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Efficacy of different fertilizers on maximization of green back mullet (*Chelon subviridis*) fry production in nursery ponds

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Abstract
The study was conducted to pave the way for expansion and maximize production through supply of quality seed of *Chelon subviridis* by means of development of sustainable nursery management technique of this important species in the vast coastal water bodies of Bangladesh. As a result, supply of this fish in both national and international markets will be increased. The study was conducted for the period of 3 month in the earthen ponds situated in the pond complex of Brackish water Station of Bangladesh Fisheries Research Institute with different fertilizers to compare the efficacy of those fertilizers in the production of quality fry of *C. subviridis*. The differences in length among three treatments were significant (p<0.05) in nursery ponds. Highest Final wt. of the fry, 0.21±0.05 g was recorded from the ponds fertilized with organic fertilizers only while growth of fry was 0.24±0.05 g and 0.34 ± 0.025 g in ponds treated with only inorganic fertilizer and mixture of inorganic and organic fertilizer, respectively. The differences among them were significant (p<0.05). However, average survival of the stocked hatchlings was highest (85.5%) in ponds fertilized with mixture of organic and inorganic fertilizers (T_3) followed by 71.5% survival in ponds fertilized with inorganic fertilizers only (T_2) and 68.5% survival in ponds with organic fertilizer only (T_1). The differences in survival among three treatments were significant (p<0.05). After 27 days of rearing (with three subsequent trials), production of fishes in treatment T_3 (23.22 Kg/dec) was significantly highest than those of T_1 (15.92 Kg/dec) and T2 (16.62 Kg/dec). The present findings indicate that growth, length, production and survival of *C. subviridis* fries were significantly higher in ponds fertilized with mixture of organic and inorganic fertilizer due to higher plankton production during the culture period.

Keywords: Green back mullet, fry, brackish water, nursery, culture, water quality, management, fertilizers, fish production, Bangladesh

1. Introduction
Brackish water aquaculture in Bangladesh is mostly directed to traditional farming of brackish water shrimp, *Penaeus monodon* with some accidental intrusion of some fin fishes [22, 23]. As a result, productivity of the *ghers* is very poor. Moreover, invasion of viral disease in shrimp makes the farmers cautious to culture of fin fish with shrimp or without shrimp to increase productivity of the *ghers* [26]. Realizing the importance of stocking fin fish in the *ghers*, farmers were advised earlier to stock tilapia to their *ghers*. Presently, brackish water finfish aquaculture is developing rapidly in the Asia–Pacific region and the reason for this expansion is the high prices and demand for live reef food fish, particularly of green back mullet in markets of Bangladesh [17]. This fish is popularly known as *parse* in Bangladesh.This is a very tasty and popular commercially important fish in the coastal region of the country. Consequently, demand for green back mullet juveniles for grow-out in sea cages is increasing [24]. Recently Bangladesh Fisheries Research Institute successfully developed technology for the production of seed of green back mullet, *Chelon subviridis*. This species has a high demand in the national and international market. It is now imperative to develop a suitable culture technology of this species to increase productivity of the *ghers* [24]. But no potential attempt has yet been taken in this regard. Long back, a few attempts were undertaken by Bangladesh Fisheries Research Institute and studies were conducted on the production performance of this fish with shrimp [3, 22, 23] using mullet seed from wild source. Later on, no further attempt was undertaken in this regard for the development of either nursery management or monoculture technology due to unavailability of seed artificial sources of this important fish.

In the present context, realizing the importance of this fish and having success of developing seed production technology, further study is being proposed to develop a sustainable nursery management technology of green back mullet, *Chelon subviridis* to maximize fry production and produce quality fries.

2. Materials and methods

2.1 Study area and study period

The study was conducted in the pond complex of Bangladesh Fisheries Research Institute, Brackish water Station, Paikgacha Upazilla (22º35.3'N 89º20.2'E), Khulna district, Bangladesh. Nursery pond management of green back mullet was conducted for a period of 3 months (January-March) with three trials (each with 27 days of culture) in 2015 in nine experimental ponds.

