Biofloc-Based Fish Farming in the State of West Bengal: A Case Study with Genetically Improved Farmed Tilapia (GIFT)

[1]Jagadish Mondal, [2]Pallavi Dutta, [1]Sufia Zaman, [1]Subhra Bikash Bhattacharyya and [1]Abhijit Mitra

[1] Department of Oceanography, Techno India University, West Bengal,

[2] Department of Zoology, Charuchandra College, University of Calcutta

Abstract : Biofloc technology has emerged as a transformative aquaculture practice, offering sustainable solutions to traditional fish farming challenges. This study investigates the technical viability of biofloc-based farming in West Bengal, focusing on the cultivation of genetically improved farmed tilapia (GIFT). Conducted over 120 days in four outdoor biofloc ponds, the research monitored key growth metrics, including Average Body Weight (ABW), Specific Growth Rate (SGR), and Average Body Length (ABL) of the candidate species (GIFT), along with relevant water quality parameters. Results indicate consistent growth across ponds, with Pond 2 achieving the highest ABW (461.31 g) and Pond 4 excelling in SGR (1.65%) and ABL (25.42 cm). The biofloc system's ability to convert organic waste into nutrient-rich flocs enhanced growth efficiency, reduced feed costs, and maintained optimal water quality. These findings underscore the potential of biofloc farming as a climate-resilient, economically viable model for sustainable aquaculture, aligning with the global goals for food security and environmental conservation.

Keywords: Genetically Improved Farmed Tilapia (GIFT), Biofloc, Average Body Weight, Specific Growth Rate, Average Body Length

1. Introduction

Biofloc fish farming has emerged as a rapidly advancing aquaculture technology, characterized by its ability to conserve feed and reduce dependency on external inputs through microbial manipulation. This eco-friendly farming method relies on *in-situ* microbial production (Avnimelech, 2009; Emerenciano et al., 2017) and operates on a zero-exchange or minimal water exchange regime. The organic matter present in the system fosters the growth of a heterotrophic microbial community, which serves as a natural food source for fish species (Azim and Little, 2008). The core principle of biofloc technology lies in converting waste into nutrient-rich flocs under optimal conditions of aeration, water circulation, and maintenance of a suitable Carbon:Nitrogen (C:N) ratio (Azim and Little, 2008). Carbon sources such as jaggery, yeast, and molasses are often added to the system to enhance organic matter and regulate the C:N ratio (Avnimelech, 1999; Hargreaves, 2006). Compared to conventional aquaculture systems, biofloc significantly reduces the risk of disease outbreaks, as it functions as a closed recirculatory system with minimal external inputs (FAO, 2015). This results in improved fish survival rates, enhanced growth, and higher productivity (Azim and Little, 2008; Kenneth et al., 2018). However, the initial investment required to establish a biofloc unit remains prohibitively high for many traditional fish farmers (NFDB, 2020). During the COVID-19 pandemic, which posed severe threats to food and nutritional security in India

(Boyacı Gündüz et al., 2021), the state of West Bengal implemented several biofloc projects mostly through private parties as a development initiative to address the crisis. Similar model was also adopted in Kerala, but with Government support. This people-centric campaign at Kerala aimed to boost the production of essential commodities such as vegetables, paddy, tuber crops, fruits, milk, eggs, fish, and meat, with a budget allocation of ₹1,500 crores from various developmental departments (Kerala State Planning Board, 2021; Paul et al., 2020). Within this framework, biofloc fish farming was introduced to Kerala farmers as a sustainable alternative, adhering to pandemic restrictions due to its closed farming system. Financial assistance, including fixed subsidies, was provided to farmers adopting this innovative technology under the project. In the maritime state of West Bengal biofloc was mainly introduced by the private sectors. A random survey of promising biofloc farming units was conducted to gather technical and economic data. The present research is the output of a biofloc system carried out at Naihati region of North 24 Parganas district of West Bengal during 2024. The primary objectives of the survey were to: (1) assess the growth and productivity of GIFT tilapia within the biofloc system and (2) evaluate the technical efficiency of biofloc farming compared to traditional tank-based aquaculture. The findings are anticipated to shed light on the potential of biofloc farming as a sustainable and productive aquaculture model.

