Bottlenecks in the Application of Advanced Technologies in Indian Aquaculture

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Abstract— Aquaculture is the generations of rearing practice where aquatic animals such as finfish, crustaceans, molluscs, and aquatic plants, primarily algae and seaweeds, were raised in freshwater, seawater, brackish water, and inland saline water. Aquaculture offers benefits like food, nutrition, employment and income generation which convinced many of the maritime and non-maritime countries to promote aquaculture at commercial venture. In the case of Indian aquaculture, the industry is heavily depending on traditional fish culture systems like pond culture and composite fish culture for producing the fish. The successful operation of any fish farming depends on multiple factors and it starts with proper planning and construction, quality seed stocking and rearing, water quality and health monitoring, etc. Above all, the type of farming and system practiced are highly influence the successful operation of fish farming. The Indian scientist and farmers have developed numerous technologies to boost the aquaculture production, however, those technologies were not evenly implemented among the farmers due to various issues. The present article discusses about the technological interventions and their bottlenecks in effective implementation of modern technologies at farmer’s level.

Keywords: Bottlenecks, Application, Technology, Indian Aquaculture

I. Introduction

Aquaculture is an age-old practice where farming of aquatic animals, including finfish, crustaceans, molluscs, and aquatic plants, mostly algae, is being carried out using freshwater, seawater, brackish water and inland saline water. The exponential growth of human population in the past and present centuries has placed an immense pressure on the food production sectors, especially over the fish production sector. As per the latest Food and Agricultural Organization (FAO) report, the annual per capita consumption of fish is 20.5 kg. On the other side, the global fishery was supported by both captures as well as culture fisheries [3]. However, among the two fish production sectors – capture and culture – aquaculture is showing a steady increasing trend in the past few decades compare to capture fishery. The over-exploitation of major fish stocks and other climate-induced changes in capture fishery directly opened the gate for culture fishery. The additional benefits like food, nutrition, employment and income generation in aquaculture, convinced many of the maritime and non-maritime countries to promote aquaculture.

India – a highly biodiveresed country in the world – has vast resources for fisheries development which includes marine, coastal-brackishwater, freshwaters, cold waters, *etc*. In 2018, the government of India has launched the Fisheries and Aquaculture Infrastructure Development Fund (FIDF) to meet the infrastructural requirements to achieve blue revolution by 2020. The target was set to produce 20 million tonnes by 2022-23, in a sustainable growth of 8% to 9%, with the additionally created facilities [5]. The present export of marine products is 13.93 lakh metric tons which value about Rs.46,589 crores (USD 6.73 billion) during 2018-19. India alone contributed to about 3.7% of the Global seafood exports. Foreseeing the immense potential for the development of fisheries and for providing focused attention to the sector, the Government in its Union Budget, 2019-20 has announced a new scheme, the Pradhan Mantri Matsya Sampada Yojana (PMMSY).

The present Indian aquaculture is heavily depending on traditional fish culture systems like pond culture and composite fish culture which are rearing finfish as well as shellfish. In this system, water is maintained in an enclosed area by artificially constructed ponds where the hatchery produced seeds were stocked and reared [4]. The ponds may be filled with canal water, rainwater, and bore well water or from other water sources. On the other side, in composite fish culture, fish which are compatible and non-competing are cultured together in a single pond [8]. Yet, the future is not going to be rely simply on these age-old practices. The present context – where more fish is expected from aquaculture – is switching to the advanced technologies to maximize the fish production in one side and double the farmer revenue in other side. The Indian scientist and farmers have developed numerous technologies to boost the aquaculture production, however, those technologies were not evenly implemented among the farmers due to various issues. The present article discusses about the technological interventions and their bottlencks in effective implementation at farmer’s level.

II. Interventions and their Bottlenecks in Indian Aquaculture

A. *Seed Production Interventions in Aquaculture and Their Bottlenecks*

Seed is a base material for any aquaculture activities and called in different names such as fry, fingerling, post-larva, crablets, seedlings, spat, etc., based on the species cultured. Without captive seed production, nothing could have been happened in world aquaculture. To date, the reason for sustained aquaculture production is the successful seed production. Over the period, when the aquaculture entered into the 21st century, it demanded sophisticated seed production techniques to yield high-quality seeds rather than simple induced breeding.

