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Quality Seed and Its Assessment for Successful Aquaculture Production

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Seed quality is a critical determinant of aquaculture productivity, influencing survival, growth, disease resistance, and overall system performance. The transition from dependence on riverine seed to hatchery-based production has enabled large-scale aquaculture expansion, but concerns regarding declining seed quality persist due to unregulated hatchery practices and inadequate standardization. Quality seed is characterized by health, uniformity, absence of deformities, and strong growth potential, and is primarily influenced by broodstock management, hatchery and nursery husbandry, seed handling, and disease control. Seed quality assessment involves a combination of gross morphological examination, behavioural evaluation, stress tolerance tests, and pathogen screening, though standardized protocols remain limited for several freshwater species. Shrimp and prawn systems have more advanced selection frameworks, whereas freshwater fish seed quality assessment is still evolving. In this context, hatchery accreditation and seed certification based on process standards have emerged as effective strategies for ensuring consistent seed quality, improving traceability, and supporting sustainable aquaculture development.

Key words: Quality seed, Hatchery accreditation, Seed certification, Stress test

Introduction

Seed is the most critical input in any aquaculture system, and its quality largely determines the success or failure of farming operations. In India, aquaculture initially depended on riverine seed resources, which were often unreliable due to issues such as mixed species composition, poor availability, and inconsistent supply. A major breakthrough occurred in 1957 with the successful induced breeding of Indian Major Carps which enabled large-scale hatchery seed production. Since the 1990s, the sector has completely shifted to hatchery-produced seed, ensuring reliable availability and supporting the expansion of aquaculture. This transition played a crucial role in the rapid growth of aquaculture and contributed significantly to the country's emergence as one of the world's leading producers (DoF, 2025). At present, induced breeding technologies support the mass production of seed for numerous freshwater, brackishwater, and marine species, contributing substantially to India's fish production. However, despite this progress, concerns over seed quality have intensified, as poor growth, survival, and disease outbreaks are often linked to inferior seed. It is important to recognize that while quality seed is essential, overall farm success also depends on effective post-stocking management practices such as water quality, nutrition, and disease control (Basavaraja, 2007)

What is Quality Seed?

Seed quality is that which optimizes the potential for aquaculture production and is related to the quality of the broodstock used and the seed produced. "Seed" can mean eggs, milt fry, fingerlings or nursed animals. The quality considerations are those which meet the

expectations and demands of the producer (grow-out operations) and the final consumer of the end product.

Quality seed in aquaculture refers to early life stages (spawn, fry, fingerlings, or post-larvae) that exhibit desirable biological and health characteristics (Mair, 2002). Good quality seed is typically:

- Active and responsive
- Healthy in appearance and free from deformities
- Uniform in size
- Free from pathogens and infections
- Capable of high survival, fast growth, and better adaptability

Such seed ensures better performance in grow-out systems, regardless of species. Seed quality is influenced by factors such as broodstock health and genetic makeup, as well as hatchery and nursery management practices (Mohan, 2007)

Importance of Seed Quality Assessment

Seed quality assessment is essential to ensure that only healthy and high-performing seed are stocked in aquaculture systems. It helps farmers make informed decisions, reduces the risk of crop failure, and improves productivity and profitability. Common assessment methods include gross examination, behavioural observations, stress tests, and screening for specific pathogens. In high-value species, these assessments are often standardized and scored to guide seed selection. The importance of seed quality assessment extends beyond farm productivity. It also plays a key role in maintaining genetic integrity, preventing the spread of diseases, and meeting requirements for traceability and international trade. Seed producers and suppliers have a responsibility to deliver quality seed, while farmers must understand quality indicators and adopt best management practices (BMPs) to optimize performance. Governments and regulatory bodies further support this process through certification systems, broodstock management programs, and adherence to global standards. In essence, the principle “what you sow is what you reap” strongly applies to aquaculture. Ensuring the availability and proper assessment of quality seed is fundamental for sustainable and successful aquaculture development, as inadequate seed quality remains a major constraint in many regions (Little et al., 2002a).