2. Methodology

During 2024, an outdoor biofloc system was studied across four ponds in Madarpur, Naihati located in the North 24 Parganas district, for the cultivation of tilapia fish. The preparation of flocs followed the method as outlined by Avnimelech (2009). Floc volume and water quality parameters were monitored at regular intervals throughout the study period of 120 days. Each pond of 0.05 ha was stocked with 2000 fingerlings (@4 pc/m^2) of genetically improved farmed tilapia (GIFT), weighing approximately 25 gram and measuring 12 cm in length, during February 2024.

Feeding was administered using commercial floating pellet feed, with protein levels adjusted between 25-40% according to the life stage of the fish. The feeding ration was maintained at 2-4% of the fish body weight throughout the culture period. Water quality parameters, including temperature, dissolved oxygen (DO), total ammonia nitrogen (TAN), nitrate-nitrogen, and phosphate-phosphorus, were systematically measured in the four biofloc systems during the early morning hours at 5:30 am, following the procedures described in Strickland and Parsons (1972)..

3. Results

The graphs presented as Figs. 1 to 3 illustrate the trends in Average Body Weight (ABW), Specific Growth Rate (SGR), and Average Body Length (ABL) for the four biofloc ponds (P1, P2, P3, P4) over 120 days. Each metric demonstrates the comparative performance of the ponds during the study period.

The results of the four biofloc ponds are highlighted in points:

1. **Average Body Weight (ABW):**

All ponds showed a consistent increase in ABW over 120 days, with pond 2 achieving the highest final ABW (461.31 g), followed by pond 4 (452.56 g), pond 1 (448.06 g), and pond 3 (437.31 g). The growth pattern across the ponds indicates that Pond 2 had the most favorable conditions or efficient management practices, leading to superior weight gain.

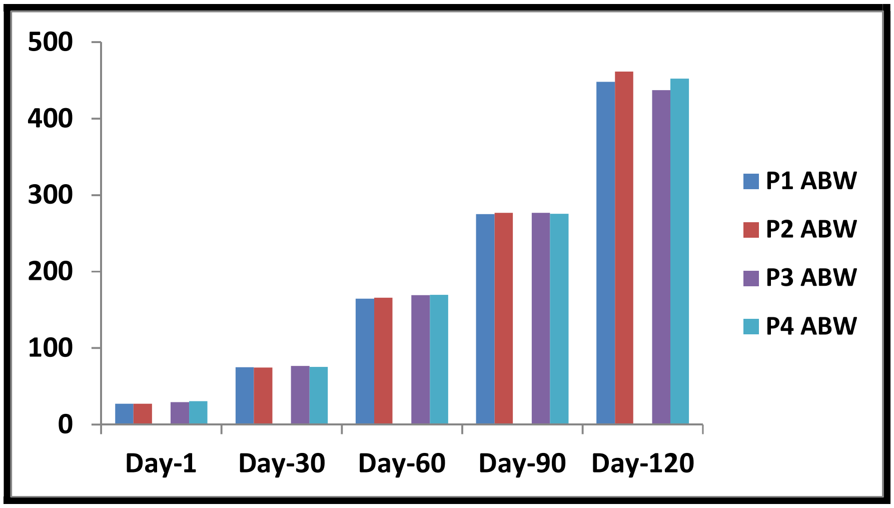

Fig. 1 Day-wise ABW across four selected ponds during the culture period

2. **Specific Growth Rate (SGR):**

SGR showed a declining trend across all ponds as the study progressed, which is typical as fish mature and growth rates stabilize. Pond 4 demonstrated a higher SGR at the end of the study (1.65%), outperforming other ponds slightly, suggesting optimal conditions for maintaining growth efficiency toward the latter stages.

