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ORIGINAL RESEARCH ARTICLE

Effect of stocking density on growth performance, survival and production of Monosex Tilapia (*Oreochromis niloticus*) under nursery ponds in northern regions of Bangladesh

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ABSTRACT

The present study was to assess and evaluate the culture potential of Tengra with short-cycle species in the seasonal water bodies of farmers' fields and disseminate the cultural technologies in a different part of the country. The research study was evaluating the improvement of nursery management technique in drought prone area of Northern region in farmer field level. Before conducting research fish farmers of Different upazila were selected by departmental authority and pre training management. Growth, survival and production performances of *Oreochromis niloticus* fingerlings were evaluated for 40 days in nine nursery ponds having an area of 20 decimal each with an average depth of 1.0 m. Three stocking densities such as 1000 dec^{-1} (T_1=Treatment-1), 1200 dec^{-1} (T_2= Treatment-2) and 1400 dec^{-1} (T_3=Treatment-3) were tested with three replications. Fry were fed with commercial nursery feed (30% crude protein). The rate of feeding was 25% to 8% of the estimated body weight of fry. The physico-chemical and biological parameters of pond water were within the suitable range for fish culture. Growth in terms of final weight, final length, weight gain, length gain and specific growth rate was significantly higher in T_1 than those obtained from T_2 and T_3. The survival of fish fingerlings was higher in T_1(85.67%) than T_3(76%) and T_2(83%) respectively. Maximum of fingerlings was produced in T_2 than those in T_1 and T_3. Among the treatments evaluated, 1000 dec^{-1} was the best stocking density considering the growth performance of the fingerlings of monosex Tilapia, *O. niloticus* in nursery ponds.

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INTRODUCTION

Tilapia is a worldwide fish of great commercial importance, and it is recognized as one of the most important aquaculture species of the 21st century. On a global basis, tilapia has become the second most consumed farmed fish after the carps (Shamsuddin *et al*., 2022). Culture of this species has expanded rapidly under a wide range of farming environments from extensive to intensive scale in both fresh and brackish water in Asia and many other countries of the world. Tilapia has great potential in Bangladesh, and they are going to be the main culture species in near future. Aquaculture is rapidly gaining importance due to increase in human population and reduced natural fisheries resources. Pond aquaculture is growing fast in many Asian countries (Ahamed *et al*., 2017a). Greater Rangpur region is a drought prone area and water retention capacity of earthen pond very low. Generally, water retention capacity 5-6 month. So short cycle fish species like Tilapia culture is most viable technology in northern region for proper utilization of farmers ponds (Hasan *et al*., 2023). Climate change is the most valuable issue in the worldwide (Hossain *et al*., 2018 and 2019). As a result, we faced flood, cyclone, and drought etc natural hazard as common matter. (Ahamed *et al*., 2017b) Effect of the climate change we have loosed fertility of agricultural land, water depth and efficient of water current in the water body (Both are lentic and lotic) and total biodiversity stay in extreme condition which wait for threaten to extinct (Ahamed *et al*., 2020). It provides one of the most important sources of animal protein and income throughout the world. (Ahamed *et al*., 2020) Farming of tilapia is gaining popularity day by day in Bangladesh and several entrepreneurs have already initiated its hatchery development for commercial monosex seed production. (Hasan *et al*., 2020) The stocking density is the major concern for monoculture. Several research publications are available on the effect of stocking density on growth and survival rate of different fish species like *Mystus vittatus* nursery technique (Mou *et al*., 2018) studied the seed production of *Clarias batrtus* (Ahamed *et al*., 2023) conducted experiment on *C. batrachus*, (Kohinoor *et al*. (2015) studied effect of stocking density of *Amblypharyngodon mola* in seasonal ponds. However, it is generally used to refer to the density of fish at any point of time. It is one of the important factors that affect fish growth, feed utilization and gross fish yield. Stocking density influences survival, growth, behavior, health, water quality, feeding and production. Both positive and negative relationships between stocking density and growth have been reported and the pattern of this interaction appears to be species specific. Due to lack of knowledge and proper nursery management technique fish farmer faced in trouble to produced fry and fingerlings production of tilapia, and most of the fish pond were unused for long time for scarcity of short cycle fingerlings. That's why the present experiment was conducted to establish optimal fry stocking density as part of the development of practical and economically viable seed production technique for *Oreochromis niloticus*.