2.2 Methodology

Study on the efficacy of different fertilizers on the growth and survival of green back mullet, *Chelon subviridis* in nursery phase was carried out in nine nursery ponds of 60 m^2 each. Management techniques of nursery ponds are as follows.

2.2.1 Pre-stocking management

Pond preparation: The ponds were prepared by sun drying followed by 6 cm bottom soil removal

Boom and dyke repair: Dyke was repaired carefully before stocking the fry in nursery pond.

Liming: Liming of soil was done with CaO and dolomite (3:1) @ 250 kg/ha by means of method throwing diluted lime.

Filling of pond: Nursery ponds of 60 m^2 were filled with tidal brackish water up to 100 cm directly from river through screening using pumps.

Removal of unwanted fish or other aquatic animal: Water of the ponds was treated with rotenone as powder forms @ 1.5 ppm used to kill unwanted fishes and removal of predatory and unwanted species of animal.

Liming: The pond was treated with dolomite @ 20ppm to increase the buffer capacity of the ponds. Most common method of application was identified as diluted lime and applies it by throwing.

Fertilization: After 5 days, particular pond was fertilized with respective fertilizers and dose following the experimental design as given below:

Table 1: Design of the experiment

Treatments (T)	Name of fertilizers	Doses
T_1	Only organic	
	Mustard Oil Cake	375 Kg/ha
T_2	Only inorganic	
	Urea	50 kg/ha
	TSP	21 kg/ha
\T_3	Mixture of organic & inorganic	
	Mustard Oil Cake	187.5 Kg/ha,
	Urea	25 kg/ha
	TSP	10 kg/ha

Replications: three of each treatment with three cycles

Control of aquatic insects: After Five days of fertilization, dipterex @ 1 ppm was spread all over the water surface followed by netting for mixing uniformly to kill aquatic crustaceans and insects. dipterex was a popular liquid insecticide in study areas and found in local markets. It was very effective to remove "Haspoka" and "Argulus (Fish lice)".

2.2.2. Stocking Management

2.2.2.1 Fry collection: Fry was collected from the natural source of adjacent Shibsha river during full moon from local fry collectors. 1.1 cm and 0.3 g small fish were transported mainly by rickshaw in a polythene bag with oxygen supply.

2.2.2.2 Water toxicity test: Twenty four hours after spreading of dipterex, toxicity of water was tested by releasing some fries in a drum full of nursery pond water for 24 hrs before stocking the fry in the pond.

2.2.2.3 Natural food testing: For testing natural foods in ponds transparency was measured.

2.2.2.4 Conditioning of fry: Conditioning of fry was done for 30 min in the mixture of pond water and water used in transportation @ 1:3, 1:1, 2:3.

2.2.2.5 Releasing: Twenty four hours after spreading of dipterex, 1.1 cm and 0.3 g small fry were released in 60 m^2 pond. The fry was stocked in the early morning (around 6:30 am). fry of *C. subviridis* was stocked uniformly @ 200 Nos/m^2 in all ponds

Releasing method of fry in the nursery pond was simple. The polythene bag containing fish fry was immersed in the pond water and after 20 minutes, bag was opened to release the fry.

2.2.3. Post-stocking Management

2.2.3.1 Pond monitoring: Growth and well-being of the fries Effect of plankton production on production of fish was checked at weekly interval. Physico-chemical parameters of water *viz*., temperature, salinity, transparency, pH, dissolved oxygen (DO) and alkalinity was determined following standard methods and plankton samples was analyzed at four days interval. After 27 days of nursing, all fries were harvested first by repeated netting, followed by draining the ponds and growth and survival of fingerlings was estimated.

2.2.3.2 Fertilization: Subsequent to stocking of fry, the ponds were fertilized regularly at weekly interval with one fourth of the initial dose (Table 1) of fertilizer.

