Draft Study Material

Fish Seed Grower

(Qualification Pack: Ref. Id. AGR/Q4908)

Sector: Agriculture

Grades 12

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NCERT

PSS CENTRAL INSTITUTE OF VOCATIONAL EDUCATION
(a constituent unit of NCERT, under MoE, Government of India)
Shyamla Hills, Bhopal- 462 002, M.P., India
www.psscive.ac.in

Preface

Vocational Education is a dynamic and evolving field, and ensuring that every student has access to quality learning materials is of paramount importance. The journey of the PSS Central Institute of Vocational Education (PSSCIVE) toward producing comprehensive and inclusive study material is rigorous and time-consuming, requiring thorough research, expert consultation, and publication by the National Council of Educational Research and Training (NCERT). However, the absence of finalized study material should not impede the educational progress of our students. In response to this necessity, we present the draft study material, a provisional yet comprehensive guide, designed to bridge the gap between teaching and learning, until the official version of the study material is made available by the NCERT. The draft study material provides a structured and accessible set of materials for teachers and students to utilize in the interim period. The content is aligned with the prescribed curriculum to ensure that students remain on track with their learning objectives. The contents of the modules are curated to provide continuity in education and maintain the momentum of teaching-learning in vocational education. It encompasses essential concepts and skills aligned with the curriculum and educational standards. We extend our gratitude to the academicians, vocational educators, subject matter experts, industry experts, academic consultants, and all other people who contributed their expertise and insights to the creation of the draft study material. Teachers are encouraged to use the draft modules of the study material as a guide and supplement their teaching with additional resources and activities that cater to their students' unique learning styles and needs. Collaboration and feedback are vital; therefore, we welcome suggestions for improvement, especially by the teachers, in improving upon the content of the study material. This material is copyrighted and should not be printed without the permission of the NCERT-PSSCIVE.

Deepak Paliwal
(Joint Director)
PSSCIVE, Bhopal

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Study Material Development Committee

MEMBERS

1. Dr. Pramod Kumar Pandey, Dean, College of Fisheries, Rani Lakshmi Bai Central Agricultural University, Datia, Madhya Pradesh
2. Dr. Abhishek Srivastava, Associate Professor, College of Fisheries, Rani Lakshmi Bai Central Agricultural University, Datia, Madhya Pradesh
3. Dr. Anuj Tyagi, Associate Professor, College of Fisheries, Rani Lakshmi Bai Central Agricultural University, Datia, Madhya Pradesh
4. Dr. Sudhanshu Raman, Assistant Professor, College of Fisheries, Rani Lakshmi Bai Central Agricultural University, Datia, Madhya Pradesh
5. Dr. Neelesh Kumar, Assistant Professor, College of Fisheries, Rani Lakshmi Bai Central Agricultural University, Datia, Madhya Pradesh
6. Mr. Aman Kumar, Assistant Professor, Department of Agriculture and Animal Husbandry, PSSCIVE, NCERT, Shyamla Hills, Bhopal, Madhya Pradesh

MEMBER-COORDINATOR

Dr. Rajiv Kumar Pathak, *Professor and Head*, Department of Agriculture and Animal Husbandry, PSSCIVE, Bhopal

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Module 1
Nursery Management

Module Overview

Fish seed is a most important component of fish culture. Availability of quality fish seed (spawn/fry/fingerling) of desired fish species at appropriate time in adequate quantity is a prime and basic requirement for successful fish culture. Previously, fish seed was primarily collected from natural water bodies such as rivers and canals during or after the breeding season. However, with the success of induced breeding techniques for carps, the technology has significantly transformed the production of carp spawn in captive environments in fish hatcheries. Spawn is the stage after the yolk sac of fish hatchlings has been absorbed. Further, the challenge includes the effective rearing of fish spawn under controlled facility. In aquaculture farm, nursery ponds are used to rear fish spawn in to fish fry stage in a well-managed aquatic environment. In carps, it takes around 15-20 days to grow spawn to fry size. These nursery ponds are smaller in size (200-500 m^2) and are generally seasonal in nature. The effective management of nursery pond is very crucial for the better growth and higher survival of fish seed and it also increases the overall success of aquaculture operations.

This Module defines the nursery management practices, with focus on carps. The nursery management practices can be defined into three categories i.e. Pre-stocking management, stocking management and post-stocking management. The detailed activities under these categories are given in the following sessions.

Learning Outcomes

After completing this module, you will be able to:

- Describe the steps involved in preparing nursery ponds, including site preparation, water quality management, and eradication of unwanted species.
- Explain the procedures of stocking quality seed and managing post-stocking activities such as feeding, water monitoring, and disease prevention.

Module Structure

Session 1: Pre-stocking management

Session 2: Stocking and Post-Stocking Management

Session 1: Pre-stocking management

The preparation of nursery ponds is a crucial step for successful nursery rearing; thus, efficient management of these ponds is essential. The set of management practices being followed before the stocking of fish spawn in nursery ponds is called as pre-stocking management. The nursery ponds should be prepared in such a way that the pond environment provides optimum condition for better survival and growth of the fish spawn. Depending upon the type of nursery ponds (drainable or non-drainable nursery pond), the management practices can include draining and drying of the pond, removal of all undesirable aquatic weeds, weed and predatory fishes, aquatic insects, liming and manuring/fertilization etc.

The drainable nursery ponds are generally small, seasonal ponds which can be drained and dried according to management needs. (i) The pre-stocking pond management of drainable ponds includes draining and drying of pond, removal of organic matter deposited at the pond bottom, desilting, liming and manuring/fertilization etc. (ii) The non-drainable nursery ponds are large perennial ponds and the pre-stocking management in these ponds includes eradication of aquatic weeds, weed fish and predatory fish and animals, aquatic insects followed by liming and manuring/fertilization. The details of each activity are as follows:

Draining and drying of ponds

During nursery preparation, it is considered as the initial step in preparing the pond for the upcoming cycle of spawn rearing. In this process, water is completely removed from the pond and pond bottom is exposed to direct sun light for 7-10 days till complete drying. While drying, other activities such as desilting, removal of organic matter deposited at the pond bottom, repair of pond dyke etc. can be carried out in the nursery pond. Pond drying not only helps in soil mineralization and removal of organic matter and toxic gases but also helps in self-elimination of pathogenic microorganisms, aquatic weeds, undesired and predatory fish and aquatic insects.

Aquatic weeds and its Management

What are aquatic weeds?

Aquatic weeds are undesirable plants that thrive, reproduce, and complete their life cycle in water, becoming detrimental when present in excessive quantities. If left unmanaged, they can infest the entire water body, posing a significant threat to fish culture. The existence of these unwanted aquatic plants in nursery ponds negatively impacts the spawn/fry, aquatic environment, and the

productive potential of the pond, either directly or indirectly. Therefore, they must be managed and eradicated effectively prior to the stocking of spawn, particularly in non-drainable nursery ponds.

How they are harmful for nursery ponds?

- These aquatic weeds, particularly floating weeds, cover the entire surface of the pond and restrict sunlight penetration, thereby adversely affecting photosynthesis and overall pond productivity.
- They obstruct the pond and restrict the living space and movement for fish, as well as hinder access to the water body.
- They utilize the nutrients present in the pond, thereby limiting their availability for phytoplankton (a natural food of fish).
- Their excessive growth can lead to a depletion of oxygen in water body, especially during night or early morning hours which could be a reason of spawn/fry mortality.
- They may serve as a hiding or harboring place for unwanted fishes, insects, parasites and pathogens.

Types of aquatic weeds

The accurate identification of aquatic weeds is essential for effective control measures. Based on their behavior and habitat, they have been broadly categorized in to two botanical groups i.e. algae and aquatic weed plants.

i. **Algae:** The algae can be further classified in to two sub categories viz. planktonic algae and filamentous algae. The common examples of planktonic algae are *Oscillatoria, Microcystis, Anabaena, Euglena, volvox* etc. The excessive growth of these algae results in algal blooms, which are undesirable in nursery ponds. Sudden die-off of algal bloom causes deficiency of dissolved oxygen in water and mortality of fish spawn/fry. Filamentous algae, commonly referred to as "pond scum," frequently pose challenges in nursery ponds, typically manifesting as mats or dense growths on the edge of water surface or bottom. Most common filamentous algae found in freshwater nursery ponds are *Spirogyra, Pithophora, Oedogonium, Ulothrix, Cladophora* etc.

Fig. 1.1: Algal bloom in pond

ii. **Aquatic weed plants:** These plants are found in the different parts of water bodies and accordingly grouped into following broad categories.

a) Surface free floating weeds: They are found floating freely on the water's surface since their roots are not attached to the pond's bottom soil. Examples: *Azolla*, *Eichhornia*, *Pistia*, Duck weeds such as *Spirodella, Lemna, Wolffia* etc.

Fig. 1.2: Azolla

Fig. 1.3: Eichhornia

b) Submerged weeds: They can be of two types i.e. submerged rooted and submerged free floating/submerged non-rooted weeds. (i) The submerged rooted weeds are found completely immersed in water and their roots are attached to the bottom soil. The common examples are *Hydrilla*, *Najas*, *Potamogeton, Vallisneria* etc. (ii) Submerged free floating weed remains floating in the column of water and their roots are not attached to the bottom soil. Example: *Ceratophyllum*, *Utricularia etc.*

c) Emergent weeds: These aquatic weeds are rooted in the bottom soil but their leaves or shoots emerges out of the water surface. Examples: *Trapa*, *Nymphaea* etc.

d) Marginal rooted weeds: These types of weeds grow on the margin or shoreline or shallow area of the ponds and are mostly rooted in the water logged soil. Examples: *Typha*, *Ipomea*, *Marsilea* etc.

Control of aquatic weeds: Aquatic weeds can be controlled by the following methods:

1) Physical/Mechanical method: Under this category, aquatic weeds are managed using a variety of techniques, including draining and drying of nursery ponds, manual cleaning and mechanical weed control.

a) **Draining and drying of nursery ponds:** This process involves complete dewatering and drying of nursery ponds and exposing the pond bottom soil to direct sun light. It will lead to the death of all aquatic plants, which will subsequently be removed. This method is applicable for small, drainable nursery ponds.

b) **Manual cleaning:** Manual cleaning is the most traditional and economical way for controlling aquatic weeds specially in shallow ponds but it is labour intensive and time taking process. Surface floating weeds can be removed by repeated netting in the pond or hand picking. Hand pulling is used to get rid of emergent and marginal weeds, or they can be controlled by continuously chopping off their floating leaves. Barbed wires or bottom rakers or chain are used to uproot the submerged rooted weeds which are then picked up manually or collected by netting.

c) **Mechanical weed control:** In this method mechanical cutter or under water cutter or devises such as hand scythe, weed saw etc. are used to physically cut the aquatic weeds over and under the water.

2) Chemical method: The chemical used to control the aquatic weeds are called as weedicide or herbicide. Use of herbicide may be a useful and more effective strategy for eradicating aquatic weeds but residual effect of herbicides is a matter of concern. The choice of herbicide, its application time and techniques depends on many factors but the kind of weed flora and the habitat may be the key factors to decide it.