Factors determining the seed quality

Poor performance of fish seed is not always because of seed quality itself but also results from inadequate management by grow-out farmers. A good quality seed is defined as one that benefits the hatcheries, nurseries, intermediaries in the seed supply network and finally the producers. Seed which are active, healthy in appearance, uniform in size, with potential for high survival, better growth, less or no disease, irrespective of the species (Little et al., 2002a, b). There are several factors which could contribute to the quality of seed. Some of the important ones which are perceived to have a significant impact on quality include:

1. Broodstock
2. Husbandry (hatchery and nursery)
3. Seed movements and availability (transport, holding and distribution, transboundary movements)
4. Pathogens and diseases (important parasitic, bacterial, fungal and viral diseases)

1. Broodstock: Broodstock plays a fundamental role in determining seed quality, as its source, genetic makeup, health status, and spawning practices directly influence progeny performance. Poor broodstock management, including inbreeding, frequent or out-of-season spawning, and inadequate nutrition during gonadal maturation, can lead to inferior seed. Even though poor seed quality is often attributed to inbreeding pressure of the broodstock used, over short timescales, it would actually be very unlikely that inbreeding is a major contributor. Additionally, vertical and horizontal transmission of pathogens from broodstock to offspring is a critical concern, particularly in shrimp and prawn systems where screening for pathogens and the use of SPF/SPR stocks have improved seed quality (Mair, 2007).

2. Husbandry practices in hatcheries and nurseries significantly affect seed quality. Poor management during spawning, larval rearing, feeding, water quality maintenance, and biosecurity can result in stressed or diseased seed. Practices such as proper disinfection, separation of healthy and dead eggs, optimal stocking densities, and routine health monitoring are essential for producing high-quality seed. Inadequate feed quality, indiscriminate use of chemicals (e.g., antibiotics), and lack of biosecurity measures can further compromise seed health and performance. Adoption of best management practices (BMPs), including proper infrastructure, clean water supply, and responsible chemical use, is critical to maintaining quality (Mohan, 2007)

3. Seed movement and distribution also influence final seed quality. Stress during handling, transport, and prolonged distribution chains can lead to deterioration in seed condition and increased susceptibility to disease. Poor handling practices, lack of acclimatization, and inadequate transport conditions exacerbate stress and mortality. Furthermore, large-scale and transboundary movement of seed and broodstock has been a major pathway for the spread of pathogens, necessitating the implementation of biosecurity measures, risk analysis protocols, and adherence to international guidelines (Briggs et al., 2004; Arthur et al., 2004).

4. Pathogens and diseases are critical limiting factors in seed quality, especially during early developmental stages when immune systems are not fully developed. Hatchery and nursery environments often favour disease outbreaks, leading to mortality, reduced growth, or production of carrier seed that may appear healthy but transmit infections to grow-out systems. Common pathogens include parasites, bacteria, viruses, and fungi, and their impact depends on environmental conditions and management practices (Little et al., 2002b; Hasan and Ahmed, 2002).

Seed quality assessment

In culture-based fisheries, seed quality assessment is equally important, although overall success depends not only on seed quality but also on environmental, socio-economic, and institutional factors. A common limitation in such systems is the lack of availability of larger-sized fingerlings, which often reduces stocking success in developing countries (Lorenzen and Garaway, 1998)

A variety of quality assessment criteria have been developed, especially for high-value species. These generally include gross examination (color, pigmentation, fin condition), behavioral observations (activity, swimming pattern, phototaxis), stress tolerance tests (salinity or formalin exposure), and pathogen screening (e.g., WSD in shrimp; MrNV and XSV in prawn). In commercial systems, these parameters are often scored to guide seed selection decisions (Mohan, 2007).

Shrimp seed quality assessment methods are among the most advanced and widely adopted. Detailed post-larvae (PL) selection criteria described by Chanratchakool et al. (1998) have established industry benchmarks, later simplified for both small-scale and intensive farming systems. The primary objective of larval selection is to predict survival and growth performance in grow-out conditions (Fegan, 1992), although it is acknowledged that hatchery-based indicators do not always perfectly correlate with field performance.

