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Influence of feeding, periphyton and compost application on the performances of striped grey mullet (*Mugil cephalus* L.) fingerlings in fertilized brackishwater ponds

G. Biswas[a,*,1], J.K. Sundaray[b,1], S.B. Bhattacharyya[a], P.S. Shyne Anand[c], T.K. Ghoshal[a], D. De[a], Prem Kumar[a], K. Sukumaran[c], A. Bera[c], B. Mandal[c], M. Kailasam[c]

[a] ICAR-Central Institute of Brackishwater Aquaculture, Kakdwip Research Centre, Kakdwip, South 24 Paraganas, West Bengal 743347, India
[b] ICAR-Central Institute of Freshwater Aquaculture, Kausalyaganga, Bhubaneswar, Odisha 751002, India
[c] ICAR-Central Institute of Brackishwater Aquaculture, 75 Santhome High Road, R.A. Puram, Chennai - 600028, India

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ABSTRACT

To evaluate the effects of different management systems on performances of grey mullet (*Mugil cephalus* L.) fingerlings, a 120-day experimental trial was conducted in twelve brackishwater ponds (600 m^2 each). Rearing management systems assessed were: fertilization alone (FR), combined fertilization-feeding (FF), fertilization-periphyton (FP) and fertilization-compost application (FC) in triplicate ponds. Soaked mustard cake was used as a fertilizer @ 100 kg ha^{-1} at 15-day intervals in all the treatment ponds. Formulated crumble diet containing 29.7% protein and 4.9% lipid was used as a supplementary feed in FF. Bamboo poles were used as substrates (equivalent to 10% of pond surface area) to facilitate periphyton growth in FP and composted aquatic weed was applied @ 500 kg ha^{-1} in FC at monthly intervals. Ponds were stocked with grey mullet fry (3.36 ± 0.32 g/ 63.70 ± 4.61 mm) at 30,000 number ha^{-1}. The experiment revealed significant differences in most of the water quality parameters among the four treatments. In FP ponds, a significant reduction ($P < 0.05$) in inorganic nitrogen and phosphorous, chlorophyll-a contents, and plankton population was observed. The highest fish growth (28.39 ± 1.94 g) and survival (94.3 ± 4.2%) were recorded in FP followed by in FF, FC and FR ($P < 0.05$). A significantly higher total fish biomass ($P < 0.05$) was obtained in FP (803 ± 29 kg ha^{-1}) followed by in FF (730 ± 37), FC (507 ± 33) and FR (362 ± 22). Condition factor (K) and isometric exponent (b) of length-weight relationship indicated that fingerlings were in better condition with isometric growth ($K = 1.37 \pm 0.13$; $b = 3.01 \pm 0.12$) in FP. Inferior condition with allometric growth was observed in FR, FF and FC systems. These results suggest that periphyton based system can be an appropriate rearing technique for grey mullet fingerling production in brackishwater fertilized ponds as an environment-friendly and sustainable practice.

1. Introduction

Mugil cephalus L. is commonly known as the striped, grey, or black mullet (Nelson et al., 2004), and inhabits tropical and subtropical coastal regions between 42°N and 42°S (Thomson, 1963). It is a commercially important euryhaline and eurythermal species that contributes considerably to the coastal fisheries of many Asia-Pacific, African and European countries (Biswas et al., 2012). Being omnivorous, it feeds on plant detritus and microflora (Moriarty, 1976; Odum, 1970), thus it remains an ecologically important species feeding at the lowest trophic level. Due to these attributes, this species is suitable for monoculture and compatible with other species in polyculture. Although, mariculture and coastal aquaculture production contributed only 15.9% to the world fish production in 2014, a striking share was by relatively high-valued crustaceans and finfishes cultured in brackishwater. Striped/flathead grey mullet as one of the species contributed substantially to the whole share of marine/coastal aquaculture that was 36.2% of the total aquaculture production (FAO, 2016).