Further, the herbicide chosen for the use should have the qualities like-

- It should be effective at low dose.
- It should have short half-life and shouldn't have any residual effect on fish and aquatic ecosystem.
- It should be easy to apply in pond and does not require any special and costly equipment.
- It shouldn't exhibit any toxic effects on aquatic animals or humans.
- It should be affordable and readily available in the market.
- It should be approved by the government.

Aquatic weeds can be effectively managed by applying appropriate herbicides via foliar spray or other suitable methods during the preparation of nursery ponds. Herbicides such as 2,4-D, Simazine, Diquat, and Anhydrous ammonia etc. are commonly used for the eradication of aquatic weeds, while CuSO4 and Simazine can be applied for the control of algal blooms or filamentous algae. The recommended dose of these chemicals depends upon the several factors viz. type of aquatic weeds, its growth intensity, age, environmental factors etc.

3) **Biological method:** Biological control is an easy, cost-effective, eco-friendly and long-term control method, in which herbivorous/weed eating fish can be stocked in ponds to mitigate or inhibit the growth and reproduction of aquatic weeds, specially in perennial non-drainable nursery and stocking ponds. Grass carp (*Ctenopharyngodon idella*), which is a truly phytophagous fish, can be used to control the surface floating and submerged weeds, whereas silver carp (*Hypophthalmichthys molitrix*) can be introduced to control algal bloom. Common carp (*Cyprinus carpio*) helps in uprooting the submerged rooted weed during burrowing activity. Additionally, gourami (*Osphronemus goramy*) and silver barb (*Puntius gonionotus*) etc. can also be used for the control of aquatic weeds.

Aquatic Insects and its Management

What are aquatic Insects?

Nursery pond harbors a range of predatory aquatic insects, some of which can be detrimental to fish spawn and fry, impacting their growth and survival. These insects frequently make their way into the prepared nursery ponds from the nearby production/rearing ponds, where they reproduce quickly and in large numbers.

- They compete with spawn and fry for space, oxygen, and food, resulting in a lower growth and survival of fish seed.
- They cause significant injury to fish seeds and often kill the fish spawn through devouring or pricking and sucking the body fluid leading to poor survival.
- The occurrence of these insects in nursery ponds may result in a decline in fish population, limiting the success of nursery operations. Therefore, it is crucial to eliminate these insects prior to the stocking of spawn in nursery ponds.

The common aquatic insects found in nursery pond belong to beetles, bugs, and dragon flies. Among beetles, the common aquatic insects are diving beetles (*Cybister*, *Dytiscus*, *Acilius* etc.) and water scavenger beetle (*Sternolophus*), whereas *Notonecta* and *Anisops* (back swimmer), *Belostoma* (Giant water bug), *Ranatra* (water stick insect) *Gerris* (pond skates) and *Laccotrephes* (water scorpions) are the common bugs found in nursery ponds. The adults and larvae of these beetles and bugs do substantial damage in nursery ponds, with back swimmers being particularly harmful since it is capable of killing carp seed of larger (even 10-13 mm) size. The other certain aerial insects, such as the dragon

fly and damsel fly, reproduce in water and their larvae (nymphs) are also highly detrimental to the spawn.

Control of aquatic Insects: In order to get the good survival of spawn, the aquatic insects must be controlled effectively before the stocking of spawn in nursery pond. The methods used for it are given in Table 1.

Table-1: Details of methods used for the control of aquatic insects

Type of method	Description of method
Physical Method	✓ It is done by manually carrying out the repeated netting in smaller nursery pond with appropriate mesh size, one day and just before the stocking of spawn. This can be helpful in controlling the aquatic insects up to some extents but it is a short term control method. ✓ Further, this strategy cannot be employed after the stocking of spawn, as it may cause physical harm, leading to fish mortality.
Chemical Method	i. **Soap-oil emulsion:** it is very simple and effective method of eradication of aquatic insects. In this method, an emulsion of a cheap soap and vegetable oil (18 kg/ha soap and 56 kg/ha vegetable oil) is applied 12-24 hrs. before the stocking of spawn. ii. **High speed diesel (HSD)-**It is applied @ 50-60 liters/ha iii. **Kerosene oil-**It is applied @ 80-100 liters/ha iv. **Turpentine oil-**It is applied @ 75 liters/ha • The soap-oil emulsion/HSD/kerosene oil etc. is evenly spread over the pond's water surface during the calm weather. Do not apply it during the rainy or high wind time as will not form a uniform oil layer over the water surface. • The emulsion/oil creates a barrier between water surface and atmosphere. Since these insects breathe by air, they come to the water's surface to breathe. However, they

	become stuck in the oil layer and die as a result of their gills being chocked or suffocated. • These methods do not affect the fish spawn/fry and may thus be used during spawn rearing as well for effective control of insects.

Common weed and predatory fishes and its management

The weed and predatory fishes are undesirable in nursery pond. They are mostly found in unmanaged perennial nursery ponds or ponds which are filled with canal water. Therefore, it is essential to completely eliminate weed and predatory fishes from nursery ponds prior to the stocking of spawn in these ponds. Their details are as follows:

i. **Weed fish:** In nursery ponds, weed fish are small-sized, non-target fish species that are uneconomical and exhibit high fecundity. They are not suitable for the nursery pond as they disrupt the stocking density and compete for essential resources such as space, food, and oxygen. Additionally, they may transmit diseases inspawn and fry. Consequently, these species adversely affect the growth and survival of cultivable fish species. The effective management of weed fish is essential for the success of nursery operations. The common weed fish includes *Esomus danricus, Puntius* spp., *Rasbora* spp, *Colisa* spp., *Oxygaster* spp., *Amblypharyngodon* spp., *Tilapia* spp., *Ambasis* spp., *Gudusia chapra, Barbas Danio* etc.

ii. **Predatory fish:** Predatory fish are carnivorous species that actively prey on cultivable fish spawn and fry, significantly impacting the survival rates of cultivable fish in nursery ponds. They also compete for space, oxygen and food with the cultured fish. Therefore, in spite of having the economic value, they are not desirable for nursery ponds. The common predatory fish includes Snakeheads (Murrels; *Channa* spp.), Catfishes (*Clarias batrachus*, *Heteropneustes fossilis, Wallago attu*, *Ompak* spp., *Mystus* spp.), *Mastocembelus* spp. and *Notopterus* spp. **etc.**

Control measures:

a) **Netting:** Repeated netting in the nursery pond serves as a cost-effective method for the removal of undesirable fish species, particularly those that inhabit the surface and water column. This method is more suitable in perennial nursery ponds where dewatering is not possible. However, achieving complete removal of all unwanted fish, especially bottom dwellers, poses a significant challenge with this approach.

b) **Dewatering**: The process of dewatering, succeeded by sun drying, serves as an effective method for managing weed and predatory fish in the nursery pond. This approach demonstrates significant effectiveness in small and seasonal nursery ponds; however, its applicability is limited in deep and large perennial nursery ponds.

c) **Use of piscicides/fish toxicants:** The nursery ponds which cannot be dewatered (non-drainable nursery ponds); piscicides can be used to completely eradicate the weed and predatory fishes. Piscicides are used in nursery ponds prior to the stocking of spawn, adhering to the specified detoxification period, which typically lasts 2-4 weeks. A suitable piscicides should have the following characteristics:

- Works well at low dosages
- It should be cost-effective and easily available in the local market.
- Does not render fish unfit for human consumption.
- Don't have toxic effect on animals and human.
- Becomes detoxified rapidly

Table-2: Details of the commonly used piscicides:

Sr. No.	Name of Piscicides	Dose	Detoxification time
Piscicides of plant origin:			
1.	Mahua oil cake (Saponin)	2000-2500 kg/ha-m (200-250 mg/L)	3 weeks
2.	Derris root powder (Rotenone)	15-20 kg/ha-m	30 days
3.	Tea seed cake	60-75 mg/L or 300 kg/acre-m	-
4.	Tamarind seed meal	700-800 kg/acre-m	-

Piscicides of chemical origin:			
5.	Bleaching powder (30% Chlorine)	350 kg/ha-m	3 days
6.	Urea+ Bleaching powder	Urea@ 100 kg/ha-m followed by Bleaching powder@ 175 kg/ha-m after 1-2 days	3 days
7.	Anhydrous ammonia	20-25 mg/L	4-6 weeks

Liming and Manuring

Liming: Liming involves the application of various compounds that neutralize acids, specifically those containing calcium or a combination of calcium and magnesium. Liming is a crucial management practice that enhances soil and water quality, thereby helps in increasing the productivity of nursery ponds. Therefore, it should be applied at recommended dose during the preparation of nursery ponds, depending upon the soil pH.

Role of liming materials in Nursery Ponds:

1. pH is one of the important chemical factors and for fish ponds, a soil pH ranging from 6.5 to 7.0 and a water pH between 6.5 and 9.0 (slightly basic) are regarded as optimal for productivity. Liming helps in enhancing the pH of soil and water (neutralizes the acidity) when it falls below the recommended level.

2. Liming helps in pond soil quality improvement. The soil at the bottom of the pond serves as a reservoir for nutrients. Liming improves the decomposition/mineralization process of organic matter at the pond bottom and increases the availability of several essential nutrients (primarily phosphorous). These nutrients contribute to enhancing the natural productivity of the pond, thereby increasing the phytoplankton population, which serves as the natural food for spawn and fry.

3. Liming can improve the effectiveness of pond fertilization.

4. Liming reduces the toxic effects of harmful compounds and helps to disinfect the pond bottom.

5. Liming contributes calcium and magnesium, which play a crucial role in fish physiology.

6. Liming helps to improve the buffering capacity of pond water and prevents wide diurnal fluctuation in pH.

7. Liming helps to enhance the alkalinity and hardness of water, if it falls below the recommended level.

8. Liming reduce the water turbidity and also helps in controlling algal bloom.

Liming materials used in ponds: A variety of liming materials are used in pond such as:

1. Calcium oxide/quicklime - CaO

2. Calcium hydroxide/slaked line $Ca(OH)_2$

3. Agricultural limestone or calcite limestone ($CaCO_3$)

4. Dolomite [$CaMg(CO_3)$]

Quick lime (CaO) is more reactive and highly caustic therefore, it is generally preferred for pond bottom soil treatment during pre-stocking management for bottom soil correction (soil pH, organic matter etc.). Limestone is the safest and effective liming material for the pH, alkalinity, hardness, turbidity correction of pond water during fish rearing process.

Dose of lime material: The dose of a particular variety of lime depends on its effectiveness, the nature of the bottom soil (heavy clay requiring more lime than sandy soil), and soil pH etc. In general, if the soil is acidic, lime is applied at least 1-2 week prior to the application of fertilizers/ manuring, as per the details given in the Table 3.

Table-3: Lime requirement for pH correction during pond preparation:

Soil pH	Soil Type	Lime dose (Kg/ha)
4.0-5.0	Highly acidic	2000
5.0-6.5	Moderately acidic	1000

6.5-7.5	Near Neutral	500
7.5-8.5	Mildly basic	200
>8.50	Highly alkaline	Nil

Source: Sinha, V.R.P & Ramachandran, V. (1985). Fresh water Aquaculture. ICAR, New Delhi

Method of application of lime

- Prior to the filling of water in nursery ponds, dry lime powder can be applied directly by broadcasting it evenly all over the pond bottom.
- After the filling of water, it can either be broadcasting evenly all over the water surface or it can be dissolved in sufficient quantity of water and then added to the pond.
- Lime should not be applied during windy condition if applying in dry powdered form.