MATERIALS AND METHODS

Study area

The experiment was carried out in nine similar earthen ponds i.e., the size, depth, basin configuration and water supply facilities were almost same of all ponds. The size of each pond was 20 decimals, and the shape was rectangular. The experiment was carried out during the period from September to November in the project implementation period in earthen ponds located at the north region of Bangladesh under the supervision of Bangladesh Fisheries Research Institute (BFRI) Freshwater sub-station Saidpur, Nilphamari.

Pond preparation

The ponds were prepared by dewatering, liming the bottom soil (@ 1kg dec-^{1} of CaO) and enclosed by fine nylon mosquito net. Then after five days, ponds were filled up with underground water and fertilized with organic fertilizer at the rate of 100g dec-^{1} urea and 50g dec-^{1} TSP to enhance the growth of plankton population especially zooplankton in the water bodies and waited for a week to allow the water becoming suitable for stocking (Hossain, 2019).

Experimental design and stocking of fry

After two weeks of fertilization, of monosex tilapia (*O. niloticus*) were stocked at the rate of 1,000, 1,200 and 1,400 dec^{-1} under treatment-1 (T_1), treatment-2 (T_2) and treatment-3 (T_3) on September. Before stocking the initial mean weights of the fry were measured using sensitive balance (OHAUS Model CS-2000).

Feeding

Throughout the experiment supplemental feed which contains 30% protein was given at the rate of following Table 1. The feed was supplied in the dried form and feeding was done directly without any feeding trays. Feeding times were 09.00 am, 01.00 pm and 05:00 pm.

Water quality parameter

The pond environment parameters such as surface water temperature, water depth, transparency, dissolved oxygen and pH was measured weekly using a Celsius thermometer, a graduated pole, a secchi-disk a portable dissolved oxygen meter (HI 9142, Hanna Instruments, Portugal) and a portable pH meter (HI 8424, Hanna Instruments, Portugal).

Table 1. Tilapia feeding trial for 40 days.

Age of fry (days)	Feed Type	Quantity of Feed (% of body weight)
1 -5	Pre - nursery	25
6 – 11	Pre - nursery	20
12- 17	nursery	15
18 - 22	nursery	12
23 – 28	nursery	10
29 -34	nursery	10
35 - 40	nursery	8

Growth and production

The growth and production of fishes were measured 10 days intervals through random sampling method. The weight of fish (in gm) was measured by using a portable balance (Model: OHAUS) and were calculated by following formula. (Hossain, 2019, Hasan *et al*., 2023)

Weight gain = Mean final weight gain – Mean initial weight gain

$$\text{Percent weight gain (\%)} = \frac{\text{Mean final weight gain} - \text{Mean initial weight gain}}{\text{Mean initial weight gain}} \times 100$$

$$\text{Survivability (\%)} = \frac{\text{No. of harvested individuals}}{\text{No. of stocked individuals}} \times 100$$

$$\text{SGR (\% day}^{-1}) = \frac{\text{Ln}W_2 - \text{Ln}W_1}{T_2 - T_1} \times 100\%$$

$$\text{Gross yield} = \frac{\text{Total harvested fry weight (kg)}}{\text{Total area (dec} - ^1)} \times 100$$

Production = No of fish harvested × final weight of harvested fish × area (ha-^{1})

Data analysis

The live fingerlings were counted and weighed. Survival (%) of fingerlings were then estimated and compared among the treatments. The mean values for growth, survival, production and water quality parameters of different treatments were tested using one-way analysis of variance (ANOVA), followed by testing of pair-wise differences using Duncan's Multiple Range Test (Vann, 1972). Significance was assigned at the 5% level. All statistical analysis was done by using the SPSS (Statistical Package for Social Science) version-17.5.

