

A Comparative Study on the Growth, Feed Conversion and Production of Fry of Improved and Non-improved Strains of the Nile Tilapia *Oreochromis niloticus*

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Abstract

Two experiments were conducted consecutively to evaluate and compare the mean weight (MWT), daily growth rate (DGR), feed conversion ratio (FCR), survival and production rate (PR) in the non-improved strain (NS) of the Nile tilapia, *Oreochromis niloticus* (Cichlidae) with those in the Genetically Improved Farmed Tilapia (GIFT) strain and the FaST selected tilapia (FaST), from the swim-up fry stage to fish weight of 1.0 g (Experiment 1) and from fish weight of 1.0 to 20 g (Experiment 2). In both experiments, results showed the GIFT and FaST strains to have significantly higher MWT, faster DGR, lower FCR and higher PR than those of the NS. Unlike in Experiment 1, survival rates did not differ significantly among the three strains. In Experiment 1, the improvements in the FaST for the MWT, DGR and PR over those for the NS were 77.9, 72.9 and 33.6%, respectively. In Experiment 2, the improvements for the same parameters were 58.7, 57.8 and 54.5%, respectively. These results indicate the advantage and potential of culturing the FaST or the GIFT strain in Kuwait for improving the production of fresh tilapia, reducing the production cost and increasing the profitability of tilapia farms.

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Introduction

Tilapia farming in Kuwait is still in its early stages. However, research on tilapia was initiated in the late 1970s by the Aquaculture, Fisheries and Marine Environment Department (AFMED) of the Kuwait Institute for Scientific Research (KISR) to accelerate the development of the aquaculture sector and to investigate the feasibility of culturing tilapia under local environmental conditions. The total annual production of tilapia in Kuwait is estimated to be 110 tons produced from 65 farms (Al-Ahmed 2004). However, the slow growth rate, poor feed conversion and inadequate supply of quality seeds are the major factors responsible for the low profitability of the tilapia farms. Therefore, an adequate and dependable supply of quality tilapia fingerlings that can grow at a fast rate in a short time would allow the hatchery operators and growers to increase their production cycles.

The Genetically Improved Farmed Tilapia (GIFT) strain developed through selective breeding in a base population derived from eight strains of the Nile tilapia (*Oreochromis niloticus*) proved to have superior growth performance than the local strains of the Nile tilapia (Eknath et al. 1993; Macaranas et al. 1993; Bentsen et al. 1998). Therefore, it is anticipated that growing the improved strains in Kuwait would have a positive impact on the production potential of tilapia and on the profitability of the tilapia farms.

As there is no account in the literature on the growth performance of the improved strains starting from the early stages of life, the present study was conducted to evaluate and compare the daily growth rate (DGR), feed conversion ratio (FCR), survival and production rate (PR) of the GIFT strain and a selected line (FaST) of the Nile tilapia with an existing non-improved strain (NS) in the first nursery stage from the swim-up fry to 1.0 g and in the second nursery stage from 1.0 to 20 g.

Materials and Methods

Test fish and experimental design

Three strains of the Nile tilapia (*O. niloticus* L.) were tested: (1) Non-improved strain (NS) the offspring of a pure stock of the of Egyptian-Ismaelia strain imported from the Aquasafra, Inc. Florida, USA, (2) the Genetically Improved Farmed Tilapia strain (GIFT) and (3) the FaST selected line (FaST)

strain. The GIFT and FaST strains were imported from the Bureau of Fisheries and Aquatic Resources-National Freshwater Fisheries Technology Center (BFAR-NFFTC), Department of Agriculture, Philippines. The introduced GIFT strain was progeny-produced from mass spawning of the family material from the 6th generation of the Genetically Improved Farmed Tilapia (GIFT) Project (Eknath and Acosta 1998). The FaST strain originated from a mass spawning of the 13th generation of selection FAC Selected Tilapia (FaST) produced from within family selection of *O. niloticus* (Bolivar and Newkirk 2000).