2.2.3.3 Feeding: From the second day of stocking, fries were fed twice daily with a mixture of finely powdered commercial shrimp nursery feed (35% protein). Feed was supplied @ 6 kg/million of fry and feed was increased to 10 kg from the 6th day of stocking. Subsequently, feed was increased by 5 kg/million hatchlings in every five days.

2.2.3.4 Control of aquatic weeds: Traditional methods were followed (manual and using simple device like bamboo stick, straw made twisted rope, netting etc.) to control aquatic weed.

2.2.3.5 Harvesting: After 27 days of rearing (with three trials), the fish seeds/fingerlings were harvested. Harvesting was done through one special type of net made by nylon which is locally called "Mosari jal" for Harvesting and performed in the early morning (around 6:00 am).

2.2.3.Statistical analysis

T-test, ANOVA and correlation of limnological aspects, growth performance and fish production of the ponds under three treatments were calculated using SPSS package programme.

3. Results

3.1. Growth performance and survival of *C. Subviridis*

After 27 days of nursing, the length of fries was recorded as 2.9±0.5 cm, 2.9±0.7 cm and 3.4±0.3 cm in T_1, T_2 and T_3 respectively (Table 3 & Figure 2) and The differences in length among three treatments were significant ($p<0.05$).As shown in Table 3, mean length of fries was highest in ponds fertilized with mixture of organic and inorganic fertilizers, followed by ponds with organic fertilizers only and ponds with only inorganic fertilizers.

Among the growth rates, the highest was obtained in ponds fertilized with mixture of organic and inorganic fertilizers and the differences among different treatments were significant ($p<0.05$). Again, in terms of final weight (g), the highest growth of fry, 0.21±0.05 g was recorded from the ponds fertilized with organic fertilizers only while growth of fry was 0.24±0.05 g and 0.34 ± 0.025 g produced in ponds treated with only inorganic fertilizer and mixture of inorganic and organic fertilizer (Table 3 & Figure 1), respectively. The differences among them were significant ($p<0.05$). However, average survival of the stocked hatchlings was highest of 85.5% in ponds fertilized with mixture of organic and inorganic fertilizers (T_3) followed by 71.5% survival in ponds fertilized with inorganic fertilizers only (T_2) and 68.5% survival in ponds with organic fertilizer only (T_1) (Table 2, Figure 6). The differences in survival among three treatments were significant ($p<0.05$). The findings indicate that growth of *C. subviridis* fries and survival was significantly high in ponds fertilized with mixture of organic and inorganic fertilizer. Growth, length and survival were highest in T_3 due to higher plankton production during the culture period.

Table 2: Survival of *C. subviridis* fry under different treatments.

Treatments (T)	Name of Fertilizers	Harvesting (no/m^2)	Culture Period (Days)	Survivability (%)
T_1	Only organic	137	27	68.5
T_2	Only inorganic	143	27	71.5
T_3	Mixture of organic & Inorganic	171	27	85.5

3.2. Fish Production

After 27 days of rearing, production of fishes in treatment T_3 (23.22 Kg/dec) was significantly highest than those of T_1 (15.92Kg/dec) and T_2 (16.62 Kg/dec) (Table 3, Figure 5). The findings indicate that *C. subviridis* fry production was highest in mixture of organic and inorganic fertilizer. The main reason for the highest production in T_3 was higher plankton production during the culture period.

Table 3: Growth and production of *C. subviridis* fry under different treatments.