In India, grey mullet is a candidate species suitable for culture in brackishwater ponds and has a high consumer preference due to its flesh quality and good flavour. Pond culture of traditional and semi-

* Corresponding author.
E-mail address: gbiswas@ciba.res.in (G. Biswas).
[1] Both the authors contributed equally to this work.

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intensive systems mainly depends on seeds available from natural water. In west coast, fry of *M. cephalus* becomes available from the onset of south-west monsoons in November–April (Curian, 1975), whereas in north-east coast, it is available in two phases, January–March and July–August (Biswas et al., 2012). Direct stocking of small fry (15–25 mm) to culture ponds often results in poor production. At initial life stage, this fish grows slowly (Hickling, 1970; Bishara, 1978; De Silva, 1980; Saleh, 2008), therefore, a pre-stocking seed rearing step will be desirable to obtain advanced fingerlings (100–120 mm) that are suitable for grow-out culture.

In different farming environments, in addition to natural food organisms, grey mullet accepts supplementary feed (Curian, 1975; Luzzana et al., 2005). Application of different organic manures and inorganic fertilizers influenced the natural food organisms and had subsequent effects on growth of this fish during farming in pond (Bishara, 1978). Therefore, previously, we tested combination of fertilization with feeding system for rearing of grey mullet fry and observed that fish performance was better in this system than in feeding or fertilization alone at a stocking density of 15,000 number ha^{-1} (Biswas et al., 2012). However, in the context of increasing price of fish feed, eutrofication due to organic load in fish ponds and sustainability issue, it is high time to explore the method that harnesses natural productivity. For this purpose, organic input based systems would be appropriate eco-friendly methods. In this regard, composted aquatic weed as low cost farm-made organic manure could be an effective alternative as it is often used in traditional brackishwater aquaculture ponds in India. Another environment friendly and unconventional natural feed supplementation system, production and utilization of periphyton are a recent concept in aquaculture. Employing various submerged substrates, growth and use of periphyton which is a complex of microalgae, bacteria and detritus to convert into fish biomass have been extensively evaluated in freshwater aquaculture, particularly in carps (Wahab et al., 1999; Keshavanath et al., 2001; Azim et al., 2002), tilapia (Asaduzzaman et al., 2009), catfish (Amisah et al., 2008) and giant freshwater prawn (Asaduzzaman et al., 2008). Similarly, periphyton utilization was also tested for mullets, for instances, *M. cephalus* performed better in inland saline groundwater ponds (Jana et al., 2004) and *Liza aurata* in marine cages (Richard et al., 2010). In addition to the contribution of periphyton to fish biomass, the submerged substrates added to aquatic system improve water quality by trapping suspended solids and thereby enhance nitrification (Ramesh et al., 1999; Thompson et al., 2002). Although various works demonstrated the benefits of periphyton or fertilization system in fish fingerling rearing, there is a dearth of information on the comparative performance of periphyton system with other alternative cheap organic input based systems. In this context, the present study aims at comparing growth, survival and organism condition indicators along with hydrobiological parameters and economic returns for different pond management systems (fertilization alone, combined fertilization-feeding, fertilization-periphyton and fertilization-organic compost application) during grey mullet fingerling production in brackishwater.

2. Materials and methods

2.1. Experimental site and design

The experiment was conducted for a period of 120 days in the brackishwater farm of Kakdwip Research Centre (KRC) of ICAR-Central Institute of Brackishwater Aquaculture (CIBA), Kakdwip, South 24 Parganas, West Bengal, India.

Twelve rectangular earthen ponds (600 m^2 each) were used. Four rearing systems tested in this experiment formed four treatments: fertilization alone (FR), combined fertilization-feeding (FF), fertilization-periphyton (FP) and fertilization-compost application (FC). Each treatment had three replicate ponds which were randomly assigned between treatments. Stocking density of grey mullet advanced fry (3.36 ± 0.32 g/63.70 ± 4.61 mm) was 30,000 number ha^{-1}. This stocking density was derived based on our previous study (Biswas et al., 2012) that suggested use of higher density than 15,000 number ha^{-1}, and consequent experiments conducted at our farm (unpublished).