Manuring and fertilization: During the preparation of nursery ponds, it is essential to evaluate the soil fertility and nutrient status to determine its productivity. Occasionally, soil may lack essential nutrients such as nitrogen, phosphorus, and potassium. To enhance the availability of nutrients and the fertility of soil and water in nursery ponds, it is advisable to apply organic manure, fertilizers, or a combination of both at the recommended dosage during pre-stocking management. This facilitates the development of natural fish food organisms in the pond, such as plankton, leading to improved growth and survival of spawn.

Use of Organic manure:

- Cow dung is applied @ 5-15 tons/ha, at least 15 days before the stocking of spawn in one instalment.
- In another practice, cow dung is applied @ 10 tons/ha 15 days prior to stocking of spawn followed by subsequent manuring @ 5 tons/ha, a week after the stocking of spawn.

- If mahua oil cake is used as a piscicide in nursery ponds (for the control of unwanted fishes), the dose of cow dung can be reduced to 5 tons/ha, specially in shallow nurseries.

- Further, as demonstrated at CIFRI's pond culture division, mustard oil cake, cow dung and poultry manure in ratio of 6:3:1 can be applied @1000 mg/l for culturing zooplankton for carp spawn.

Use of Inorganic fertilizers:

In nursery ponds, inorganic fertilizers can be used to improve primary productivity by supplying essential nutrients (specially N, P and K), which subsequently support other fish food organisms and growth of spawn. These fertilizers contain a fixed percentage of individual nutrient or combination of more than one nutrient viz. urea (nitrogen, N), single superphosphate (phosphorus, P), and diammonium phosphate (both N & P) etc. The soil composition in the nursery pond can affect the selection of inorganic fertilizer, since different fertilizers are more appropriate for acidic, neutral, or alkaline soils. For better productivity in nursery ponds, N and P in 4: 1 are considered most effective. Further, weekly application of N: P: K in 8:4:2 ratio also augment the production of fish food organisms.

Practical Activities

Activity-1: Collection and identification of common aquatic weeds.

Material required: Fine mesh hand net, hayfork/bamboo pole with scrapper, bottom rake, knife, buckets/containers, enamel tray, glass jar, formalin solution, forceps, blotting paper, magnifying lens, microscope, camera, reference book, practical notebook etc.

Procedure:

1. Visit the nearby nursery pond and collect whole plant samples of each weed from the nursery pond using appropriate tools such as hand net/rake/scrapper/hayfork etc.
2. Clean the weeds with fresh water to remove all debris.
3. Identifying the weeds through visual observation or magnifying lens. For correct identification, take the help of any standard reference book.
4. Examine the collected samples with the help of microscope.
5. Note down the following observations:

- Weed name
- Characteristics
- Control measures

6. Preserve the weed sample in formalin solution and label them for future use.

Activity-2: Demonstration of liming in nursery pond

Material required: pH meter or pH strip, liming material, weighing balance, tub/drum, bucket, mug, water, tray, beaker, stirring rod etc.

Procedure:

1. Visit the nearby nursery pond. If pond is empty, collect the multiple soil samples from different locations of the pond, and check the soil pH with the help of portable pH meter/pH strip.
2. If pond is already filled with water, check the pH of pond water, either directly in pond or after collecting the water samples in beaker.
3. Calculate the required dose of liming material on the basis of soil or water pH.
4. Select the liming material according to its use.
5. Weigh the calculated quantity of liming material and apply evenly over the dry pond bottom by manual broadcasting.
6. If the nursery pond is already filled with water, dissolve the calculated amount of liming material in water in tub/drum and allow it to cool down.
7. Apply the lime solution evenly over the pond water surface.

Check Your Progress

Fill in the blanks

1. The most commonly used fish for biological control of aquatic weeds is_____ .
2. The pH range considered optimal for fish pond water is between ____ and _____
3. In carp culture, _____ pond is used for the rearing of spawn into fry stage.

4. _____application helps in maintaining the water pH in proper range, if it falls below the recommended range.

5. _____fish are carnivorous species that actively prey on spawn in nursery pond.

Multiple Choice Questions

1. Which of the following is a floating aquatic weed?
   a. Vallisneria
   b. Hydrilla
   c. Pistia
   d. Ceratophyllum
2. Which fish is used to control algal bloom in nursery ponds?
   a. Grass Carp
   b. Silver Carp
   c. Gourami
   d. Common Carp
3. Out of following, the example of free floating surface aquatic weed is
   a. *Hydrilla*
   b. *Potamogeton*
   c. *Ceratophyllum*
   d. *Azolla*
4. Which herbicide is commonly used to control filamentous algae?
   a. Diquat
   b. Simazine
   c. Urea
   d. Glyphosate
5. Which insect is known as a water scorpion?
   a. Laccotrephes
   b. Belostoma
   c. Gerris
   d. Notonecta

Match the following:

	A		B
1.	Bleaching powder	a)	Control of Aquatic weeds
2.	Dolomite	b)	15-20 kg/ha-m
3.	Derris root powder	c)	pH regulation
4.	Simazine	d)	350 kg/ha-m

Subjective Questions

1. Describe management of algal bloom in aquaculture pond.
2. Enlist the liming materials used in pond and discuss the benefits of liming in nursery pond.

Session 2: Stocking and Post-Stocking Management

Stocking Management

It covers the management practices being followed during the stocking of fish spawn in nursery ponds**.** It includes procurement of fish seed, transportation of fish seed, acclimatization of spawn to pond water temperature, proper stocking strategies to avoid overcrowding and stress. These practices aim to ensure the smooth transition of spawn into the new environment, promoting better survival and growth. It involves the following steps:

1- Procurement of fish seed

It involves obtaining the good quality spawn of desirable fish species (like carps) and its transportation to the well-prepared nursery pond for the stocking process. It is very important to understand the significance of sourcing good quality seed. Always recommend high-quality seed and attempt to evaluate its quality prior to procurement. Spawn can be procured from the following sources:

a. **Natural collection**- it is a traditional method involving the collection of spawn from rivers and inundated areas during the monsoon season with the help of shooting net/ Midnapore type net.

b. **Bundh Breeding**: it is a method is to breed the fish in bundh-type facility to produce the seed of desired fish species.

c. **Hypophysation/Induced Breeding**: Spawn can be produced through hypophysation and induced breeding of fish using pituitary gland extract and synthetic hormones, respectively in a properly managed fish hatchery (such as Chinese circular carp hatchery).

In order to get the good quality pure seed, the fish seed (spawn) should be procured from reputed and registered hatcheries.

2- Transportation of fish seed

Transportation of fish seed is a crucial activity in nursery management. It involves moving fish seed from hatcheries or seed collection point to stocking sites. Efficient and safe transport ensures good survival and health of fish seed which is a prerequisite for successful fish culture.

Conditioning of fish seed before transportation

- The spawn procured for the stocking in nursery pond should be adequately conditioned.

- For conditioning, fish seed are kept in a 'hapa' fixed in fish pond or in FRP pool, in proximity to the fish hatchery. In case spawn are collected from natural resources, it should be conditioned in hapa fixed in relatively calm water in a canal or river.

- The conditioning time depends on the size of fish, water temperature, weather and duration of transport.

- The advantages of seed conditioning include that fish become accustomed to confined conditions, recover from the handling stress and gut evacuation takes place etc.

- No supplementary feed is provided to spawn during the conditioning process in order to keep the gut of spawn empty. It will reduce the metabolic activity of the spawn, resulting in minimal nitrogenous waste being introduced into the transport water and consequently lower seed mortality.

Fig. 1.4: Fish spawn conditioning hapa

Important point to remember before transportation of fish seed

- Pack fish spawn in clean source pond water as far as possible. Packing fish seeds in turbid water can lead to gill chokes. About 10-30% canal or de-chlorinated tap water may be added to source water, if source water is turbid.
- Before transferring and packing fish spawn to water other than source pond
- water, seed should be properly accustomed.
- Weak seeds should be discarded since it may die either during transportation or after stocking in nursery ponds.
- Sampling and quantification of fish spawn should be carried out before seed packing. For it, 4-5 random samples of spawn can be counted with the help

of metallic or plastic sieve cups (commonly known as 'Bati') of known volume. This will help to measure the required number of seed during packing.

Methods of fish seed transportation: Transportation methods differ according to the life stage, travel distance, duration, and the infrastructure that is available. Two basic transportation systems are available for transport of live fish seed viz. open system and closed system.

a) **Open System:** The traditional and simplest transport carrier is the earthen vessel, such as the traditional 'Hundi', which is now being replaced by unbreakable round metal (aluminum) vessels with a wide mouth. In spite of being cheaper, open system involves continuous vigilance and frequent renewal of water during long journeys. Now days, fish seed can be transported in open carriers of trucks lined with plastic sheets and filled with water, or truck-mounted open tanks with mechanical aeration and water circulation.

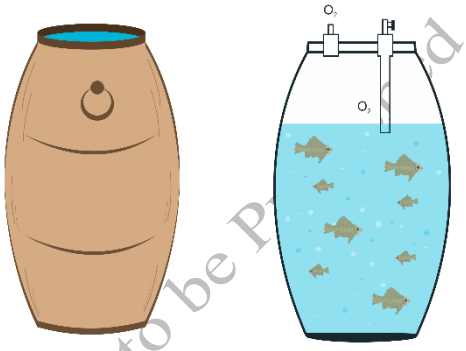


Fig. 1.5: Open System

b) **Closed system:** This method commonly involves the use of polythene bags for the transport of fish spawn, In this method the bag is filled up to 1/3 of its capacity (6-7 liters) with water and the required number of seed is put into it and the bag is inflated with oxygen in high pressure from an oxygen cylinder, up to 2/3 of the bag and the bags are sealed air-tight.

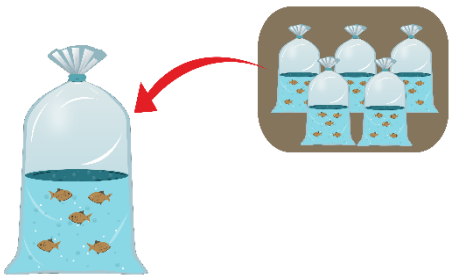


Fig. 1.6: Packing in plastic bags

Many Factors affects the success of seed transportation viz. total biomass of fish to be transported, species, water temperature, stocking density, water quality, rate of utilization of oxygen & initial oxygen content of water, rate of accumulation of harmful excretory wastes, travel time, and distance etc.

3- Acclimatization of fish seed during stocking

Acclimatization is the process of gradually adjusting fish to new environmental conditions (temperature, pH, dissolved oxygen, salinity) after transportation to reduce stress and mortality. It should be done very carefully to avoid any post-stocking mortality due to shock or infections.

Importance of Acclimatization:

- Reduces thermal shock due to sudden temperature differences.
- Minimizes osmotic stress in fish caused by differing salinities or water chemistry.
- Prevents mortality and enhances post-transport recovery.
- Helps maintain immune response, reducing disease susceptibility.