Two experiments conducted consecutively with three treatments each were tested. The treatments were the non-improved strain (NS), the Genetically Improved Farmed Tilapia strain (GIFT) and the FaST strain (FaST). Three tanks were assigned for each treatment. In Experiment 1, swim-up fry having mean body weight of 0.01 g were stocked in aerated 120-liter rectangular fiberglass tanks (1.0 x 0.4 x 0.3 m, L x W x H) at a density of 1.7 L⁻¹ (200 fry tank⁻¹). The tanks were provided with a continuous flow of dechlorinated filtered freshwater at a rate of 0.12 L min⁻¹ tank⁻¹. The fry were handled for 42 days 4 to 5 times per day with powdered marine feed (Biomar, France) containing 50% crude protein at 20% of the total body weight for the first two weeks. The feeding rate was then reduced to 15% day⁻¹ for another two weeks and finally reduced to 10% day⁻¹ for the rest of the duration of the experiment.

In Experiment 2, fingerlings of the NS, GIFT and the FaST strains having mean body weights of 1.1, 1.2 and 1.8 g, respectively, were stocked in 0.42 m³ fiberglass square tanks measuring 1.0 x 1.0 x 0.42 m. The effective water volume was about 300 liters. The fish tanks were attached to a 0.42-m³ biofilter tank within the same recirculating water system filled with extruded plastic chips. The fish were stocked at a density of 0.8 fish L⁻¹ (90 fish tank⁻¹) and were fed at a rate of 10% of the total body weight day⁻¹ with 0.3 mm marine pellets (Biomar, France) containing 45% crude protein for the first two weeks. The feeding rate was then reduced to 7.5% day⁻¹ for another two weeks and finally to 5% day⁻¹ for the rest of the duration of the experiment using 1.5-mm pellets. The water flow rate was adjusted to 0.85 L min⁻¹ tank⁻¹. About 20-30% of the culture water was replaced with new clean water on a daily basis. The experiment lasted for 56 days.

Water quality and statistical analysis

In both experiments, water temperature was maintained throughout the study at 29.0 ± 2.0 °C using immersion heaters. The following water quality

parameters were regularly monitored every two to three weeks: dissolved oxygen (DO) using YSI portable meter Model 55, pH, total ammonia-nitrogen (TAN), $\text{NH}_3\text{-N}$, nitrite-nitrogen ($\text{NO}_2\text{-N}$) and nitrate-nitrogen ($\text{NO}_3\text{-N}$) using the HACH water test kit (HACH Company, USA).

On a weekly basis, the fish in each tank were weighed to adjust the amount of food and to calculate the growth rate. At the end of each experiment, fish in each tank were weighed to determine the means for the total body weights (MWT), daily growth rate (DGR), feed conversion ratio (FCR), survival and production rate (PR) were determined. The DGR was calculated as total weight gain per fish/culture days while FCR was calculated as total weight of dry feed given/total weight gain. Survival was determined as $100 \times (\text{final total fish number}/\text{initial total fish number})$ and PR as final total fish weight/water volume. Significant differences among the means of the above parameters were determined through one-way analysis of variance at $\alpha = 0.05$ and Duncan's new multiple range test using the SPSS statistical package (SPSS 1996).

Results and Discussion

Growth performance

In Experiment 1, the FaST fry had significantly higher MWT and DGR with 1.38 g and $0.033 \text{ g fish}^{-1} \text{ day}^{-1}$, respectively than those of the GIFT and those of the NS fry (Table 1). The lowest values for the MWT and DGR were observed in the NS with 0.78 g and $0.018 \text{ g fish}^{-1} \text{ day}^{-1}$, respectively. The differences in MWT and DGR in the FaST strain over those of the NS were 77.9% and 72.9%, respectively (Table 2). Similar results were obtained in Experiment 2. However, the GIFT and the FaST strains had higher MWT of 48.7 and 58.4%, respectively and 52.2 and 57.8%, respectively higher DGR than the NS (Table 2). These results show that the superior growth performance of the improved strains is evident from the swim-up fry stage. The faster DGR of the FaST and the GIFT strains in Experiment 1 allowed the swim-up fry to attain the size of 1.0 g seven to ten days earlier than the NS fry and in Experiment 2 to reach the size of 20 g 10-14 days earlier than the NS. This will reduce the production cycle time and increase the number of production cycles per season. However, the lower survival of the FaST fish in Experiment 1 and the higher initial size of the FaST fish at stocking of Experiment 2 could have contributed to the higher harvest biomass encountered in this group. However, it is not always possible to obtain fish of uniform size at the begin