B. *SPF/SPR/SPT Seed*

When we look into the journey of Indian shrimp farming, it signifies the need of SPF/SPR seed. Till date, the single factor which is threatening the shrimp farming, throughout the world, is a disease, especially viral diseases. Almost the entire Indian shrimp farming was collapsed at the end of 20th century due to single viral spread – WSSV. Later, to tackle the viral attacks in shrimp farming, a special seed was developed and inseminated into shrimp farming which was named as SPF seed. Within a short period, after its introduction, the brand name flourished among shrimp farmers and produced a greater result.

The SPF animals – it is called as SPF when both animal and environment are free of particular pathogen – are produced in a highly bio secured facilities – nucleaous breeding centre – and kept under a rigorous monitoring system. These animals are subjected to various sensitive and accurate diagnostic methods to certify them as SPF seeds. They are repeatedly bred under controlled conditions to maintain their SPF strain. However at farm level, the SPF seed is highly susceptible to infection when they encounter a particular pathogen. On the other side, Specific Pathogen Resistant (SPR) shrimp are repeatedly exposed to a particular pathogen and make sure that at one stage they are not susceptible to infection to that particular pathogen. Similarly, Specific Pathogen Tolerant (SPT) shrimp are produced by rearing the animals under pathogen dominated environment which leads to the development of tolerance strain in shrimp. The assorted merties of these seeds are disease-free, disease resistance, fast growth rate, better survival, FCR and high production.

The scientific problem associated with SPF/SPR seed production is the loss of genetic variability or genetic deterioration due to inbreeding. This ultimately leads to poor immunity, lower growth and other developmental abnormalities which in turn significantly affect the farmer preference. Production and culture of SPF/SPR seed require highly secured hygienic condition which is economically unfeasible for small scale farmers. On the other side, rearing of those stocks under non-biosecure or outdoor open culture conditions favours pathogen attacks. Additionally, no proper enforcement of seed certification and hatchery makes the seed production and insemination as a more challenging task.

C. Stunted Seed Production

The success in induced breeding paved the way for commercial inland fish farming. However, the improper management practices of broodstock lead to poor quality seed production which ultimately affected the growth and overall production. On the other side, the global climatic changes (reduced the water availability period) and intensification practices adopted in fish farming forcing the farmers to shorten their crop duration. In this context, future aquaculture anticipates a seed with high immunity and faster growth potential to meet the global food fish demand.

Keeping the normal seeds under heavy stocking and feeding them at sub-optimal level lead to stunting – growth retardation. Fish, subjected to stunting process, exhibits accelerated growth when reared under optimal culture condition which is termed as compensatory growth (CG). CG makes the stunted seed more special as it shortens the crop duration, reduces feed input and yields better production. Therefore, many of the Indian farmers are started stocking their grow-out ponds with stunted seeds, especially Andhra Pradesh farmers, which boomed their production.

Till date, a stunted seed is a successful practice only in carps. Since stunting is a successful option only in late-maturing fish, it could not be amplified in other species. However, diversification of high-value species in aquaculture demands the availability of quality seeds. On the other side, compensatory growth exhibited by stunted seed at normal culture conditions depends on the severity of stunting process and duration of stunting. Therefore, the duration and severity of stunting need to be optimized for high-value candidate species to promote their seed production.

D. Feed Interventions and their bottlenecks

In aquaculture, especially under captive enclosed conditions, stocked fish entirely rely on supplementary feed – major input in fish farming – for its normal growth and metabolism. In earlier days, when the natural fish stocks get trapped in low-lying area or pits, people started throwing household wastes i.e. vegetable peelings, spoiled rice and other kitchen wastes to feed them. When the time passed, people started using low cost feed materials like rice bran, broken rice, vegetable leaves, *etc* and cooked feed ingredients to feed the fish. However, the introduction of commercial pellets in late 80's completely changed the production trend of the sector.