Fig. 1.7: Fish seed acclimatization in pond

Methods of Acclimatization:

- Keep the closed fish seed transport bags in floating condition for 15–30 minutes in destination water (nursery pond) for temperature balance and allows gradual temperature equalization. Pond water can be sprinkled on these seed bags to facilitate quicker acclimatization.
- Slowly add small amount of destination water to transport bags and release fish seed by allowing them to swim out of bags into pond water.
- Spawn transported in open containers is acclimatized with gradual addition of pond water into it.
- During the mixing process, it is also important to ensure adjustment of other water quality parameters viz. pH, hardness, and salinity.
- Observe the condition of seeds for their swimming behavior, agility etc. after they are released in the nursery pond.

4-Stocking strategies

In nursery pond fish spawn is reared under monoculture i.e. only one species can be reared at a time in a nursery pond. Combined rearing of two or more species of spawn is normally not recommended in nursery pond.

i. **Stocking rate:** It is defined as the number of spawn to be stocked in nursery pond per unit area.

- **Stocking rate in earthen nurseries**: The seed of carps can be stocked @ 3-5 million/ha, but it can be increased up to 10 million/ha with better management practices.

- **Stocking rate in cemented/concrete nursery tanks:** stocking can be done up to 20 million/ha.

ii. **Stocking Size:** Spawn (6–7.5 mm) is stocked in nursery pond. Spawn is the stage after the yolk sac of fish hatchlings has been absorbed, which usually takes three days in case of carps.

iii. **Stocking time:** The spawn is stocked in nurseries during the cool hours of the day, i.e. early morning and evening. During this period, the occurrence of mortality is low due to lower temperature.

Important point to note before stocking of seed in nursery ponds:

- Prior to the stocking of fish seed in nursery pond, a hapa should be fixed in the pond and some fish seed should be put inside the hapa to confirm the complete detoxification of the piscicides applied earlier in the nursery pond.

- Absence of distress and mortality after 24 hours confirm complete detoxification and the pond is considered ready for stocking.

Post Stocking Management:

It includes the management practices being followed after the stocking of fish spawn in nursery ponds, mainly water quality management, feed and feeding management, supplementary liming and manuring (as per the need), health care and harvesting of fry etc.

1- Water quality management:

Water quality includes all the physico-chemical factors that influence productivity of the pond water. Therefore, it is vital to maintain water quality parameters within the optimum range throughout the rearing period. Various parameters including temperature, dissolved oxygen, pH, and ammonia etc. are

consistently monitored and managed to maintain optimal conditions. As spawn are very small in size, a variation in water quality beyond the recommended limits may leads to mortality.

- **Water depth**: In nursery ponds, ideal water depth should be 3-4 feet for carps. Some scientists suggested that phased increase in water level improves the growth and survival of spawn in nursery ponds.

- **pH:** Slightly basic pH should be maintained for better growth and survival. Liming can be done with $CaCO_3$, as per the water pH, during the rearing period, if it falls below the recommended level.

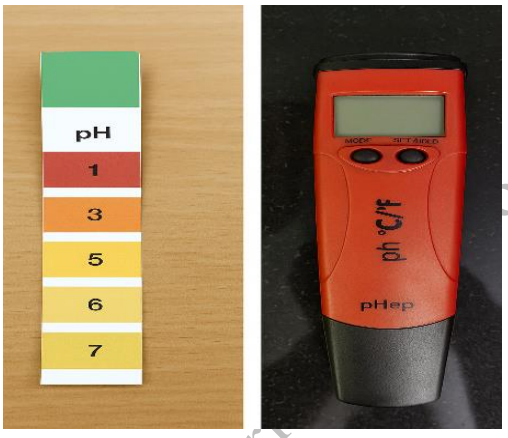


Fig. 1.8 pH strip and pH meter

- **Dissolved Oxygen (D.O.):** The D.O. is the most critical water quality variable in aquaculture and should be maintained ≥5 mg/l. Desired D.O. level can be maintained through regular addition of fresh water or through mild aeration using fountain type aerators.

- **Total Alkalinity and Hardness:** It should be maintained between 50-150 mg/l as $CaCO_3$ and their values more than 300 mg/l have adverse effect on fish.

- **Ammoniacal Nitrogen:** Fish are very sensitive to unionized ammonia and its acceptable limit for aquaculture is <0.05 mg/l.

Regular water samples should be collected, analyzed, and the appropriate corrective measures should be performed to keep the water quality parameters within the recommended limits.

2-Supplementary feeding:

The survival and growth of spawn are influenced by the quality and quantity of food available in the nursery pond. After stocking, the spawn starts feeding on the plankton present in the nursery pond but it may not be sufficient to sustain high growth in shorter nursery rearing period. The lack of unbalanced diet to

supplement the depleted natural food in the nursery pond has been identified as one of the major reasons for poor seed survival. Therefore, in order to meet out the nutritional demand of developing spawn and ensure their better growth and survival, finely powdered good quality supplementary feed should be provided.

The nutritional requirement of carp swan is as follows (as per the ICAR Handbook of Fisheries and Aquaculture)**:**

- Protein-30-40%
- Fat-4-6%
- Carbohydrate-22-26%
- Vitamin+ mineral supplements

- Locally available cost-effective feed ingredients can be used to formulate supplementary feed for spawn.
- Traditionally, supplementary feed prepared by using finely powdered groundnut oil cake and rice bran (1:1 ratio) has been commonly used for the nursery rearing of carp spawn.
- Other feed ingredients and feed additives viz. fish meal, different oil cakes (ground nut, mustard, soy bean etc.), silkworm pupae, vitamins, and minerals can also be added in different combinations to formulate the efficient supplementary feed for fish spawn.
- For the feeding in nursery pond powdered feed is recommended as it is easily taken by the small size spawn.
- The required quantity of supplementary feed is broadcasted over the water surface in nursery ponds for its easy availability to spawn, preferably in two equal split doses, daily in morning and evening.

Feeding schedule: During the rearing of spawn to fry stage (15-20 days), the spawn are fed 4–8 times of its initial body weight, daily, where as another opinion recommends 2-4 times of its initial body weight. The detailed feeding schedule followed in nursery pond is given in Table 4.

Table-4: Feeding schedules of spawn during nursery rearing

Days since stocking	**ICAR Handbook (2022)**		**As per Alikunhi,1957**	
	Feeding rate	**Feed/1.0 million spawn**	**Days since stocking**	**Feeding rate**
1-5 days	4 times the total initial weight (400%)	6 kg/day	1st-5th day	Double of the total initial weight

Subsequent days	8 times the total initial weight (800%)	12 kg/day	6th-10th day	Three times the total initial weight
After 15-20 days of rearing	Harvesting of fry	-	11th-15th day	Four times the total initial weight
-	-	-	16th day	Harvesting

I. **Supplementary liming:** In order to maintain the desired pH level, and to control algal bloom, subsequent liming is required (based on water pH) during the nursery rearing at recommended dose.

II. **Supplementary manuring:** Due to feeding by fish, the plankton biomass may get depleted in nursery pond. For sustainable development of plankton biomass, post-stocking supplementary manuring can be done at recommended dose during the nursery rearing.

3- Health and biosecurity during nursery rearing:

- Regular observation should be made in nursery pond to check the general health conditions of the spawn/fry
- For biosecurity purpose, fix nylon threads and reflecting tapes over the nursery ponds to protect from predation.
- Cover the nursery ponds with fine mesh cover net to control predation and to protect the entry of unwanted animals and birds, which may be a carrier of any disease causing agent.

4- Harvesting of fry:

Spawn takes around 15-20 days to develop in to fry stage (20-25 mm). The survival in nursery pond largely depends on the preparedness and management of nursery ponds. After attaining the fry stage, harvesting is done using a close meshed drag net (fry net) during the cool hours, preferably morning or evening hours. Fry should not be given any supplementary feed a day before the harvesting. Now they can be transferred to rearing pond for further growth and development. If fry need to be transported to some distant place, it should be properly conditioned and then packed in recommended numbers in polythene bags inflated with oxygen. This packing facilitates the transportation of fry over long distances, involving a travel of 20-24 hours. The survival rate is nursery ponds vary depending upon the management practices being followed.

Practical Activities

Activity-1: Solve the following questions with the assumptions that stocking rate of carp spawn in nursery pond is 10 million/ha.

(i) Calculate the number of carp spawn that can be reared in nursery pond of 500 m^2 area.

(ii) Calculate the number of nursery ponds of (200m^2 area each) to be required to stock 10 million of carp spawn.

Activity-2: Preparation of supplementary feed for spawn.

Material required: Powdered feed ingredients/additives (such mustard/soybean/groundnut oil cake, rice bran, fish meal, vitamin-mineral mixture, common salt etc.), weighing balance, plastic tub

Procedure:

- Calculate the quantity of each dry feed ingredient according to the desired protein level in fish feed, using *'Pearson Square'* method.
- Weigh each ingredient as per the quantity calculated above.
- Mix all the feed ingredients properly in a plastic tub to prepare a homogenous mixture of supplementary feed.
- Store the feed in air tight container, label it and place it in cool, dry and well ventilated place.

Check Your Progress

Fill in the blanks

1. During _____ no supplementary feed is provided to spawn.
2. The acceptable limit of unionized ammonia in aquaculture is less than _____ mg/l.
3. The ideal water depth in nursery ponds for carps is _____ feet.
4. _____ is the process of gradually adjusting fish to new environmental conditions after transportation.
5. A plastic sieve cup, commonly known as _____, is used for the sampling and quantification of fish spawn.

Multiple Choice Questions

1. Which of the following is a traditional method of fish seed collection?
   a. Hypophysation
   b. Natural collection
   c. Bundh breeding
   d. Induced breeding
2. What is the most critical water quality variable in aquaculture?
   a. Temperature
   b. pH
   c. Dissolved Oxygen
   d. Ammonia
3. Which system uses polythene bags filled with oxygen for seed transportation?
   a. Closed system
   b. Open system
   c. Bucket system
   d. Vessel system
4. The carp spawn are stocked at which stage?
   a. Egg
   b. Hatchling
   c. Spawn (6–7.5 mm)
   d. Fry
5. Fry stage is generally attained after _____ days of nursery rearing.
   a. 5–7 days
   b. 10–12 days
   c. 25–30 days
   d. 15–20 days

Match the following:

	A		B
1.	Optimum DO in nursery pond	a)	Fish seed with yolk sac
2.	Hatchling	b)	7.5-8.5
3.	Desired water pH	c)	Fish seed without yolk sac
4.	Spawn	d)	≥5 mg/l

Subjective Questions

1. Describe feeding schedule in nursery pond.
2. Enlist the important water quality parameters with describe significance of dissolved oxygen in nursery pond.
3. Explain importance of conditioning and acclimatization of spawn during seed transport.