Table 1. Mean Weight (MWT), Daily Growth Rate (DGR) Feed Conversion Ratio (FCR), Survival and Production Rate (PR) of the Non-improved (NS), IFT and FaST Strains of the Nile tilapia

Parameter	Experiment 1			Experiment 2		
	NS	GIFT	FaST	NS	GIFT	FaST
<i>Stocking data</i>						
Number tank ⁻¹	200	200	200	90	90	90
MWT (g)	0.01 ± 0.0	0.01 ± 0.0	0.01 ± 0.0	1.1 ± 0.02	1.2 ± 0.03	1.8 ± 0.03
<i>Harvest data</i>						
Duration (days)	42	42	42	56	56	56
MWT (g)	0.78 ± 0.04 ^b	0.82 ± 0.1 ^b	1.38 ± 0.1 ^a	14.6 ± 0.6 ^b	21.7 ± 0.9 ^a	23.7 ± 0.7 ^a
DGR(g fish ⁻¹ day ⁻¹)	0.018 ± 0.01 ^b	0.021 ± 0.02 ^b	0.033 ± 0.01 ^a	0.24 ± 0.01 ^b	0.37 ± 0.02 ^a	0.38 ± 0.01 ^a
FCR	0.89 ± 0.02 ^a	0.80 ± 0.01 ^b	0.83 ± 0.02 ^b	1.04 ± 0.03 ^a	0.96 ± 0.02 ^b	1.06 ± 0.01 ^a
Survival (%)	98.8 ± 0.7 ^a	98.2 ± 0.9 ^a	75.2 ± 4.0 ^b	99.6 ± 1.6 ^a	98.3 ± 1.2 ^a	95.2 ± 1.0 ^a
PR (kg m ⁻³)	1.28 ± 0.06 ^a	1.54 ± 0.18 ^a	1.71 ± 0.02 ^a	4.35 ± 0.13 ^c	6.18 ± 0.22 ^b	6.80 ± 0.18 ^a

Data are means of three replicates ± SEM. In each experiment means having different superscripts are significantly different (P<0.05) (horizontal comparison).

Table 2. Difference (%) in mean weight (MWT), daily growth rate (DGR), feed conversion ratio (FCR) and production rate (PR) in the GIFT and FaST strains over the non-improved strain (NS)

Parameter	Experiment 1		Experiment 2	
	GIFT	FaST	GIFT	FaST
MWT (g)	6.5	77.9	48.7	58.7
DGR (g fish ⁻¹ day ⁻¹)	15.0	72.9	52.2	57.8
FCR	11.3	8.4	7.3	0
PR (kg m ⁻³)	20.3	33.6	40.9	54.5

ning of the experiment due to factors related to early growth and spawning behavior (Palada-de-Vera and Eknath 1993).

No data are available in the literature on the growth performance of the improved strains of the Nile tilapia from the swim-up fry stage. However, for comparison, the MWT obtained in this study for the NS group of 0.78 g is lower than the MWT of the 0.89 g as reported by El-Sayed (2002) for the Nile tilapia fry stocked in tanks at 3 fry L⁻¹. In floating freshwater net cages, Beniga and Circa (1997) observed an increase in growth rate with time in 3.3-g fish selected line, GIFT and non-improved local strains of the Nile tilapia. In ponds, Hussain et al. (2000) and Mather and Nandlal (2000) obtained better growth performance in the GIFT strain than the non-improved Nile tilapia for 13- and 11-g fish, respectively. Bolivar and Newkirk (2000) found comparable growth performance between the 13th generation of selected line and the 5th generation of the GIFT strain for 3.6-g fry stocked in ponds. However, both strains had higher final body weight than the commercial strains. On the other hand, the DGR of 0.76-g fish⁻¹ day⁻¹ reported by Dey et al. (2000) for the 1.3-g GIFT tilapia strain in ponds were higher than the DGR of 0.37-g fish⁻¹ day⁻¹ obtained in this study for the GIFT strain. This is probably due to the different culture systems and to the lower stocking density used by these authors (12 fish m⁻³) compared with the higher density used in this study (300 fish m⁻³).

