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Accessing Economic Competitiveness of Rohu (Labeo Rohita) in Biofloc Based Aquaculture System in Khyber Pakhtunkhwa Pakistan

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ABSTRACT

Biofloc technology has been emerged as a sustainable aquaculture alternative to conventional pond-based fish farming due to its limited or zero water exchange, zero discharge of effluents into running water bodies and effective recycling of nutrients. This study focuses on economic and performance-based comparison of biofloc technology and earthen conventional pond culture system for *Labeo rohita* in Khyber Pakhtunkhwa Pakistan. Data was collected from 30 fish farmers across different districts of Khyber Pakhtunkhwa using structured questionnaire, interviews and on-site assessments. Results reveled thar Biofloc technology has improved growth performance, lowering per kilogram fish production and hence enhancing net profitability to PKR 240,333 per year compared to PKR 132,733 of conventional earthen ponds. Biofloc systems further demonstrated reduced exchange of water, reduced environmental discharges and enhanced diseases control due to the presence of beneficial microbial fauna. However, limited adoption persists due to lack of technical knowledge, high initial installation costs and operational challenges.

INTRODUCTION

The inculcation of modern techniques in aquaculture are mainly concerned with the sustainability and Biofloc technology has been in consideration as one of the major substitutes to conventional pond aquaculture systems with minimal to zero water exchange and involvement of biological fauna including communities of microbes (Crab et al., 2012). Biofloc technology has been substantiated to be an efficient tool that promotes fish growth, lowers financial costs and simultaneously reduces hazardous environmental impacts. Labeo rohita (locally known as Rohu, Dambra) is one of the eminent Indian carps and is adored for its delicious taste. Studies have reported its improved outcome, reared in biofloc technology (Debnath et al., 2005). Superior feed efficiency and weight gain has also been reported by Kamiliya et al., (2017). Similar outcomes have been documented for Tilapia with improved hematological responses, better water quality parameters and growth in comparison to traditional ponds by Jamal et al., (2025).

In Khyber Pakhtunkhwa province of Pakistan aquaculture practices are predominantly accomplished in earthen ponds following semi-intensive or extensive culture system (Chugtai & Mahmood, 2012). This conventional fish farming is cost effective in term of low initial cost and reduced operational charges. However, these practices face challenges of land scarcity, low fish stock carrying capacity, water pollution and inconsistency in yield (Hassan et al., 2020). These all shortcomings have been effectively overcome by biofloc technology (Manan et al., 2023).

This study will help to evaluate the economic performance of rohu cultured in biofloc system compared to culture in earthen pond un term focusing on growth, survival, issues and profitability. The findings aim to guide potential fish farmers, policy makers and researchers in understanding the economic perspective and feasibility of adopting the biofloc technology for culturing rohu fish.

METHODOLOGY

A cross-sectional research study design was employed to compare the economic and production performance of biofloc technology with conventional earthen ponds culture systems in different districts of Khyber Pakhtunkhwa. Both survey-based data collection and on-site validation were integrated to obtain reliable

qualitative and quantitative information. Total of thirty progressive fish farmers were selected, representing equal distribution of biofloc (15) and ponds (15) farms for aquaculture. Only those farms were included if they had been operational for the last one year, has maintained a verifiable record of production activities and provided information consent to participate.

Farms were selected from similar geographical and ecological conditions, with special attention paid to water supply sources, prevailing climatic conditions and species in culture, with special interest in rohu. Primary data was collected through pre tested questionnaires during in-person visits, telephonic interactions and online forms via Google form. The questionnaire was designed to gather information on stocking densities, feeding strategies, probiotics preferences, management of water quality, operational challenges and economic perspectives.

Additionally, key production parameters including initial fish weight before stocking, final harvest weight, number of feedings per day, and survival rate were cross verified during the on-site visits. For Biofloc fish farms, additional emphasis was placed on evaluating probiotics usage pattern, frequency of water exchange and microbial fauna management. This framework of methodology enabled a holistic assessment of operational efficiency, growth outcomes and economic feasibility associated with biofloc and conventional aquaculture system across Khyber Pakhtunkhwa.