Module 2
Feeding and Monitoring of Fish Seed

Module Overview

Feeding and monitoring of fish seed are crucial components in the successful rearing of healthy and fast-growing fingerlings. Fish feed, which provides essential nutrients for growth and development, can be either commercially available or prepared on-farm using ingredients like rice bran, groundnut cake, soybean meal, and fish meal in proper proportions. The feed should be nutritionally balanced and offered in appropriate quantities at regular intervals to avoid overfeeding and water pollution. Alongside feeding, continuous monitoring of fish seed is essential to assess their health, growth rate, feeding behavior, and overall condition. This involves regular observation, maintaining water quality parameters, and making timely adjustments in feeding practices to ensure optimal survival and growth of the fish seed.

This module equips students with knowledge and practical skills on the feeding and monitoring practices essential for healthy growth and survival of fish seed. In Session 1, students will learn about Fish Feed and its Preparation, including the types of feed, nutritional requirements of fish seed, feed formulation, and methods of feed preparation to ensure cost-effective and balanced nutrition. Session 2 focuses on Monitoring of Fish Seed, covering techniques for observing feeding behavior, assessing growth and survival rates, maintaining water quality, and identifying early signs of stress or disease to ensure effective management of the nursery system.

Learning Outcomes

After completing this module, you will be able to:

- Explain the types of fish feed, their nutritional requirements, and the methods of preparing balanced feed for fish seed.
- Describe the techniques for monitoring fish seed, including assessing growth, survival, feeding behavior, and early signs of stress or disease.

Module Structure

Session 1: Fish feed and its preparation

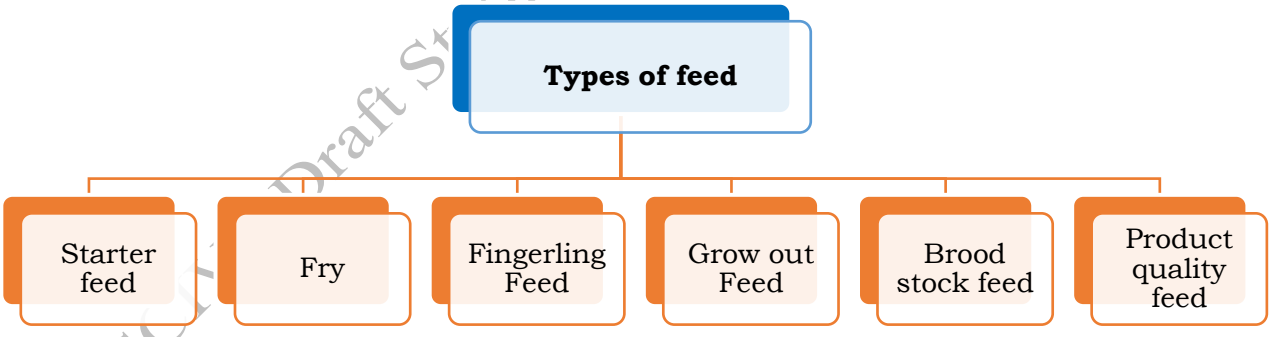
Session 2: Monitoring of Fish Seed

Session 1: Fish feed and its preparation

In fish seed rearing, nutrition plays an important role in warranting good growth, healthy and better survivability of fish seed. For this nutritional requirement of various fish seed species need to be met. There are different types of feeds that are utilized at different stages. The fish feed need to be formulated scientifically in order to meet nutritional requirement of fish seed. The feed preparation process encompasses a series of mandatory steps. It is also important the prepared fish seed shall be delivered to seed in best possible manner, so that there is less wastage of fish feed and feeds are consumed by fish in timely manner. Understanding these aspects is essential for sustainable and economically viable aquaculture operations.

Different types of feeds

The availability of reasonably priced, nutritionally balanced fish feed is crucial for aquaculture. The good growth and productivity of fish species kept in captivity are all significantly influenced by their diet. The formulation and preparation of high-quality feed are crucial because feed costs make up a significant portion of total operating costs in fish farming, typically between 50- 70 percent, depending upon fish species cultured. In order to ensure optimal growth and feed conversion efficiency, the main goal of fish feed preparation is to satisfy the dietary needs of fish at different life stages. Different feed types are prepared using different techniques. As a result, we should first understand the various kinds of aquafeed that are used to feed fish. Based on stage of the life cycle of fish feed are of following types: -



1. **Starter feeds:** When the endogenous food supply (yolk) of first-feeding fry or larvae is depleted or about to deplete, starter feeds are administered. For all aquatic organisms, the transition from an endogenous to an exogenous food source is essential. It is the stage when excessive mortality occurs. Starter feeds should have the right particle size, easily digestible, and should be nutritionally complete. Depending on the organism's size and nutritional needs at first feeding, starter feeds differ in type and composition. Typically, starter feeds are of tiny flake or crumble shape. In many cases, like shrimps and some cultured

marine finfish, the first feeding is based on live foods rather than on formulated starter diets.

2. **Fry feeds:** The unmetamorphosed juvenile stage of a finfish's life cycle is referred to as a fry. Since the early stages of life are thought to have significantly higher protein and energy requirements on a unit mass basis, fry feeds typically contain higher protein levels. At fry stage greatest relative weight gain (specific growth) is attained, so it's critical to make sure that the fish should reach their maximum growth potential during this phase of development. Typically, at fry stage fish accepts crumbles or flakes shape feed.
3. **Fingerling feeds:** The period between metamorphosis and a growth of roughly 10–20 g is known as the fingerling stage. Depending on the species and size of the fingerlings, their diet can range from crumbles to pellets. Additionally, compared to fry and starter diets, fingerling diets typically have lower protein and energy contents.
4. **Grow-out feeds:** Weight increase typically happens at a consistent rate during the grow-out stages, with a slight decrease as the fish's weight increases. As a result, the nutritional needs during growth are fairly consistent. It's crucial to make sure that the feed's protein is primarily utilized for growth rather than metabolic processes when using grow-out diets. During grow-out, biomass of the culture system increases and so total quantity of feed required reaches its maximum. Therefore, at this point in the culture system greatest feed cost-saving could be made.
5. **Broodstock feeds:** During sexual maturation, gonadal growth speeds up and the somatic growth slows down until spawning. The quality of the offspring is known to be impacted by the quality of the feed during this time. Consequently, the nutritional requirements of the reproducing fish should be taken into consideration during broodstock feed formulation. For the majority of cultured species, little is known about the nutrition of broodstock. In general, broodstock feed formulations just have more protein.
6. **Product quality feeds:** These feeds are used to improve the product's marketability. In order to increase the final product's consumer acceptability, these feeds are used near to harvesting. Supplementing with carotenoid to improve the colour of their flesh is one example of this. High-value species are the only ones for which product-quality feeds are utilized.

Feeding practices for carp

The feed particle size should be proportionate to mouth aperture of fish. Fine particles of fish feed often cause clogging gills thus damaging them. Feeding formulated diets like crumbles for fry and early fingerlings are encouraged. Feeding schedule are different at different life phases of carp fish which are as follows: -

Stage	Culture period	Feeding Frequency	Quantity
Spawn to fry	Culture period 15 days	Feeding is provided twice a day.	4 times of initial body weight during first weekand 8 times of initial body weight during second week.
Fry to fingerlings	Culture period 90 days	twice a day.	6-8% of biomass during first month, 5-6% of biomass during second month and 3-4% of biomass during third month.
Grow-out culture	Culture period 10-12 months	twice a day	3-5% of biomass in the first month and 1-3% of the biomass in the subsequent months provided.

Ingredients used in fish feed

In order to satisfy the growing demand for aquatic food, the aquaculture industry worldwide is shifting from traditional vast farming to intense culture techniques. The availability of affordable, sustainable feed ingredients that also balance nutrition is crucial for achieving increased productivity in such systems. Even though they are more nutritious, traditional feed ingredients like fish meal and fish oil are becoming scarce, costly, and unsustainable for the environment.

Formulations for aquafeed primarily rely on imported sources of lipid and protein, such as soybean meal, corn gluten, and different vegetable oils. However, the use of many plant-based ingredients is restricted because they contain toxicants and anti-nutritional elements (ANFs). Plant-based and non-conventional feed resources (NCFRs), which, when managed appropriately, provide an acceptable alternative, can now partially replace traditional components thanks to extensive research. The fish feed ingredient used in preparation of fish feed can be divided into two broader terms: -

Conventional	Non- Conventional
• Soybean Meal • Groundnut Cake • Mustard Oil Cake • Rice Bran • Fish Meal	• Mulberry leaf meal • Sweet potato leaves • Leaf meals from aquatic plants like *Nymphoides cristatum*, *Pistia stratiotes*, *Eichhornia crassipes*, and *Hydrilla verticillata etc.*

Conventional Feed Ingredients

- **Soybean Meal:** CP content ranges from 44–48%. The feed industry is quickly adopting and using this feedstuff more and more. It can substitute

a significant portion of fishmeal and has a balanced amino acid profile. However, because of its high fat content and trypsin inhibitor, its use is restricted.

- **Groundnut Cake:** Groundnut cake has roughly 45% crude protein, it is deficient in lysine, an essential amino acid. It turns toxic when it gets moldy because it contains the mycotoxin aflatoxin.
- **Mustard Oil Cake:** Made from the pressed cake of mustard seeds, mustard de-oiled cake is a premium protein source. It is a beneficial supplement to fish feed and a good source of vitamins, minerals, and essential amino acids. It is also a good source of minerals, vitamins, and energy. CP content ranges from 33% to 40%.
- **Rice Bran:** When rice is processed and the grain husks are removed, rice bran is created as a byproduct of the milling process. After milling, 65% of the grain is rice, 25% is husks, and 12% is bran. It is a common energy source in feed ingredients with a high fiber content. It has 11-12 % crude protein.
- **Fish Meal:** Fish meal serves as an attractant in addition to having a high protein content. Fish waste from the canning industry or trash from trawling are used to make fishmeal. The source of the fish product and the process used to make the fishmeal determine the percentage of crude protein (CP). Normally, CP content ranges from 60–72%.

Non-Conventional Feed Ingredients (NCFRs)

- **Mulberry leaf meal:** This is one the cheapest source of protein with 20-22% crude protein. It has been found that mulberry leaf meal can successfully be used in the diet of fishes.
- **Sweet potato leaves:** Animals can effectively use sweet potato leaves as an alternative energy source. This crop is grown all over the world and is an essential food source in tropical areas. Location and variety have a significant impact on the amount of protein and fiber in sweet potato leaves. Normally crude protein level is in between 25.5 and 29.5%.
- There are other terrestrial leaf that can be incorporated in fish feed are *Sesbania*, Moringa leaf meal, Subabul leaf meal, Alfalfa leaf meal etc.
- **Leaf meals from aquatic plants:** there are some aquatic weeds that exhibit potential for use in aquatic feeds include *Nymphoides cristatum, Pistia stratiotes*, *Eichhornia crassipes*, and *Hydrilla verticillata. Azolla pinnata* has been investigated as a potential source of protein for fish with crude protein levels that range from 25 to 35 percent depending on the location. Water hyacinth leaf meal is abundant in organic resources and is widely available. Because of its rapid growth, it is regarded as one of the most noxious weeds

in the world. It has 15–18% crude protein. In freshwater environments in India's tropical and subtropical regions, duckweed grows extremely quickly. Farmers can also grow this on their own farms because its farm culture has already been standardized. During the rainy season, this aquatic weed grows rapidly, and cattle and Indian major carps commonly eat it when it is fresh. In its dry form, it is widely used for feed preparation and contains a good amount of protein and minerals. Spirulina is also one the potential fish feed ingredients.