In both experiments, the three strains showed a steady and linear increase in the individual body weight with time (Fig.1), indicating favorable conditions for growth and survival.

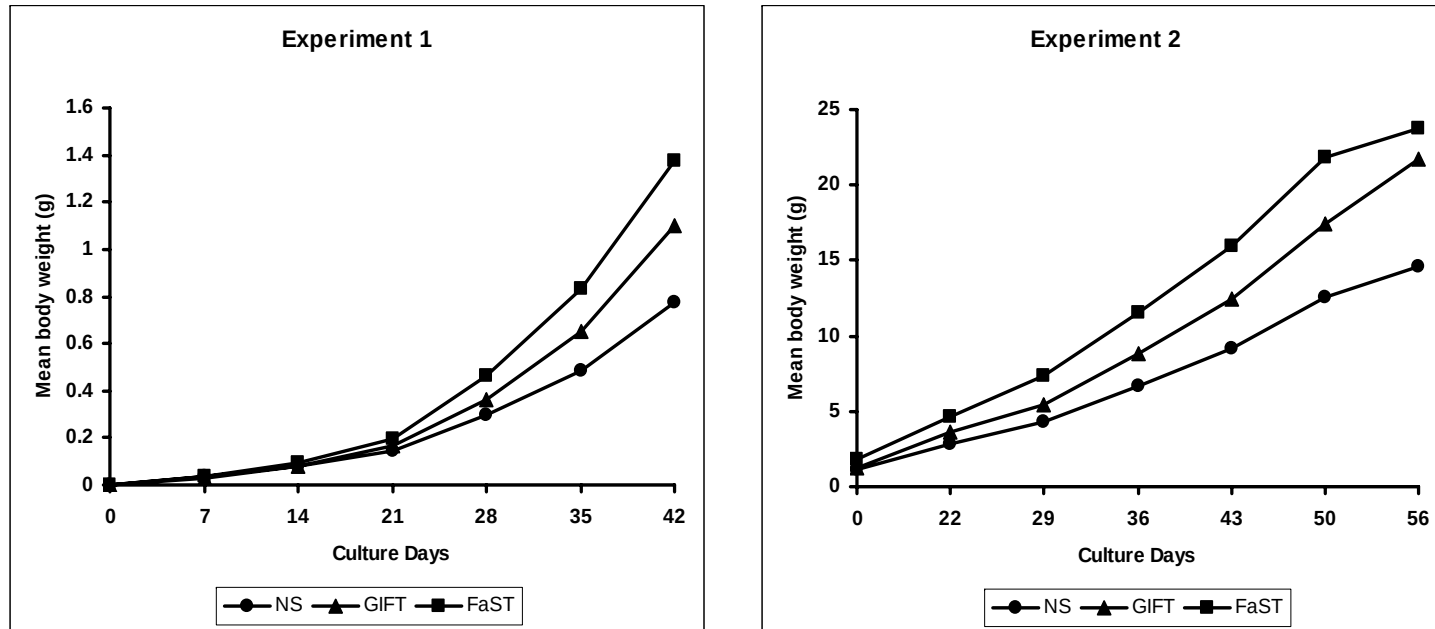


Fig. 1. Growth of SN, GIFT and FaST strains of Nile tilapia in tanks

Feed conversion and survival

In Experiment 1, the GIFT and the FaST strains had significantly lower ($P < 0.05$) FCR (0.80 and 0.83, respectively) than the NS (Table 1). In Experiment 2, the lowest FCR value was observed in the GIFT strain (0.96) which was significantly lower than those of the NS and FaST strains (Table 1). However, in both experiments the difference in FCR in the GIFT and FaST strains over the NS was small (Table 2) and was comparable with the 11.9% improvement reported by Mather and Nandlal (2000) for the GIFT strain over the Chitralada strain. The lower FCR encountered in the improved strains suggests more efficient food utilization and extraction of nutrients from the food and converting it into flesh (Bhikajee and Gobin 1997). Moreover, it appears that the impact of FCR on the production cost would be more significant during the grow-out stages rather than during the fry stages due to the higher amount of consumed food in the grow-out phase.