RESULTS AND DISCUSSION

Growth in terms of final length, length gain, final weight, weight gain and specific growth rate of fingerlings of monosex tilapia was significantly higher in T_1 where the (1000 dec^{-1}) was low compared to those of T_2 (1200 dec^{-1}) and T_3 (1400 dec^{-1}) although the same food was applied at an equal ratio in all the treatments. The maximum growth of the fish is obtained at stocking level of 1000 fish dec^{-1} (Table 2). (Hasan *et al*., 2023) found better growth rate at Lower density in case of *Mystus vittatus* in northern region of Bangladesh. Stocking density is highlighted as an area of particular concern in the welfare of intensively farmed fish. (Ahamed *et al*., 2018; Hossain *et al*., 2022). The average survival of monosex tilapia in this study collaborates well with other tilapia culture. Different authors had found limited effect of stocking density on fish survival and demonstrated that cannibalism could be a main cause of tilapia fry mortality at high stocking densities (Hasan *et al*., 2023). In this study, the high survival rates of tilapia fry at high stocking density (85.67 % at 1000 fry dec^{-1}). However, this can also be attributed to favorable environmental conditions during the experiment. During the experimental period, ecological factors, pond preparation, feed quality, quality healthy fry and stocking rate was influenced the high percentage of survival rate of fish Result were also found in different researcher with stocking density in different fish species. (Hossain *et al*., 2019; Mou *et al*., 2018; Hossain *et al*., 2022). In the present study, a significant higher production (8.78±2.29 kg dec^{-1}) was recorded in treatment T_2 than those of treatment T_1 and T_3, respectively. It might be due to suitable stocking density (1200 fry dec^{-1}) for the higher production and others growth related factor also influence also depends on farms level management and pond conditions. The lower growth performance of tilapia at higher stocking density could have been caused by voluntary appetite suppression, more expenditure of energy because of intense antagonistic behavioral interaction, competition for food and living space and increased stress (Mou *et al*., 2018). After completion of the experiment, the highest number of fingerlings were in T_2 (2168.66kg ha^{-1}) compared to those in T_1 (2097.03 kg ha^{-1}) and T_3 (1921.66 kg ha^{-1}). Rhaman *et al*. (2019) reported that production of pabda (*Ompok pabda*) were 127333 to 147670 kg fingerlings ha^{-1} for an 8 weeks nursing. In addition, reported that production of Thai *Anabas testudineus* fingerlings was ranged from 640000 to 700000 kg ha^{-1} of 7 weeks nursing in northern region.

Table 2. Growth performances, survival and production of monosex tilapia fingerlings after 40 days of nursing.

Parameters	Treatments		
	T_1(1000 dec^{-1})	T_2(1200 dec^{-1})	T_3(1400 dec^{-1})
Initial length (cm)	2.0 ± 0	2.0 ± 0	2.0 ± 0
Final length (cm)	8.54 ±0.75^{a}	7.87 ±1.18^{b}	7.18 ±0.34^{b}
Initial weight (g)	0.2 ± 0	0.2 ± 0	0.2 ± 0
Final weight (g)	10.42 ±0.89^{a}	8.47± 2.00^{b}	6.71±0.62^{c}
Length gain (cm)	6.54 ± 0.75^{a}	5.87±1.18^{b}	5.18±0.34^{b}
Weight gain (g)	10.22±0.89^{a}	8.27±2.00^{b}	6.51±0.62^{c}
Specific growth rate (SGR)	9.85±0.20^{a}	9.21±0.56^{a}	8.76±0.22^{b}
Survival rate (%)	85.67± 4.41^{a}	83.33±1.45^{b}	76.00±1.53^{c}
Production of fingerlings (kg dec^{-1})	8.49±0.51^{a}	8.78±2.29^{a}	7.78±0.65^{b}
Health condition (HC) gcm-^{1}	1.22	1.08	0.93

Values in the same row with same superscripts are not significantly different (P>0.05).

Table 3. Physico-chemical properties of experimental pond during the study period.

Water quality parameters	T_1(1000 dec^{-1})	T_2(1200 dec^{-1})	T_3(1400 dec^{-1})
Temperature (°C)	27.28±1.846^a	27.25±1.750^a	27.45±1.790^a
DO (mgl^{-1})	5.03±0.165^a	5.16±0.133^b	5.15± 0.224^b
pH (Water)	7.35±0.083^a	7.33±0.079^a	7.44± 0.156^b
Transparency (cm)	27.99 ±1.619^a	28.84± 1.413^a	28.38±1.571^a
NH_3 (mgl^{-1})	0.11± 0.043^a	0.16± 0.072^a	0 .20± 0.073^a

Values in the same row with same superscripts are not significantly different (P>0.05).