Different Fish Feed Ingredients

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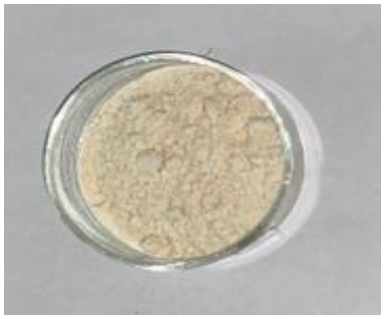
<td> 
Fig. 2.1: Wheat floor</td>
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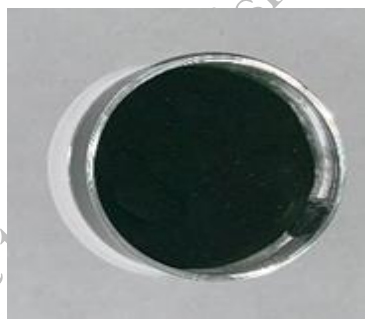
Fig. 2.2 Blood Meal</td>
<td> 
Fig. 2.3 Spirulina</td>
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Fig. 2.4 Mustard oil cake</td>
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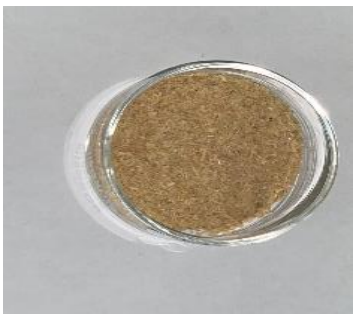
Fig. 2.5 Meat Meal</td>
<td> 
Fig. 2.6 Rice Bran</td>
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Fig. 2.7 De-oil Rice Bran</td>
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Fig. 2.8 Fish Meal</td>
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Fig. 2.9 Sesbania leaf meal</td>
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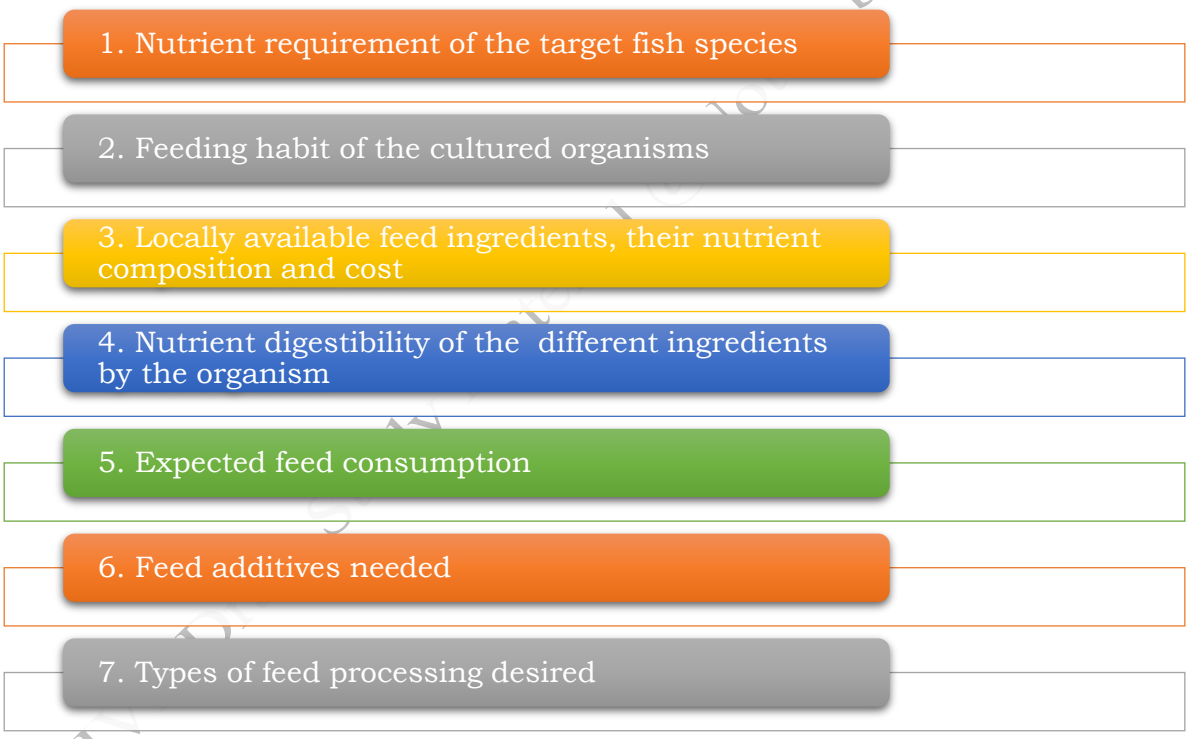
The development of affordable, nutrient-dense, and sustainable aquafeeds is essential to the industry's sustained expansion. With careful quality assessment, combining conventional and non-conventional feed ingredients can greatly

improve fish health, growth, and environmental sustainability. To fully realize the potential of alternative feed resources, ongoing research and development is underway.

Formulation and preparation

Feed formulation

The process of choosing and combining the right feed ingredients to create a diet that contains the necessary amounts of vital nutrients is known as feed formulation. The nutrient requirements of any fish cannot be met by a single ingredient. Creating diets with key nutrients is necessary to provide different aquaculture species with enough nutrition. Creating the perfect diet requires a lot of information. This information is carefully compiled in feed formulation to meet a species' nutritional needs. Therefore, the following pre-requisite information for feed formulation must be gathered before beginning any feed formulation: -



Methods of feed formulation

Diets are designed to balance the necessary amounts of fish in terms of protein, lipid, energy, vitamins, minerals, and protein: energy ratio. Since it is difficult to balance all nutrients and energy during formulation, aquafeed should at least balance protein and energy. Other nutrients are almost automatically increased if the diet's energy and protein content are balanced. However, if necessary, a small amount of supplementation of certain essential nutrients is needed to prevent deficiency. At farm level fish feed can be easily prepared by Pearson's Square Method. The feed formulation process for food fishes and ornamental fishes is the same, with the exception of a few special additives for the

latter. For instance, carotenoid dietary supplementation is particularly taken into consideration for ornamental fish in order to enhance and augment their vibrant colouring.

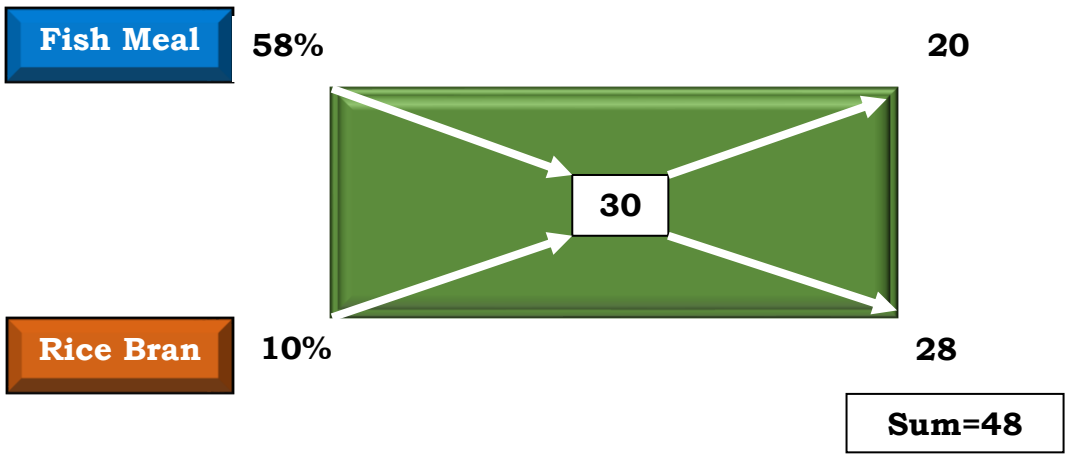
Pearson's Square Method

This method may be used in case of two or more feed ingredients. Examples of feed formulations with two and more ingredients are shown below.

Example 1: - Two Ingredients:

Find the proportions of rice bran and fish meal required for making a feed containing 30% crude protein

1. Draw a square
2. Place the desired protein level at the center of the square. In this case, 30%.
3. Place the two ingredients on the two left corners of the square along with the protein content of each.
4. Calculate the difference in crude protein content of the two ingredients (58 and 10) and record this number (48) near the lower left corner of the square
5. Subtract the desired protein level (30%) of the feed from the protein content of each ingredient. Ignore positive or negative signs. The difference between percentages of protein in rice bran and in the feed (20) represents the amount of fish meal needed. The difference between fish meal and the feed (28) represents the amount of rice bran needed.
6. Add the differences obtained at the right corners of the square (20 and 28) and record their sum (48) near the bottom right corner. The sum in the right corner should equal the difference in protein content recorded near the lower left corner of the square.
7. Divide the differences obtained in step 5, which were 20 and 28 by the sum obtained in step 6, which was 48 and then multiply each by 100 to obtain the percentage of each ingredient needed for the feed, Thus, 41.67 Kg of fish meal



and 58.33 Kg of rice bran are combined to make 100 Kg of fish feed containing 30% crude protein. The feed can also be described as being composed of 42% fish meal and 58% rice bran.

Rice bran=28/48x100	**=58.33%**
Fish meal=20/48x100	**=41.67%**

Example 2: - More than Two Ingredients:

- Using fish meal (C.P. 60%), GNOC (48%) De-oiled bran (C.P. 15%) and tapioca (C.P. 4%) a prawn diet with 32 % crude protein can be prepared as follows:
- The first should be consisted of ingredients whose crude protein % is higher than the requested, second should be consisted of ingredients whose crude protein is lower than the request followed by average of their protein content.

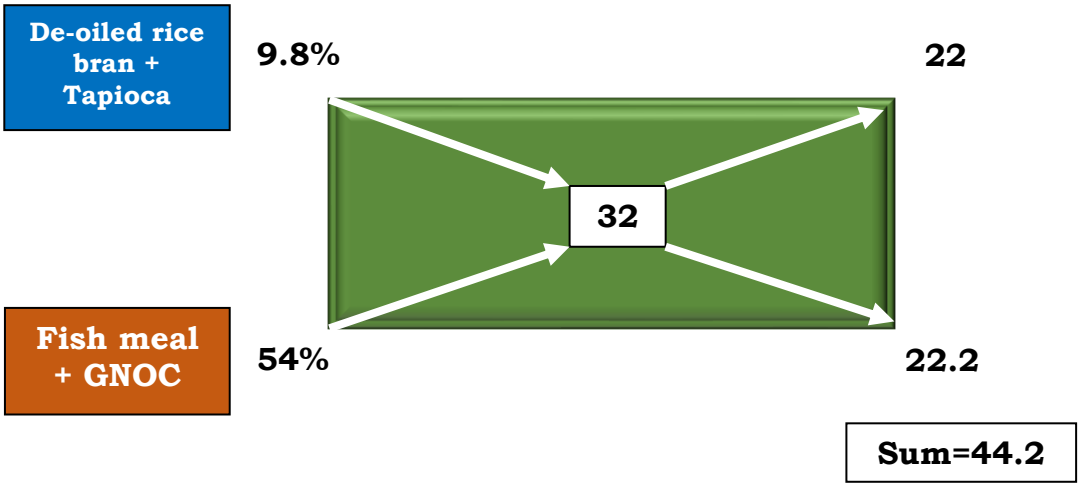
First Group:

- De-oiled rice bran (15.6) + Tapioca (4) = 19.6%
- Average = 9.8 %

Second Group:

- Fish meal (60 %) + GNOC (48 %) =108%
- Average= 54 %

Now the average protein contents are put on the two left corners of the square, and the rest is same.