The FaST strain in Experiment 1 had the lowest survival (75.2%). Most of the mortality in this group occurred shortly after stocking, and no mortality was observed during the progress of the experiment. The feed ration in this group was adjusted accordingly. However, survival in the NS and GIFT groups was high (Table 1). In Experiment 2, no significant difference was obtained in the survival which ranged from 95.2 to 99.6% among the three strains (Table 1). This range is higher than the survival of 69 and 53% reported by Dey et al. (2000) for 1.0-g GIFT and non-GIFT fish, respectively reared in ponds. In cages, Beniga and Circa (1997) had lower survival for 3.3-g fish of the selected line (85.3%) and non-improved strain (86.6%) than the GIFT strain (94.2%).

Production rate

The FaST and the GIFT strains had higher production (1.71 and 1.54 kg m⁻³, respectively) of 1.0 g fry than the NS (1.28 kg m⁻³). However, the difference was not statistically significant ($P > 0.05$). In Experiment 2, the production of 20-g tilapia differed significantly ($P < 0.05$) among the three strains. The FaST strain had the highest production (6.80 kg m⁻³), followed by the GIFT strain (6.18 kg m⁻³). The lowest production was in the NS group (4.35 kg m⁻³). The FaST and GIFT strains had 54.4 and 40.9%, respectively higher fish production m⁻³ than the NS. This improvement in fish production could be attributed to the enhanced DGR and FCR of the improved strains. However, the lower density in the FaST group caused by the lower survival might be responsible for some of the

differences in production rate between the FaST and GIFT fish. The 54.5% and 40.9% improvements in production realized in the FaST and GIFT strains in Experiment 2 were higher than the rate of 33.2% reported by [Dey et al. \(2000\)](#) for the 1.3 g GIFT strain reared in earthen ponds and higher than the rate of 26.7 and 40% for the GIFT and selected line, respectively reported by [Beniga and Circa \(1997\)](#) in floating freshwater net cages.

Water quality

In both experiments, the different water quality parameters were similar to each other, and were within the safe limits. No significant differences in water quality were detected between the two experiments. The average values for TAN in Experiment 1 and 2 were 6.7 and 6.0 mg L⁻¹, respectively and were within the safe range of 13 to 43 mg L⁻¹ reported by [Sin and Chiu \(1983\)](#) for red tilapia. The maximum concentrations obtained for NH₃-N and NO₂-N in Experiment 1 (0.015 and 0.22 mg L⁻¹, respectively) and in Experiment 2 (0.005 and 0.12 mg L⁻¹, respectively) were lower than the safe levels of 1.05 and 1.0 mg L⁻¹, respectively reported by [Otte and Rosenthal \(1979\)](#). Average DO and pH were 7.0 mg L⁻¹ and 7.2, respectively. These values are suitable for tilapia growth.

Conclusion

The findings of this study indicated that the FaST and GIFT strains had superior growth performance, better feed conversion ratio and higher production potential than those of the NS. Moreover, the divergence in growth between the improved strains and the NS was detectable from the swim-up fry stage. These results seem to indicate that the FaST or the GIFT strain of the Nile tilapia could be cultured in Kuwait to improve the production potential of tilapia and to increase the profitability of the tilapia farms. However, before replacing the existing tilapia stocks with the FaST or GIFT strains, further studies are necessary to evaluate the growth of the improved strains to market size and to evaluate their reproductive potential.