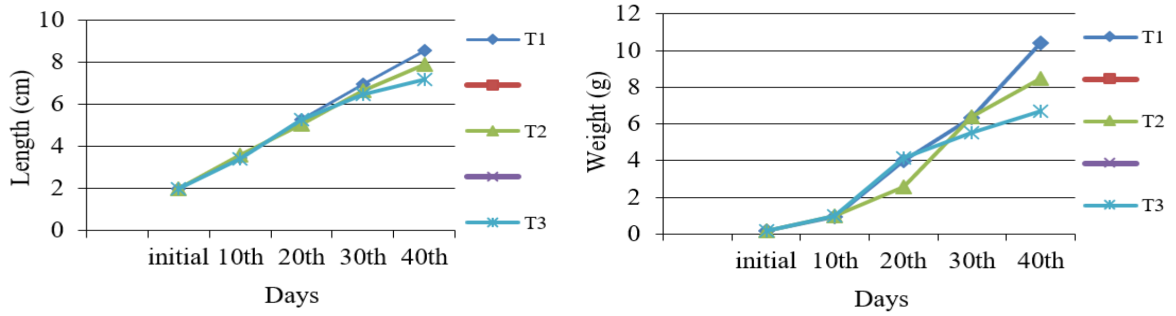

Figure 1. *Weekly length and weight improvement of monosex tilapia, O. niloticus fingerlings at different stocking densities over the nursing period.*

Different physicochemical parameters of water like temperature, DO, free CO_2, transparency and pH are generally considered to have primary importance in fish culture (Hasan *et al.*, 2023). The optimum temperature for tilapia culture is reported 20- 30^{0}C or above (Ahamed *et al.*, 2018). The temperatures in all the different stocking density were same during the nursing period (Table 3). Mou *et al.* (2018) reported that the suitable range of DO was 4-5 mg l^{-1} for tilapia culture. The dissolve oxygen in the morning was low down in the ponds of different treatment. Fluctuation of dissolve oxygen concentration in the ponds might be attributed to stop of photosynthetic activity in the night, and fish and other aquatic organisms used buffer stock of oxygen in the whole night. However, the level of dissolved oxygen is within the acceptable ranges in all the experiment ponds. Similarly, Gupta *et al.* (2019) recorded DO 5.3 to 5.0 mg l^{-1} in tilapia monoculture ponds. pH values agree well. Total ammonia was found in all the treatments because, if high density fish was stocked the droppings of the fish might be produced more ammonia in the ponds. Ahamed *et al.* (2017a) reported that excessive use of feed or fertilizer caused sediments in the pond bottom which may produce ammonia in the ponds and other gases. In this experiment, this may be happened. The suitable range of ammonia (NH_3) is below 0.1 mg l^{-1} (Hasan *et al.*, 2023)

Conclusion

Monosex tilapia is a promising species for aquaculture. The result indicates that 1000fry/decimal were suitable for better growth performance in seasonal pond of semi-arid zone of Bangladesh. Finally, it can be concluded that the growth, survival and production of monosex tilapia *fingerlings* were significantly different regarding the stocking densities of fry. In all respects, a stocking density of 1000 fry dec^{-1} showed highest performances than other two stocking densities. Hence, stocking density of 1000 fry dec^{-1} may be recommended for rearing of monosex tilapia fry over 40 days in single stage nursing rearing system.

DECLARATIONS

Author contribution statement

Conceptualization: M.H.M. and K.R.H.; Methodology: M.H.M.; Software and validation: H.A.; Formal analysis and investigation: K.R.H. and H.A.; Resources: M.H.M. and K.R.H. and H.A.; Data curation: H.A., M.H.M.; Writing—original draft preparation: M.H.M. and S.A.; Writing—review and editing: S.A. and F.A.S.; Visualization: M.H.M. and K.R.H.; Supervision: K.R.H.; Project administration: K.R.H.; Funding acquisition: K.R.H. All authors have read and agreed to the published version of the manuscript.

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Ethics approval: This study did not involve any animal or human participant and thus ethical approval was not applicable.

Consent for publication:

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