Now add the figures on the right hand side corners of the square.

$$Deoiled\ rice\ bran + Tapioca = \left(\frac{22}{44.2}\right) x100 = 49.8\%$$

$$Fish\ Meal + GNOC = \left(\frac{22.2}{44.2}\right) x100 = 50.2\%$$

De-oiled rice bran = 49.8/2	Tapioca = 49.8/2	Fish meal =50.2/2	GNOC =49.77/2
= 24.90%	= 24.90%	= 25.1%	= 25.1%

The composition of the feed is:

- De-oiled rice bran = 24.90%
- Tapioca = 24.90%
- Fish meal = 25.11%
- GNOC = 25.11%
- Total =100.0%

A crucial step in aquaculture is feed formulation, which makes sure that a balanced mix of feed ingredients is used to satisfy the nutritional needs of various fish species. A well-informed approach is required to create diets that are both economical and nutritionally complete because no single ingredient can provide all the essential nutrients. Particularly at the farm level, the application of techniques like Pearson's Square offers a straightforward but efficient tool for figuring out ingredient proportions. The secret is to balance the protein and energy content, which promotes the best possible growth and health whether you're formulating for food fish or ornamental species. Aquaculturists can create customized feeds that support productive and sustainable fish farming methods by using methodical approaches and comprehending the nutritional makeup of each component.

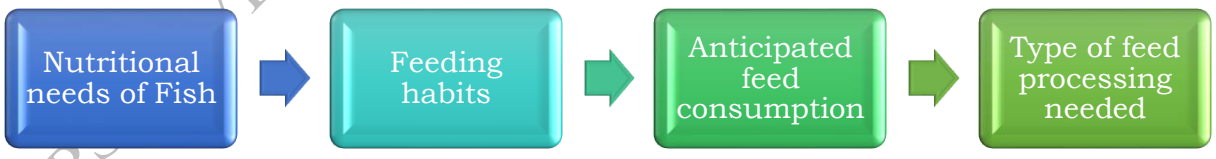
Feed Preparation Process

Nutrition plays a crucial role in fish production systems to generate high-quality, economically viable products. One of the most important inputs in aquaculture production is feed, and demand for high-quality feed is rising day by day. Using the right processing technology is crucial to determining the feed's ultimate quality. In feed formulation, the right proportions of ingredients are chosen to create a single, homogenous mixture or pellets that can be produced at a reasonable price and meet all of the target fish's nutritional needs. The fundamental procedures used in the preparation of fish feed are: -

1. Ingredients Selection
2. Grinding

3. Feed formulation
4. Mixing
5. Pelleting
6. Drying
7. Packing
8. Storage

1. **Ingredients Selection:** The selection of raw materials is the first process in the feed processing plant. The quality of the finished feed is significantly influenced by the quality of the feed ingredients. Feed ingredients should be clean and devoid of impurities such as stones, sand, and other earthen materials. Both a quality check and a nutritional analysis should be performed on the ingredients.
2. **Grinding:** A crucial stage in the production of feed is grinding, also known as particle size reduction. To achieve a consistent particle size, ingredients must be ground into a powder before use. In general, grinding ingredients enhances their acceptability, mixing qualities, pelletability, feed digestibility, and bulk density. Numerous mechanical and manual processes involving impact, attrition, and cutting are used to achieve this. The most widely used grinding devices include flour mills, pulverizers, and hammer mills. To achieve a consistent particle size, the powdered ingredients are subsequently run through a standard mesh sieve. The ingredients can be sieved to create feed pellets with a consistent and appealing physical appearance.
3. **Feed formulation:** In this procedure, suitable dietary ingredients are chosen based on their cost, availability, chemical makeup, and nutritional value. A nutritionally balanced, palatable and storage-friendly compound feed is created by blending the ingredients in the right amounts. The following factors should be taken into account when formulating feed:



4. **Mixing:** Any possible combination of solids and liquids may be used in feed mixing. In accordance with the formulation, the weighed and sieved ingredients are combined in the appropriate ratio. Typically, liquid materials are combined after dried ingredients. At the end, liquid ingredients like fish oil could be added and mixed even more. Additionally, water is added to raise the moisture content. It may take 20 to 30 minutes to properly mix the various feed ingredients into a homogenous mass. Batches or continuous mixers can be used for mixing. Shovels

or any type of container can be used for batch mixing on a level, open surface. As the material is being mixed, it passes through continuous mixers. Turbine mixers, vertical mixers, and horizontal ribbon mixers are the types of mixers that are utilized.

5. **Pelletizing:** This method involves compacting feeds by extruding separate or combined ingredients. Pelleting transforms the homogenous mixture into a high-quality feed with feed-suitable physical properties. Extruder pelleting and compressed pelleting are the two main machine types used in pelletization.

   i. **Extruder pelleting:** The term "fish feed extrusion process" describes the quick cooking of a feed ingredient mixture using an extruder at high temperatures, pressures, and moisture levels. A screw shaft conveyor coupled to a high-speed motor and a barrel with a die plate are the fundamental parts of an extruder. In extruder pelleting machine under pressurized condition the temperature is increased to 125-150°C in a chamber with 20-24% moisture. This causes gelatinization of starch present in feed ingredients and mixture turns into a dough-like consistency. Then these are forced through a die under high pressure. When pellet leaves the die, due to sudden fall in pressure, trapped water (which earlier was in liquid form under high pressure) gets evaporated and material which was gelatinized earlier gets expand leading to air pockets formation. After cooling, the pellets density is mostly around 0.25-0.3 g/cm^3. It's because of this pellets float or sink slowly.

   ii. **Compressed Pelletization:** The pelletizer operates on the idea of compression process to pellet the finely ground feed mixture. The compressed pellet is the subjected to mixture to steam for 5–20 seconds to reach 85°C and 16% moisture content, after which a roller inside the die forces the mixture through holes in the metal die. Because steam is used to precondition the mixture before compression, this process is also referred to as steam pelleting. The confluence of pressure, moisture, and heat that causes the starch to gelatinize. A stationary adjustable knife trims the pellets to the appropriate length as they emerge onto the die's exterior. The amount of fat, moisture content, and humidity all affect pellet quality. The mixture's fat content should be between 2 and 3 percent to lubricate the die's holes and lessen dustiness, and between 8 and 10 percent to prevent over lubrication that would result in insufficient feed mixture compression. The amount of moisture is also important because too much moisture makes the pellets soft, while too little moisture makes them crumbly.

6. **Drying:** The feed should be dried as soon as possible after pelleting in order to bring the moisture content down to less than 10%. This is necessary for the feed to have a long shelf life. Feed pellets are dried using a variety of dryer types, including fluid bed dryers, hot air ovens, vertical hopper dryers, and horizontal

conveyer dryers. 65 to 75 degrees Celsius is the ambient temperature used to dry feed. A higher temperature is undesirable.

7. **Packing:** Prior to packing, the dried feed is allowed to cool. To keep feed quality intact during storage and transit, high-quality packing covers are used.

8. **Storage:** Because the feeds are made of biological material, they may deteriorate if kept for an extended period of time. Feeds should therefore be kept out of direct sunlight in hygienic, cool, and dry warehouses or storage spaces. Microbial or oxidative damage could be the cause of the degradation. Additionally, measures should be taken to prevent rodent, insect, and pest infestations. Feed deterioration is accelerated by storage conditions. The two main environmental factors that affect storage are temperature and humidity. Regardless of the initial moisture content, stored feed will eventually equal the atmospheric moisture content based on the relative humidity. A high moisture content encourages the growth of microorganisms. High temperatures accelerate the deterioration process brought on by microbes and cause oxidative damage to feed additives like vitamins and reduce the nutritional value of feed. In addition to these, oxygen and light have an impact on feed decay. The feed should be kept in storage for as little time as possible.

Methods of fish feeding

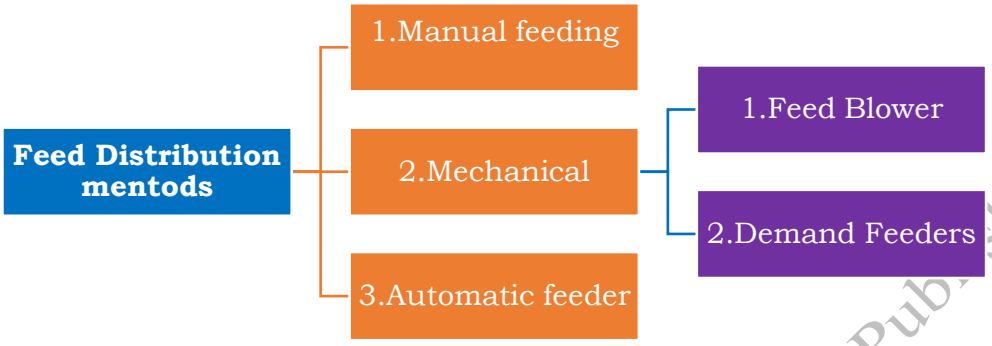
In any aquaculture operation feeding is the most important daily activity. A farmer should ensure that all the feed distributed in the water is effectively eaten by the fish. Feed should be properly utilized by the fish since feed not consumed can lead to deterioration in the quality of the rearing environment. A farmer should take proper care in dispensing the feed in pond since feed is a costly item. In practice, a farmer must adjust the amount of feed as per requirement of the fish at a given time and also should choose appropriate feed distribution methods to reduce economic loss.

Factors which decide the choice of feeding method to be employed: -

- Life cycle stage and behaviour of species
- Intensity and area under culture
- Type and quantity of feed to be dispensed
- Feeding frequency
- Availability, working hours and cost of labour
- Access to electricity
- Initial investment capacity

Feed distribution methods

The feed distribution can be done by various method. The selection of the methods depends upon various factors like economic, availability of the technology etc. However, the feed distribution method can be divided into following categories: -



1- Manual feeding

a. **Broadcasting of feed:** The most usually employed technique of feed distribution in semi-intensive aquaculture systems is broadcasting or hand feeding. Though efficient, it requires human for feed distribution into the culture system, which requires considerable manpower. Fish grow conditioned to this eating schedule over time. Still, a lot of the nutrients and feed are lost inside the system, which causes inefficiencies**.** Broadcasting can be is done by hand / scoop / shovel from dyke / by using boat.