Treatments (T)	Name of Fertilizers	Average Weight (g)		Average Length (cm)		Culture Period (Days)	Production (Kg/dec)
		Initial (DoS)	Final (DoH)	Initial (DoS)	Final (DoH)		
T_1	Only organic	0.03	0.21	1.1	2.9	27	15.92
T_2	Only inorganic	0.03	0.24	1.1	2.9	27	16.62
T_3	Mixture of organic & Inorganic	0.03	0.34	1.1	3.4	27	23.22

*DoS= Day of stocking
DoH= Day of harvesting

3.3. Effect of water quality on fry production

Temperature and salinity of water during study period were 21-27 ºC and 5-10.5 ppt respectively and almost same in all ponds. As shown in Table 4, transparency of water was initially lower in all ponds and gradually increased with the progress of culture period. Low transparency of 28-49 cm was recorded in ponds fertilized with organic fertilizer only. Transparency was 40-49 cm and 38-52 cm in ponds fertilized with inorganic fertilizers (T_2) and mixture of organic and inorganic fertilizers (T_3). pH of water of all the ponds was congenial for nursery rearing and varied from 7.8-9.3 (Table). Alkalinity was almost same in all ponds during stocking and some variations (134-152 mg/l) among different treatments were observed with the progress of culture period. However, total alkalinity of water was 134-150 mg/l, 125-140 mg/l and 135-152 mg/l in T_1, T_2 and T_3, respectively (Table 4). As shown in Table 4, concentration of dissolved oxygen was 2.5-4.1 mg/l, 2.3-3.8 mg/l and 2.5-4.2 mg/l in T_1, T_2 and T_3, respectively (Table 4). During the period of low dissolved oxygen, oxygen enhancer was used in early morning to avoid further depletion. In the Morning, Carbon dioxide was totally absent through-out the culture period. Water quality has no significant effect ($p>0.05$) on production of fry. There is no significant difference ($p>0.05$) in water quality parameters among different ponds and treatments.

3.4. Effect of plankton production on production of fry

Concentration of both phyto- and zooplankton were highest in ponds fertilized with mixture of organic and inorganic fertilizer and increased with the progress of culture period. Phytoplankton counts (No/l) were 6.05-7.05*10^3, 7.25-8.85*10^3 and 9.85-12.1*10^3 (Figure 3) and zooplankton counts (No/l) were 1.35-2.4*10^2, 1.95-3.2*10^2 and 3.95-5.1*10^2 (Figure 4) in T_1, T_2 and T_3, respectively. The findings indicate that higher plankton production causes higher growth and production which is T_3 (mixture of organic and inorganic fertilizer). Significant difference ($p<0.05$) is observed in plankton production among different ponds and treatments.

Table 4: Water quality of nursery ponds during culture period.

Treatments (T)	Water quality parameters (Min-Max)							
	Air Temperature (°C)	Water Temperature (°C)	Dissolved oxygen (mg/l)	pH	Alkalinity (mg/l)	Transparency (cm)	Salinity (ppt)	Carbon dioxide (mg/l)
T1	21-27	20-26	2.5-4.1	7.8-9.3	134-150	28-49	5-10.5	0
T2	21-27	20-27	2.3-3.8	8.2-9.0	125-140	40-49	5-10.5	0
T3	21-27	20-26.5	2.5-4.2	8.1-9.0	135-152	38-52	5-10.5	0