2.2. Pre-stocking pond management

The ponds were sun-dried and then agricultural lime ($CaCO_3$) was applied to each pond bottom at 300 kg ha^{-1} (day 1). After 3 days of lime application, ponds were filled with filtered brackishwater drawn through tide from the nearby Creek of Muriganga River to a depth of 50 cm. On day 5, all the ponds were fertilized with mustard cake (4.84% total nitrogen, N; 2.06% total phosphorus, P; 1.32% total potassium, K on dry weight basis), urea (46% available N) and single super phosphate (16% available P) at 200, 20 and 20 kg ha^{-1}, respectively. Then the ponds were left for 5 days to allow growth of natural fish food organisms and water level was finally increased to 150 cm on day 10. On day 11, semi-dried bamboo poles (2 m long; 10 cm dia) were erected vertically on the pond bottom in FP treatment ponds to act as substrates for periphyton growth. Submerged surface area of bamboo poles was calculated and accordingly, 2650 number ha^{-1} were used to provide an added surface area equivalent to 10% of pond surface. Composted aquatic weed (2.27% N, 0.16% P and 2.92% K) was applied at 500 kg ha^{-1} to all the replicate ponds of FC treatment in five nylon net bags placed at four corners and middle of ponds. The net bags were tied to vertically driven bamboo poles to allow leaching and sustained release of nutrients. For preparation of compost, aquatic weeds (*Chara* sp. and *Enteromorpha* sp.) were collected from KRC farm and composted for a month following the Indore method (Howard and Wad, 1931) with a slight modification. An earthen pit (L × B × D: 2 × 1.5 × 1.5 m) was filled with collected raw weeds in layers of 25–30 cm. Between two layers, previously prepared compost mixture was applied at 5 cm thickness. A final layer of weed was kept on top. The pit was covered with moist gunny bags and water was sprinkled at 4-day intervals. At an interval of 10 days, compost materials were turned upside down to ensure proper decomposition. On day 20, ponds were stocked with *M. cephalus* advanced fry pre-acclimated to farm conditions for 30 days in a pre-nursery pond.

2.3. Post-stocking pond management

After stocking, all the ponds under different treatments were fertilized fortnightly with mustard cake at 100 kg ha^{-1}. This was done to eliminate the effect of fertilization from other treatments and enable FR to act as the control. Mustard cake was soaked overnight and diluted with pond water prior to application. Agricultural lime at 100 kg ha^{-1} was applied one day before mustard cake application throughout the rearing period to keep pH level within desirable range. In FF treatment ponds, formulated crumble diet (1 mm) was used as a supplementary feed provided in feeding trays. Daily ration was distributed in two equal meals in the morning (0900 h) and afternoon (1500 h). Proximate composition of feed determined (AOAC, 1995) as % dry matter was as follows: organic matter (84.5), crude protein (CP: 29.7), lipid (L: 4.9), crude fibre (CF: 9.2), acid insoluble ash (4.1) and nitrogen free extract (45.3). Feed quantity was adjusted at 15-day intervals based on an estimated biomass from random samples of 15% stocked fish. Feeding rate was kept at 10–4% of the estimated fish biomass at a decreasing order. In FC treatment ponds, bags containing composted aquatic weed were replaced at 30-day intervals. Pond water depth was maintained at 150 cm after compensating seepage and evaporation loss of water during high tide at monthly intervals.

2.4. Determination of water quality parameters

At 15-day intervals, water temperature, salinity, pH, dissolved oxygen (DO), nitrite-nitrogen (NO_2-N), nitrate-nitrogen (NO_3-N), total