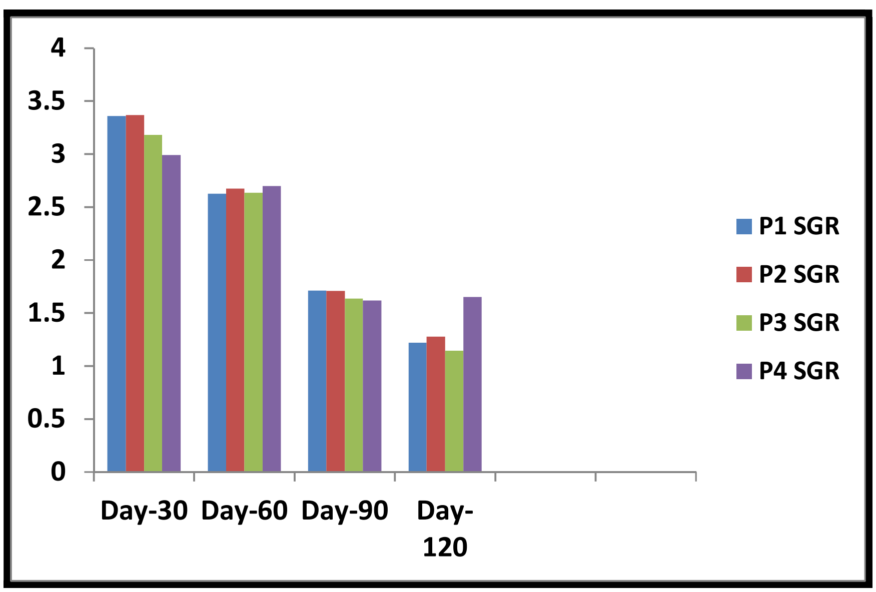

Fig. 2 Day-wise SGR across four selected ponds during the culture period

3. **Average Body Length (ABL):**

The ABL across all ponds increased steadily over time, with final lengths ranging from 24.55 cm (Pond 1) to 25.42 cm (Pond 4). Pond 4 achieved the highest ABL, indicating a marginal advantage in overall growth conditions compared to the other ponds.

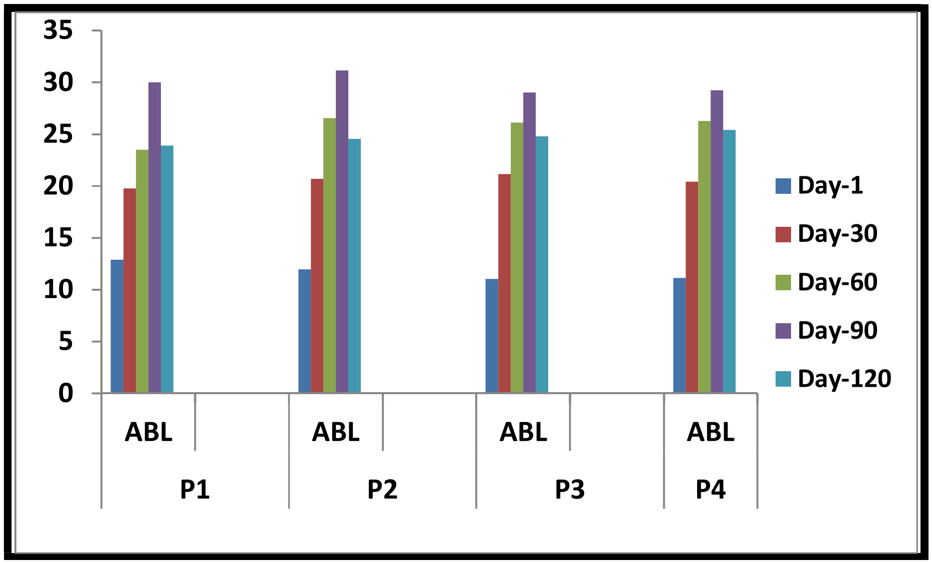

Fig. 3 Day-wise ABL across four selected ponds during the culture period

The variations of the water quality across the four ponds are shown in Table 1.

