.68 |
| Price of one kg fish (L.E) | 13.00 | 13.00 | 13.00 | 13.00 | 13.00 | 13.00 |
| Price of net production (L.E) | 62812.10 | 80996.11 | 68689.4 | 85313.54 | 69505.67 | 88837.84 |
| Price of one kg feed (L.E) | 5.214 | 5.28 | 5.34 | 5.115 | 6.30 | 6.93 |
| Feed cost / net yield (L.E) per fed | 25192.48 | 32896.88 | 28215.492 | 33567.59 | 33683.51 | 47357.40 |
| Net return (L.E) per fed | 37619.62 | 48099.23 | 40473.90 | 51745.95 | 35822.16 | 41480.344 |

*Means with the same letter in the same row not significantly different at (P>0.05).*



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Results presented in Table (4) illustrated the effects of grey mullet fish size and density at stocking on survival rates. The results indicated that survival rate ranged between 80.0% and 95.0% which indicated that grey mullet fish size and density had remarkable effects on survival rate. These results are in accordance with those reported by Eid (2006), Abdel Gawad and salem (2007) and Bakeer *et al.* (2007) who found that the survival rate improved in fish ponds applied lower total biomass (lower fish size and density at stocking).

### *Economical evaluation*

Costs of feed and profit index per one Kg fish (in LE) at different treatments are given in Table (5). Costs of feed intake per one Kg fish gain (in LE) at different treatments were 5.214, 5.280, 5.340, 5.115, 6.300 and 6.930 for the treatments $SD_1$x $FS_1$; $SD_1$x $FS_2$; $SD_2$x $FS_1$; $SD_2$x $FS_2$; $SD_3$x $FS_1$ and $SD_3$x $FS_2$, respectively. These results indicated that lower fish size and density at stocking decreased the feed intakes. The best fish size and density possessed lowest feed cost and high profit index was for the treatment ($SD_2$x $FS_2$) followed by the treatment ($SD_1$x $FS_2$ ). These results are in partly agreement with Mahmoud et al. (2003), Eid (2006) and Abdel Gawad and salem (2007). They studied the effect of stocking density on growth and yield of grey mullet. Also, Mahmoud *et al*. (2003) and Bakeer *et al.* (2007) who working on Nile tilapia, were recorded the same results and trends.

## CONCLUSION

Based on the obtained results from this study, it could be concluded that fish size at stocking density of 20 g / fish and 12000 fish / Fed. were the optimum size and density and were recommended to use in monoculture system for grey mullet, to give the best marketable size and highest yield at harvest, under pond farm management conditions.

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**Table (5):** ***Cost of feed and profit index per one kg fish (in LE) at different treatments.***

| Items | Treatments | | | | | |
|---|---|---|---|---|---|---|
| | 1000 fish/ fed. (SD1) | | 12000 fish/fed. (SD2) | | 14000 fish/fed. (SD3) | |
| | 10g./fish (FS1) | 20g./fish (FS2) | 10g./fish (FS1) | 20g./fish (FS2) | 10g./fish (FS1) | 20g./fish (FS2) |
| Feed intake per one kg gain (kg) | 1.58 | 1.60 | 1.62 | 1.55 | 1.91 | 2.10 |
| Feed intake cost (LE) | 5.214 | 5.28 | 5.34 | 5.115 | 6.30 | 6.93 |
| % of the smallest value | 101.93 | 103.22 | 104.39 | 100 | 123.16 | 135.48 |
| Profit index | 1.49 | 1.46 | 1.43 | 1.54 | 1.06 | 0.87 |
| % Of the smallest value | 171.26 | 167.81 | 164.36 | 177.01 | 121.83 | 100 |

*The economical evaluation carried out according to the local market price in 2008 inLE.*

1- *Price of one ton of feed equal 3300L.E.*
2- *LE means Egyptian pound (0.18 US$)*
3- *Profit index = income of one kg gain of fish/feed intake cost (price of fish was calculated as 13. L.E per kg ).*



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## تأثير كل من كثافة وحجم أسماك البوري (*M. cephalus*) عند بداية التخزين على أداء النمو والحجم التسويقي عند الحصاد

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المعمل المركزي لبحوث الثروة السمكية – مركز البحوث الزراعية –الجيزة – مصر

أجريت هذه الدراسة لفحص تأثير معدل التخزين السمكي وحجم الأسماك عند بداية التخزين على أداء النمو والحجم التسويقي لأسماك البوري (*Mugil cephalus*) عند الحصاد. تمت التجربة في أثنى عشر حوضاً ترابيا مستطيل الشكل , مساحة كل حوض واحد فدان ممثلة لعدد ست معاملات, ثلاث معدلات للتخزين (10000 – 12000 – 14000سمكة /فدان) وفي داخل كل معاملة تم استخدام حجمين من الأسماك (10 ، 20 جرام / سمكة), تم تكرار كل معاملة في حوضين حيث استغرقت التجربة 12 شهراً .

النتائج المتحصل عليها أوضحت تفوق المعاملة التي استخدم فيها الأسماك بحجم 20جم للسمكة عند بداية التخزين مع معدل تخزين قدره 12000 سمكة/ فدان حيث حققت اعلى انتاجية (6562.58 كجم للفدان ) ،وكان أقصى دليل ربحي 1.54 جنيهاً مصرياً وبناء على ذلك توصي الدراسة باستخدام معدل تخزين 12000 ألف سمكة / فدان بحجم ابتدائى 20 جرام / سمكة عند التربية بالنظام الأحادي النوع فى أحواض ترابية مسمدة جيدا باسمدة عضوية وكيماوية لزيادة الغذاء الطبيعى ( فيتو وزو بلانكتون) لتحقيق اقصى جدوى اقتصادية ممكنة.



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