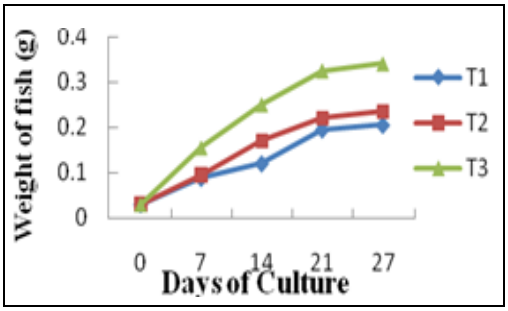

Fig 1: Growth performance of *C. subviridis*

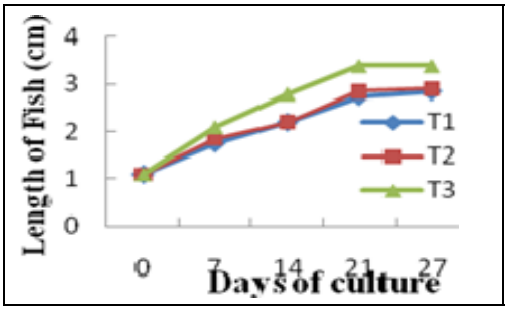

Fig 2: Length of *C. subviridis*

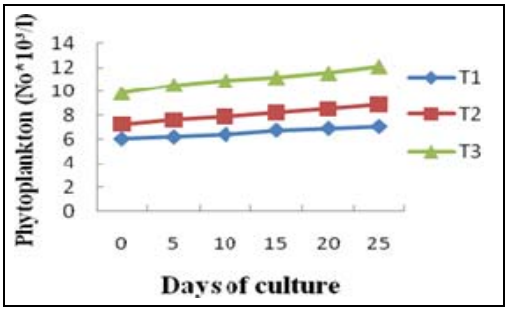

Fig 3: Phytoplankton Production in nursery ponds

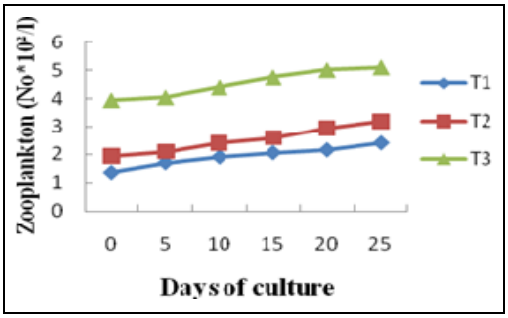

Fig 4: Zooplankton Production in nursery ponds

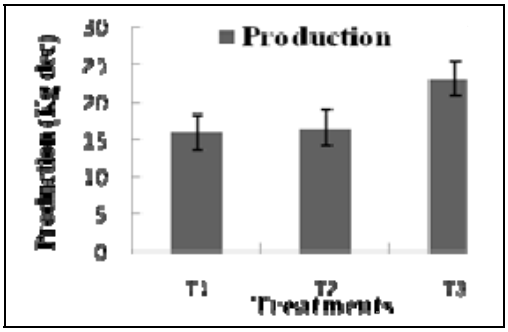

Fig 5: Fish production in nursery ponds

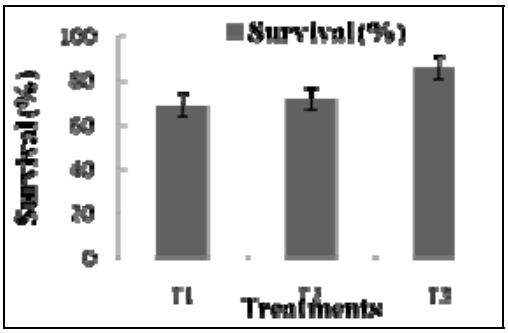

Fig 6: Survivability of fish in nursery ponds

4. Discussion

Successful fisheries management and scientific fish culture depends on the various limnological factors of the water bodies [20, 26]. According to Hickling (1968) fish farming is a practical application of limnology and fresh-water biology, According to Reid (1971) the chemical analysis for dissolved gases and solids are highly important for the study of natural waters [21]. The physicochemical characteristics of pond water are of great importance and essential in case of fish culture and fisheries management [11, 15]. The physicochemical properties play an important role in governing the production of phytoplankton i.e. primary production in fishponds [5, 10].

For successful aquaculture, knowledge on several factors is very important among which fertilization is one of them [1, 2]. Fertilizer is helpful for the increase of natural food of fish i.e. plankton, benthos and periphyton [9, 16]. Plankton is the basic food of all the organisms living in the water. The use of fertilizers in proper doses is also very important to reduce the unit cost of production [7, 18]. So, Optimizing production in pond fish culture by the use of fertilizers is an important task. Both over and under fertilization may cause adverse effects on fish production, water quality and economic returns [6, 8]. It is therefore necessary to evaluate fertilization regimes and

recommend appropriate fertilization strategies to farmers in order to maximize fish production, maintain good water quality, reduce environmental bad impact and maximize economic returns [4, 14].