Table 1 Pond-wise variation of water parameters with SD values

Pond	NO_3-N (mg/L)	PO_4-P (mg/L)	Dissolved Oxygen (DO)	Total ammonia nitrogen (TAN)
Pond 1	0.316±0.0201	0.002±0.0006	5.02±0.66	0.19±0.001
Pond 2	0.202±0.0215	0.004±0.0005	6.16±0.99	0.11±0.002
Pond 3	0.365±0.0235	0.006±0.0004	4.95±0.34	0.23±0.001
Pond 4	0.291±0.0180	0.002±0.0001	5.67±0.25	0.13±0.003

4. Discussion

The present study investigates the potential of the biofloc system in the Lower Gangetic Delta region using GIFT as candidate species. This ecologically sensitive region, known for its unique genetic diversity (Mitra 2000; Mitra et al. 2015; Mitra et al. 2016; Mitra et al. 2017; Mitra et al. 2023) as well as expanding aquaculture units, presents a unique challenge in balancing economic activities with environmental security.

The results from the four biofloc ponds studied over 120 days highlight the substantial potential of biofloc technology in enhancing the growth performance of genetically improved farmed tilapia (GIFT). This study underscores the effectiveness of biofloc systems in achieving significant improvements in Average Body Weight (ABW), Specific Growth Rate (SGR), and Average Body Length (ABL), with notable variations observed across the ponds.

Average Body Weight (ABW):

All ponds exhibited a consistent increase in ABW throughout the study, reflecting the effectiveness of biofloc technology in promoting weight gain. Pond 2 achieved the highest final ABW (461.31 g), followed by Pond 4 (452.56 g), Pond 1 (448.06 g), and Pond 3 (437.31 g). The superior performance of Pond 2 suggests optimal conditions or management practices, such as efficient aeration, feed management, and consistent monitoring of water quality parameters. The ability of the biofloc system to convert organic waste into protein-rich flocs that serve as a supplementary food source played a pivotal role in achieving these results. This not only reduces feed costs but also ensures better utilization of nutrients, promoting sustainable aquaculture practices.

Specific Growth Rate (SGR):

SGR demonstrated a natural declining trend across all ponds as the fish matured, which is characteristic of fish growth patterns. Pond 4, however, maintained a slightly higher SGR (1.65%) toward the end of the study, indicating efficient growth even during the later stages. The ability of biofloc systems to maintain water quality and provide a stable environment likely contributed to this sustained growth. The consistent monitoring of dissolved oxygen, ammonia levels, and pH in the biofloc system minimizes stress on the fish, thereby supporting continued growth and health.

Average Body Length (ABL):

The ABL across all ponds showed a steady increase over time, with final lengths ranging from 24.55 cm (Pond 1) to 25.42 cm (Pond 4). Pond 4 achieving the highest ABL suggests a marginal advantage in overall growth conditions compared to the other ponds. This emphasizes the importance of precise management of biofloc systems, including maintaining the appropriate Carbon:Nitrogen ratio, regular monitoring of floc volume, and providing adequate aeration to optimize fish growth.

Importance of Biofloc Technology:

The biofloc system is a revolutionary aquaculture technique that addresses several challenges associated with traditional fish farming. It operates on the principle of microbial conversion of organic waste into flocs, which serve as an additional food source for fish. This not only reduces feed dependency but also enhances water quality by controlling harmful ammonia and nitrate levels.