Assessment typically involves five major components:

- **Gross examination:** Evaluates size uniformity (e.g., PL 15 with minimum length of 12 mm in *P. monodon*), behavior (rapid response to stimuli), swimming pattern (straight movement), coloration (clear or dark, not red/white), fouling, and gut fullness.
- **Microscopic examination:** Involves analyzing 20–30 larvae for hepatopancreas condition, gut health, deformities, fouling, and muscle-to-gut ratio.
- **Stress tests:** Exposure to reduced salinity or 100–200 ppm formalin, where survival rates above 75% indicate good quality.
- **Bacteriological (Vibrio) analysis:** Determines bacterial load and composition, alongside detection of pathogens such as Monodon baculovirus (MBV).

- **Molecular screening (PCR):** Widely used to detect viral pathogens like WSD and TSV. Although PCR-negative seed are generally preferred, the technique requires strict quality control and skilled operation to avoid errors.

In freshwater prawn (*M. rosenbergii*), similar criteria are applied, with increasing emphasis on screening for white tail disease pathogens (MrNV and XSV), particularly in countries such as Thailand, Vietnam, and India (Mohan, 2007).

An important practical approach in quality management is the elimination of weak seed prior to stocking. Due to limited availability of high-quality seed, farmers often overstock to compensate for expected mortality, which can lead to poor management outcomes. Selective removal of weak individuals commonly done in shrimp farming through formalin stress tests (100–200 ppm for up to one hour) ensures that only active and healthy seed are stocked. This improves survival, growth, and overall farm management efficiency (Chanratchakool et al., 1998).

Accreditation of Hatcheries and Seed Certification in India (DoF, 2025)

Quality seed assessment is closely linked to farmer awareness, as informed farmers are more likely to demand and select high-quality seed, thereby encouraging hatcheries to maintain standards. With fish seed production reaching about 54 billion fry in 2022–23 and over 3000 hatcheries operating for carp alone, along with several others for species like catfish and freshwater prawn, the rapid expansion of the sector has created both opportunities and challenges. Much of this growth remains unorganized, often lacking standard operating procedures, which increases the risk of poor seed quality, loss of genetic integrity, and reduced farm productivity.

A good quality seed is typically defined as an early life stage organism that is active, free from deformities, and disease-free. However, testing every batch of seed produced is impractical. Therefore, hatchery accreditation, based on certification of management practices (process certification), is considered a more effective approach than relying solely on product testing. This includes adherence to standardized protocols, health monitoring, and periodic testing of seed to ensure compliance with quality norms.

Accreditation systems not only help in maintaining consistent seed quality but also support traceability and labelling requirements, which are increasingly important for domestic assurance and international trade. Overall, strengthening hatchery accreditation and certification frameworks is essential for sustaining productivity and ensuring reliable supply of high-quality seed in aquaculture.

Department of Fisheries, Ministry of Fisheries, Animal Husbandry and Dairying (MoFAHD) Government of India, has issued the Guidelines on Hatchery Accreditation and Seed Certification of Freshwater Finfishes and Shellfishes. It covers the major species that are having regional importance, high market demand and consumer preference. These guidelines provide the well defined benchmarks, biosecurity provisions, standard operation procedures, and quality assurance mechanisms for hatchery accreditation and seed certification across the country.

1. Indian major carps (Catla, Rohu, Mrigal)
2. Red-bellied pacu (*Piaractus brachypomus*)
3. Striped catfish (*Pangasianodon hypophthalmus*)
4. Striped murrel (*Channa striata*)
5. Catfish (Magur and Singhi)
6. Pabda/Butter catfish (*Ompok bimaculatus*)
7. Climbing perch (*Anabas testudineus*)
8. Ornamental Fish
9. Freshwater Prawn (*Macrobrachium rosenbergii*)
10. Rainbow Trout (*Oncorynchus mykiss*)

Conclusion

Seed quality assurance in aquaculture is constrained by unregulated hatchery expansion, lack of standardized assessment protocols for many freshwater species, and inconsistent broodstock, hatchery, and disease management practices. These limitations lead to variable seed quality and reduced farm performance. Future improvement depends on strengthening hatchery accreditation and seed certification systems with emphasis on process-based quality control, biosecurity, and standardized best management practices. Wider adoption of molecular diagnostics, improved broodstock management, and effective traceability systems will further enhance seed reliability. Capacity building and regulatory support will be essential to ensure consistent supply of high-quality seed and long-term sustainability of aquaculture.

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