Available information regarding culture either at nursery phase or grow-out phase of, *Chelon subviridis* is very scanty. The food and feeding habits of *Liza subviridis* and *Valamugil buchanani* from different habitats and at various stages of growth have been studied by Chua and Chua (1979) and Fatema *et al* (2013). Das *et al.* (1993) have studied efficacy of formulated feed for the culture of green back mullet, *Liza subviridis*. The study indicated that protein level, source of protein in the diets and natural live food cumulatively played a significant role on the growth and survival of juveniles of this fish. They also mentioned that with the increase in protein level in the feed, the growth and survival of this fish may be enhanced. Ali *et al.* (2000) have studied the production performance of mixed culture of *Penaeus monodon* with *Liza parsia* at different stocking densities. Al-Daham and Wahab (2001 & 2006) have studied the age, growth and reproduction of the greenback mullet, *Liza subviridis* in an estuary of Southern Iraq. Mau *et al.* (2013) have evaluated the efficacy of different fertilizers on the growth and survival of brackish water catfish, *Mystus gulio* (Hamilton) fry in nursery ponds and reported that organic fertilizer (cattle dung) was significantly more effective for nursery rearing of this fish than that inorganic (urea & TSP) and mixture of organic and inorganic fertilizer.

The present study was conducted to evaluate the effects of fertilization on growth and production of fishes on nursery rearing of *Chelon subviridis*. The fishes showed better growth and production performance in supply of mixed fertilizer as both phytoplankton and zooplankton production were highest in this condition. The physico-chemical parameters of the experimental ponds were within the productive ranges for the growth of plankton and benthos during the tenure of experiment. The results of the present study show that average gain in body weight was less in the ponds fertilized with mixture of organic and inorganic fertilizers than that in the ponds with organic fertilizers only and ponds with only inorganic fertilizers. The fertilizer increased the primary productivity and finally caused a significant increase in fish yield in T3. The net fish production in T_3 was found to be (23.22 Kg/dec); while in T_1 it was (15.92Kg/dec). However, the different in production between ponds in the present study are in line with those obtained by Al-Daham and Wahab (2006), who reported a significant increase in fish yield due to the effect of organic fertilizer on the planktonic productivity. Hassan *et al*. (2000) has reported that cow dung exerted significant effect on the growth performance of major carps. These results are also in confirmatory with those of Shofiquzzoha *et al.* (2001) & Shofiquzzoha *et al.* (2003), the optimization of stocking density of shrimp with different brackishwater finfishes in polyculture system. These authors, reported effect of different farm made feeds on the polyculture of shrimp with different mullet species *viz*., *Liza parsia*, *Mugil cephalus* and *Rhinomugil corsula*. In the present study, the enhanced production in T_3 can be justified by the fact that the fertilizer contributed to the fertility of the pond. This research would be useful for the sustainable aquaculture in Bangladesh as well as other Asian countries.

The average survival rate of fish was found satisfactory and comparatively higher in T_3. Highest (85.5%) survival rate of silver carp was in T_3 and lowest (68.5%) was in T_1. Though, the level of fish production in the present study was similar to the result of Ali *et al.* (2000) with maximum individual weights attained.

5. Conclusion

Though Brackish water finfish aquaculture particularly, green back mullet is emerging rapidly in the coastal region of Bangladesh, it is essential to develop a sustainable nursery management for the supply of quality seed and only a sustainable nursery management can meet up the increasing demand of quality seeds for different culture practices performed there. According to this study it is established that growth, length, production and survival of *C. subviridis* fries were significantly higher in ponds fertilized with mixture of organic and inorganic fertilizer compared to growth, length, production and survival of fish in ponds fertilized with only organic or only inorganic fertilizers. And the reason for highest production in ponds fertilized with mixture of organic and inorganic fertilizer was higher plankton production during the culture period and on the other hand the water quality plays a little role owing to no significant difference ($p<0.05$) in ponds which indicated that mixed fertilization might play a vital role in pond fish culture to increase production and survival of *C. subviridis* in nursery rearing.

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