In this study, the ability of the biofloc system to sustain high growth rates, maintain water quality, and minimize disease risks was evident. The closed-loop nature of the system, with minimal water exchange, ensures environmental sustainability by reducing effluent discharge into natural water bodies. Moreover, the reduction in feed costs and the high productivity achieved make biofloc technology economically viable for fish farmers.

The findings highlight the potential of biofloc systems to support climate-resilient aquaculture by promoting efficient resource utilization and reducing the environmental footprint of fish farming. This aligns with global efforts to achieve sustainable food security amidst growing environmental challenges. Future research focusing on optimizing biofloc parameters, integrating alternative feed sources, and scaling up operations can further enhance the adoption of this innovative technology.

Thus, the study reinforces the significance of biofloc technology as a sustainable and efficient aquaculture practice, capable of meeting the rising demand for fish protein while addressing environmental and economic challenges. The consistent performance across all ponds in terms of ABW, SGR, and ABL underscores the reliability and potential of biofloc systems in advancing modern aquaculture.

5. References

Avnimelech, Y. 2009. Biofloc technology: a practical guidebook. World Aquaculture Society, 258 pp.

Azim, M.E. and Little, D.C., 2008. The biofloc technology (BFT) in indoor tanks: water quality, biofloc composition, and growth and welfare of Nile tilapia (Oreochromis niloticus). Aquaculture, 283(1-4):29-35.

Boyacı-Gündüz, C.P., Ibrahim, S.A., Wei, O.C. and Galanakis, C.M., 2021. Transformation of the food sector: Security and resilience during the COVID-19pandemic.Foods,10(3):497.

Crab, R., Kochva, M., Verstrate, W. and Avnimelech, Y., 2009. Bioflocs technology application in over –wintering of tilapia. Aquaculture Engineering, 40(3):105-112.

Emerenciano, M.G.C., Martínez-Córdova, L.R., Martínez-Porchas, M. and Miranda-Baeza, A., 2017. Biofloc technology (BFT): a tool for water quality management in aquaculture. Water quality,5:92-109.

Hargreaves JA. Photosynthetic suspended-growth systems in aquaculture. Aquaculture Engineering. 2006; 34:344-363.

Kerala State Planning Board, 2021. Kerala development report: initiatives, achievements, and challenges, 338p.

Mitra A (2000) The Northeast coast of the Bay of Bengal and deltaic Sundarbans. In: Seas at the Millennium – An environmental evaluation, Chapter 62 (Editor: Charles Sheppard, University of Warwick, Coventry, UK), Elsevier Sci 143-157.

Mitra A, Banerjee K, Ray Chaudhuri T (2017) Recent Developments in Mangrove Research, published by Hindustan Publishing Corporation (India), ISBN 978-8170750932, pp. 346.

Mitra A, Jana HK, Ray Chaudhuri T (2016) Ecological Health of Sundarbans & its Management, published by Narendra Publishing House, ISBN 9789384337902

Mitra A, Trivedi S, Agarwal S, Biswas S, Pramanick P, Zaman S (2015) Decadal Variation of Dissolved Oxygen in the Lower Gangetic Delta Water. Int J Aqua Fish Sci 2(1):7-8.

Mitra A, Zaman S, Pramanick P (2023) Climate Resilient Innovative Livelihoods in Indian Sundarban Delta. Springer, Hardcover ISBN 978-3-031-42632-2, eBook ISBN 978-3-031-42633-9, XII, pp. 297 DOI: https://doi.org/10.1007/978-3-031-42633-9

NFDB, 2020. Recent trends in aquaculture: Biofloc FishCulture,16p.

Paul, N., Jacob, E.M. and Philip, S.R., 2020. A revisit to COVID-19 Challenges and Responses: A Case Study of Kerala. Space and Culture, India, 8(2): 47-61.

Strickland, J.D.H. and Parsons, T.R. (1972). A Practical Hand Book of Seawater Analysis. Fisheries Research Board of Canada Bulletin 157, 2nd Edition, 310.