RESULTS

Gathered data demonstrated clear difference between biofloc and conventional pond aquaculture system. Rohu fish cultured in biofloc system demonstrated higher final weight, better survival rate and more efficient feed utilization. The enhanced growth is linked with the continuous supply of protein rich floc and stability in water quality. Biofloc technology notably reduced the overall production cost, particularly feed and water expenses. This high yield and reduced operational cost resulted in significantly improved profitability as shown in table 1.1.

Table 1.1: Comparison of various parameters in Conventional farming with Biofloc farming

Consideration	Conventional/Pond Farming	Biofloc Farming
Area required	1.2 Acres	0.03 Acres (20,000 liters tank)
Stocking density	4800-5500 per acre	50 to 80 fishes per m^3 of water
Per KG production expenditure	PKR 240-280	PKR 235
Water changing frequency	3.5 change/year	Minimum to zero exchange
Impact on environment	High discharge of water	Lower due to reduced water exchange
Culturable species	Carps mainly	Tilapia, pangasius, Carps, catfishes
Control of diseases	Relative	Much better due to microbial fauna
Net income per annum	PKR 132,733	PKR 240,333

DISCUSSION

The findings of the current analysis clearly establish the fact that biofloc technology provides extensive biological and economic advantage over the conventional aquaculture system for culturing rohu (*Labeo rohita*). The heightened performance perceived in the biofloc system, is predominantly accredited to the role of microbial floc, which promotes the conversion of nitrogenous wastes such as ammonia into protein rich biomass. The microbial proteins oblige as a supplemental feed utilization and growth performance promoter in various fish species (Avnimelech, 2009; Crab et al., 2012). The lower feed conversion ratio recorded in the current study overlaps with the findings of early researchers who has reported that the presence of biological floc in biofloc tank reduces feed cost by improving nutrients recycling within the culture environment (Emerenciano et al., 2013).

Optimized water quality parameters in the biofloc units further contributed to the accelerate better growth and survival outcomes. Biofloc system maintains higher level of dissolved oxygen, low level of toxic nitrogen containing compounds and more coherent environmental conditions compared to conventional earthen ponds (Hargreaves, 2013). This consistency lowers the stress and encourages improved fish immunological responses which may explain the better survival rate recorded in this study. Similar results have been described in multiple studies where biofloc based systems resulted in improved welfare and higher survival in tilapia and carp species (Kumar et al., 2018).

From economic perspective, the biofloc technology authenticated a prominent reduction in overall production cost. This may be attributed to the reduced feed input and significantly lower water usage and exchange. The contemporary findings support the argument that biofloc technology is more sustainable in terms of resources efficiency and less reliant on labor intensive water exchange practices as required in conventional system (De Schryver & Verstraete, 2009). Higher final biomass and lower operational costs produced a superior net profit and cost-benefit ratio which is coherent with the financial assessment conducted in other developing countries embracing biofloc tecnology for freshwater aquaculture practices (Bossier & Ekasari, 2017).

Environmental sustainability is another critical advantage associated with biofloc technology. Due to internal recycling of nutrients facilitated by the microbial fauna, the system lessens the discharge of pollutants into the environment. Previous research has emphasized that biofloc technology significantly reduces nitrates and ammonia discharges, making it more environmentally friendly and safe for fish farming (Vrab et al., 2012). Given increasing global pressure for sustainable food production, the adoption of biofloc technology aligns well in modern ecological and economic priorities.

Although the initial investment in aeration system

installation and monitoring equipment required for water quality check is relatively higher, the extensive long term economic benefits compensate these expenses. Multiple authors have reported that the reimbursement period for the biofloc system is short due to increased production efficiency and reduced feed expenses (Kuhn et al., 2009). The outcome of this study validate these findings and further determines that, for rohu farming especially, the biofloc system offers a strong economic gain in region where aquatic resources are depleting and feed costs are intensifying.

CONCLUSION

This study establishes the fct that biofloc technology is an enriched technique that provides extensive economic and biological advantage over earthen ponds/conventional fish farming methods for culturing *Labeo roita***.** Biofloc systems boosts growth performances, enhanced and effective feed utilization, reduced usage of water and overall, expressively lessens production costs. With better profitability and curtailed environmental impacts, biofloc technology present a reliable alternative for sustainable and economically viable rohu culture in Pakistan.

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