Initially, feed is composed of traditional feed ingredients like rice bran, groundnut oil cake and slighter inclusion of fish meal. The evolution of fish nutrition and feed technology further advanced the feed making and started exploiting fish meal and fish oil to make a balanced diet to the farmed fish. In the subsequent days, the hike in fish meal prices directly hit the fish feed price. Additionally, the dumping of excessive protein-rich diet in aqua farming raised various environmental concerns. In the opposite side, the utilization of conventional feed ingredients soybean meal, GNOC, *etc*., the upraised question about the availability of feedstuffs for humans as well as other animal production sectors. Therefore, the sector currently searching the non-conventional feed ingredients to produce low-cost balanced diets for the rearing of fish.

In a farmer point of view, feed cost plays a major role while selecting the feed. In the commercial feed, the addition of feed additives like growth promotes, preservatives, probiotics, immune-stimulants, *etc*., increasing the feed cost. Additionally, the supplementary feed requires proper storage facility to maintain their feed quality. The newer technologies like automatic feeding devices and sensors demand highly technical people to monitor them. In the contemporary context, 80% of the Indian fish farmers are practicing aquaculture in a smaller scale and it is too difficult to convince them to shift their conventional practices into non-conetentaional.

III. FARM MANAGEMENT PRACTICES AND THEIR BOTTLENECKS

A. Water quality management (Automation)

Water – a medium where fish thrive and grow – and its physic-chemical parameters play an important role in fish production. In the recent scenario, most fish and shrimp farmers are using automation systems in their farms for maintaining different water quality, to reduce catastrophic losses and improve product quality [1]. The most important water quality parameters which directly affect fish growth, animal health, feed utilization and carrying capacities need to be monitored and controlled in an aquaculture system. Each water quality parameters affect fish behaviour differently, say for example water temperature affects the growth and feeding patterns, dissolved oxygen controls energy synthesis. All these parameters can be controlled and managed by advanced instruments like smart- water monitoring system, multi-water quality analyser and support vector machine *etc*.

Automation always requires highly efficient technical person for its operation and maintenance. Much of the Indian farmers are not concerned about water quality management at their farms and in this context, higher cost of automation machine is another barrier for its implementation.

B. Health Management

The intensification of aquaculture species/systems driven the sector into increased disease outbreaks and severe economic losses [2]. In the past few years, disease outbreaks caused an estimated loss of about 10 billion USD – globally, 6 billion USD in Asian countries and India – 125 million USD in shrimp industry; mainly due to WSSV [10]. The Indian farmers are advised to develop standard biosecurity protocols and adopt pathogen monitoring and disease control systems to control pathogen intrusion in shrimp farms. The non-availability of rapid diagnostic test labs at closer to farms and the higher cost of pathogen detection are the major bottlenecks associated with health management.

C. Farm/ Pond Design

The success of fish culture is mainly depending upon proper planning and construction of the pond. Mostly rectangular and the circular pond is appropriate for aquaculture. In aquaculture, different ponds like nursery, rearing, stocking, marketing, broodstock and quarantine were used for growing the fish and shrimp farming. The main purpose of all this pond is different stages of fish require different conditions for their growth and survival. Presently most of the shrimp farms are using shrimp toilet and central drainage system to maintain the water quality. The main purpose of this system is to keep the pond environment safe and free from sediment and detritus material at bottom of the pond. This technology keeps pond water clean, improves survival and enhances the sustainability of a shrimp farm. The major bottleneck is the cost of pond construction which is slightly higher than the conventional pond construction.

D. Technological Interventions and their Bottlenecks

The successful operation of any fish farming depends on multiple factors and it starts with proper planning and construction, quality seed stocking and rearing, water quality and health monitoring, *etc*. Above all, the type of farming and system practised are highly influence the successful operation of fish farming. In traditional days, small pits or earthen ponds were excavated, without proper water regulating structures and biosecurity facilities, and used for fish rearing. Still, in many parts of India, farmers are practising this kind of simple extensive fish rearing practices [7]. In contrast, a small group of farmers especially shrimp farmers, a highly advanced design, with proper water regulating structures, shrimp toilet, central drainage system, *etc*., was employed to rear high-value species. In the evolutionary context, farmers searching a technology which can double their income by maintaining water quality, lower the input supply and avoid the disease outbreaks.