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References

- Al-Ahmed, A.A. 2004. Effluents and water quality in tilapia farms in Kuwait. In: Aquaculture 2004 Book of Abstracts, p.2. Honolulu, Hawaii, USA.
- Beniga, Z.M. and A.V. Circa. 1997. Growth evaluation of genetically improved Nile tilapia (*Oreochromis niloticus* L.) in floating net cages in Lake Sebu, South Cotabato, The Philippines. In: Proceedings of the Fourth International Symposium on Tilapia in Aquaculture (ed. K. Fitzsimmons), pp. 116-126. Orlando, Florida, USA,
- Bentsen, H.B., A.E. Eknath., M.S. Palada-de Vera., J.C. Danting., H.L. Bolivar., R.A. Reyes., E.E. Dionisio., F.M. Longalong., A.V. Circa., M.M. Tayamen and B. Gjerde. 1998. Genetic improvement of farmed tilapias: growth performances in a complete diallel cross experiment with eight strains of *Oreochromis niloticus*. Aquaculture 160, 145-173.
- Bhikajee, M. and P. Gobin. 1997. Effect of temperature on the feeding rate and growth of a red tilapia hybrid. In: Proceeding of the Fourth International Symposium on Tilapia in Aquaculture (ed. K. Fitzsimmons), pp. 131-140. Orlando, Florida, USA,
- Bolivar, R.B. and G.F. Newkirk. 2000. Response to selection for Body weight of Nile tilapia (*Oreochromis niloticus*) in Different Culture Environments. In: Proceedings from the Fifth International Symposium on Tilapia Aquaculture (eds. K. Fitzsimmons and J.C. Filho), pp. 12-23. Rio De Janeiro, Brazil,.
- Dey, M.M., A.E. Eknath., L. Sifa., M.G. Hussain., T. M. Thien., N.V. Hao., S. Aypa and N. Pongthana. 2000. Performance and nature of genetically improved farmed tilapia: a bioeconomic analysis. Aquaculture Economics and Management 4, 85-103.
- Eknath, A.E. and B. Acosta. 1998. Genetic Improvement of Farmed Tilapias (GIFT) Project Final Report Part 1. International Center for Living Aquatic Resources Management, pp. 75.
- Eknath, A.E., M.M. Tayamen., M.S. Palada-de Vera., J.C. Danting., R.A. Reyes., E.E. Dionisio., J.B. Capili., H.L. Bolivar., T.A. Abella., A.C. Circa., H.B. Bentsen., B. Gjerde., T. Gjedrem and R.S.V. Pullin. 1993. Genetic improvement of farmed tilapia: the growth performance of eight strains of *Oreochromis niloticus* tested in different farm environment. Aquaculture 111, 171-188.
- El-Sayed, A.M. (2002) Effect of stocking density and feeding levels on growth and feed efficiency of Nile tilapia (*Oreochromis niloticus* L.) fry. Aquaculture Research 33, 621-626.
- Hussain, M.G., A.H.M. Kohinoor., M.S. Islam., M.A. Hossain., M.M. Dey and M.A. Mazid. 2000. Growth and production performance of GIFT strain of Nile tilapia,

- Oreochromis niloticus* L., in ponds and cages under different farming conditions in Bangladesh. *Journal of Aquaculture in the Tropics* 15, 272-280.
- Macaranas, J.M., A.E. Eknath., L.O. Agustin., R.R. Velasco., M.C.A Ablan and R.S.V. Pullin. 1993. Genetic improvement of farmed tilapia: documentation and genetic characterization of strain. *Aquaculture* 111, 296.
- Mather, P.B. and S. Nandlal. 2000. Progress towards providing Fijian farmers with better tilapia strain: evaluation of the GIFT fish in Fiji. *NAGA, The ICLARM Quarterly* 23, 46-49.
- Otte, G. and H. Rosenthal. 1979. Management of a closed brackish water system for high density fish culture by biological and chemical water treatment. *Aquaculture* 18, 169-181.
- Palada-de-Vera, M.S. and A.E. Eknath. 1993. Predictability of individual growth rates in tilapia. *Aquaculture* 111, 147-158.
- Sin, A.W. and M.T. Chui. 1983. The intensive monoculture of the tilapia hybrid, *Sarotherodon nilotica* (male) x *S. mossambica* (female), in Hong Kong. In: *Proceedings of the First International Symposium on Tilapia in Aquaculture* (eds. L. Fishelson and Z. Yaron.), pp. 506-516. Tel Aviv University, Tel Aviv, Israel.
- SPSS. (1996) *SPSS Base 7.0 Windows User's Guide*. SPSS Inc., Chicago, IL.