E. Recirculatory Aquaculture System

RAS – Recirculatory Aquaculture System - is a unique technology used for farming of high-value fish species by reusing the water. This system supported by various filters, mechanical and biological filters. The recirculation is carried out at various water flow rates based on how much water is needed to be recirculated. Presently, it is used in hatcheries and brood-stock rearing.

This is a very good technology for where the problem of water scarcity threatening the aquaculture expansion. The higher production cost and lack of technical manpower to operate this system still keeping this system in the basket of aquaculture technologies.

F. Cage Culture

Cage – rectangular or round shaped net enclosure – is a famous open water fish culture technology practised throughout the world for rearing finfish and shellfish. The global cage culture market is expected to grow by USD 88.5 million from 2019 to 2023. In general, a high-density polyethylene (HDPE) floating cages is used by the farmers to fabricate the cages.

The major bottlenecks in cage culture in poor growth of stocked fishes, diseases and other management issues. Additionally, it has some social issues like poaching and resource utilization related issues. In marine cage culture, availability of good quality seed for stocking is the major problem.

G. Biofloc technology

Biofloc – and integrated beneficial microbe dominated culture system - is a novel technology adopted in the aquaculture industries to reduce the water and feed while rearing of fish. Biofloc is an aggregate of bacteria, algae, or protozoa, held together in a matrix along with a particulate organic matter which improves water quality by converting the waste into microbial protein in an intensive aquaculture systems. BFT offers multiple benefits to aquaculture, such as zero exchange of water, live food, lower feed input, and better survival and therefore, the system is considered as an environmentally friendly sustainable technique. Lack of technicians, higher operational cost and only suitable for the nursery phase of fish rearing are the major bottlenecks associated with the effective implementation of biofloc systems.

G. Aquaponics Systems

Aquaponics, a combination of fish culture and horticulture, is an integrated sustainable model of organic agricultural practice which grows fish and vegetables [1]. In aquaculture unit, fish seed, fry or marketable size were reared and in hydroponic unit vegetables and other crops were reared without soil. The benefit of aquaponic system includes the waste produced by fish is used by plants which make the water clean. In addition to this, the hydroponic bed act as media for microbial growth - symbiotic relationship - which play an important role in the nutrients recirculation in this system.

Unlike to other traditional farming, in the aquaponics system water usage and fertilizer input get minimized. Additionally, this system not require any land with fertile soil. However, this system is not suitable for rearing of all kind of fishes (suitable for slightly acidic water fish) and needs technical person to design and operate the system.

H. Integrated Multi-Trophic Aquaculture (IMTA)

In this farming, fish from different trophic levels either from marine or freshwater ecosystem were reared in a single system [2] IMTA system integrates fed fish culture (high value finfish), organic compounds extractive fish species (mostly filter feeding shell fish) and inorganic compound extracting fish species (generally seaweed species). In the integrated multi-trophic aquaculture (IMTA), waste and uneaten feed of one species is used as nutrients or energy source for another system. By this complementary conversion and utilization pattern, waste is captured from one crop and converted into fertilizer or nutrients in synergetic way for another system. Overall, the IMTA based system provides a new farming approach which increase the food production and utilize the ecosystem in an eco-friendlier efficient way. Additionally, this system ensures sustainability, biodiversity and biosecurity to the ecosystem.

The major bottlenecks associated with IMTA are non-availability of different trophic level fish seeds, lower productivity, cross spreading of diseases and non-availability of suitable open water resources

IV. CONCLUSION

In a science driven anthropogenic era, technological interventions and advancements are becoming day to day activity. However, in reality, those interventions are not reaching the end users, small scale farmers, at the right time. Whereas in one side, scientific communities and commercial farmers are reaping the benefits of advanced technologies. On the other side, the gap between the small-scale farmers and the adoption of scientific interventions is widening which threatens the sustainable development of future aquaculture. A country like India is vastly depends on small scale farmers for its fish production. The positive impact of technological interventions should reach the end users at the right time for producing healthy fish product in an eco-friendly way. Government should keep this in mind and work towards capacity building and infrastructure development in collaborations with small scale farmers to harvest the real success of technological interventions in future by overcoming the actual bottleneck in adoption of scientific interventions at farmers field level.

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