Fig. 2.10: Broadcasting of feed

Advantages	Disadvantages
• Operator can note feeding behaviour and can access the feed required. • Operator can ensure that feed is dispersed over wide area.	• High labour cost. • Increased handling of the feed.

b. Tray feeding: Under tray feeding method sinking pellets or moist feed balls are placed in feeding trays. No. of trays required depends upon pond size,

Fig. 2.11: Tray feeding

animal density, and total feed volume to be given. Using enough trays, usually between 30 and 40 trays per hectare, helps to guarantee best feeding conditions especially in case of prawns.

Advantages	Disadvantages
• Low cost. • Simple to use.	• Limited feed distribution. • Significant nutrient leaching and feed disintegration.

Bag feeding: Most common feeding method adopted by the farmers of India. In this method, the feed mixtures (mash or moist feed) are placed in perforated bags tied to bamboo poles. About 20-30 bags can be used per hac. of pond. Fishes browse on the feed through perforations in the bag. Within 2 hrs feed kept in the bags are consumed.

Advantages	Disadvantages
• It is an easy-to-adopt and inexpensive method. • Feed is relatively protected within the bag, reducing loss due to drifting	• Dominant fish may monopolize access to the bags, leading to size variation and uneven growth. • Fixed feeding points may not reach all areas of the pond, reducing feeding opportunities for all fish.

Fig 2.12: Bag feeding

2- Mechanical Feeders

For big ponds feeding is labour intensive and in certain counties labour cost is very high. To tackle such challenges, mechanical feeders were developed to reduce cost. These feeders reduce feed handling and improve FCR. Even in off-shore cage culture operations mechanical feeders is useful for delivery of fish feed at any time of the day.

a. **Feed blowers:** It is the machine that simplify fish feeding by blowing feed. It can be mounted on a boat, truck, tractor trolley, or wheel. They convey the feed using air or water. Feed waste is more likely and some Vitamin C in the feed may be lost if is used as a water is the carrier.

Advantages	Disadvantages
• Wide area of distribution.	• Does not reflect fish appetite. • High cost and high-power consumption.

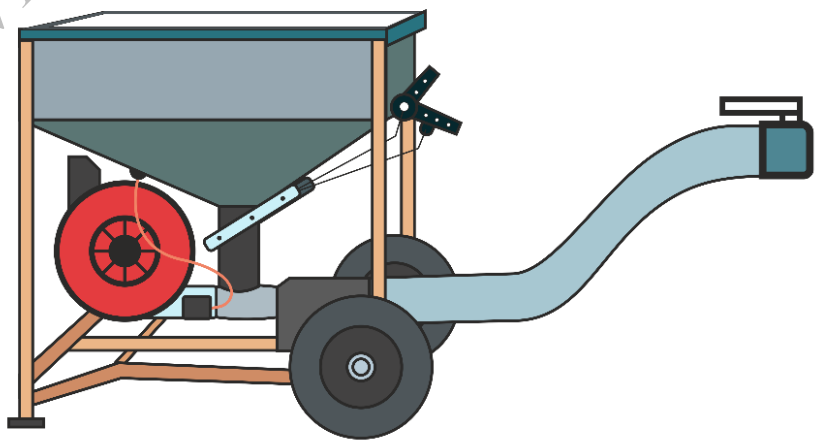


Fig. 2.13: Feed blower

b. Demand feeding: Demand feeders let fish consume feed anytime they are hungry, therefore enabling self-feeding. Some fish species pick them fast; they are not fit for small fish since they might not be powerful enough to operate them. At the bottom of the feed container, the feeder features a rod joined to a stopper or plate. Usually, this plug maintains feed within. When fish push the rod, it moves the plug and a small amount of feed drop out. The form and configuration of the plug determine the feed release quantity every time. Typical forms are an upside-down cone or a spherical.

Advantages	Disadvantages
• Cost and labour efficient. • Simple to use. • Reflects on appetite and condition of fish.	• Sensitive to waves, winds and accidental activation by fishes. • Should be used strictly with a maximum feeder: fish ratio to ensure uniform feeding cannot be used for smaller than 20 g

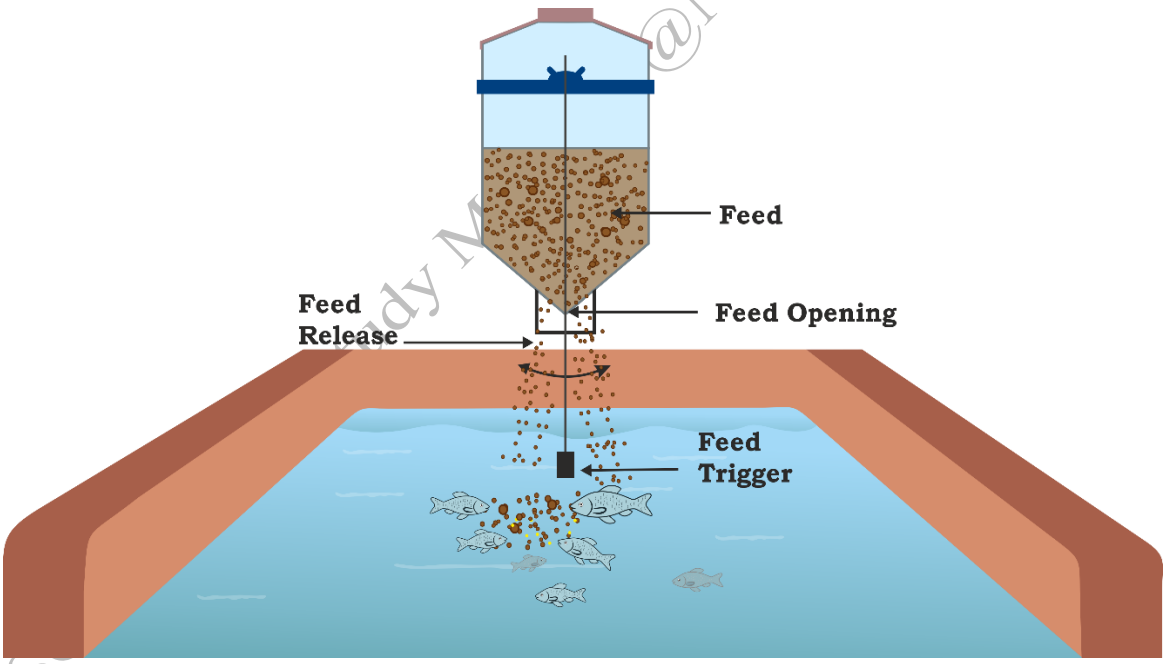


Fig. *2.14:* Demand Feeder

3. Automatic feeder

An automatic fish feeder is a device that feeds the fish in required amount and at a set time automatically. It is basically used to regulate the fish feeding activities by means of mechanical system and an electrical system instead of hand feeding the fish.

Advantages	Disadvantages
• Feed amount tightly controlled and schedule can be optimized	• High Cost

Fig. 2.15: Automatic feeder

Actually, selection of the feeding method considers based upon type, level of production and the cost of feeding system. During the production cycle, feeding strategies can be altered; so, different ways can be merged with appropriate economic strategy to help the farmers. Selection of feed method depends on type and amount of feed to be distributed, feeding frequency, initial investment and operation's economy.

Practical Activities

Activity: Identification of the various fish feed ingredients

Material required: Pen, pencil, notebook, practical file, etc.

Procedure

1. Visit a nearby Fish feed mill unit and note down the following observation:
    - Identification of different types of feed ingredients
    - Enlist Type of fish Feeds and its uses
    - Note down various Types of machineries
2. If any query, please discuss with the feed mill owner.

Activity 2: Calculate portion of rice bran (12% CP) and mustard oil cake (33% CP) required to make fish feed of 30% crude protein using Pearson square method.

Check Your Progress

Fill in the Blanks

1. When the endogenous food supply (yolk) of first-feeding fry or larvae is depleted or about to deplete, _____ are administered.
2. During sexual maturation, _____ growth speeds up and the somatic growth slows down until spawning.
3. In Soybean Meal crude protein level ranges from _____%.
4. Fish waste from the _____ industry or trash from trawling are used to make fishmeal.
5. For fish feed formulation _____ method are used in case of two or more feed ingredients.

Multiple Choice Questions

1. What percentage of operating costs in fish farming is typically attributed to feed?
   a. 20-30%
   b. 30-40%
   c. 50-70%
   d. 70-90%
2. Which type of feed is given to first-feeding fry or larvae when their yolk is exhausted?
   a. Fry feed
   b. Starter feed
   c. Fingerling feed
   d. Grow-out feed
3. What is the typical form of starter feeds?
   a. Flakes or crumbles
   b. Pellets
   c. Powder
   d. Balls
4. What is a major limitation of using soybean meal in fish feed?
   a. Low protein content
   b. High cost
   c. Poor palatability

d. Presence of trypsin inhibitor

5. Which type of pelleting involves the quick cooking of feed ingredients at high temperatures and pressures?

a. Steam pelleting

b. Extruder pelleting

c. Compressed pelleting

d. Cold pelleting

Match the Columns

A	B
1. Non-Conventional feed	(a) Demand Feeder
2.Conventional feed	(b) Duckweed
3. Mechanical feeder	(c) Pearson's Square Method
4. Feed formulation	(d) Fish Meal

Subjective Questions

1. What are different types of fish feed based upon life stage?
2. Difference between Conventional vs. non-conventional ingredients.
3. Describe Pearson's square methods feed formulation.
4. Describe feed preparation processes.
5. What are feeding techniques and their pros/cons?

Session 2: Monitoring of Fish Seed

Aquaculture practice depends on effective monitoring of fish to assure their good health, survival, and growth. Early warning of infections, stress, or poor environmental conditions can be found by regular monitoring. Thus, emphasizing on these points, this session explores techniques of fish seed monitoring and its significance.

Sampling of Fish Seed

In aquaculture, sampling fish seed is a vital and methodical process wherein a small, but representative sample of all the fish seed population are collected from the culture unit—pond, tank, raceway, or hatchery. This practice's main goal is to compile accurate data on the general state and performance of the seed stock without looking at every single fish; which is unrealistic in large-scale operations. These representative samples can be used for access multiple critical parameters such as:

A. **Seed Quality:** it involves physical characteristics including body symmetry, color, fin structure, and responsiveness to stimuli help one ascertain whether the seed is strong, healthy, free from defects or abnormalities.

B. **Health Status:** Early symptoms of bacterial or fungal infections, parasitic infestations, stress and other pathogenic diseases can all be found with sampling. Fish displaying discoloration, skin lesions, or aberrant swimming behavior can be separated for close examination.

C. **Growth Rate:** Farmers can monitor the specific growth rate (SGR) of the seed by routinely weighing and measuring the length of selected fish. These details assist farmers to access whether existing dietary inputs and the environmental conditions are perfect for growth or not.

D. **Size Uniformity:** A representative sample shows the degree of size fluctuation in the stocked seed. Significant size differences could point to issues including unequal feeding, dominance behavior, or stunted individuals that might cause cannibalism or lower productivity.

In order to ensure accuracy sampling must be carried out carefully, using appropriate tools like caste net and with standardized protocols. The fishes should be gently handled to avoid injury and stress. Sampling must be carried out at consistent intervals and at particular time of the day. Correctly performed sampling provides crucial understanding for making correct management decisions, like modifying water quality parameters, adjusting feed rations, or any health-related interventions, thus contributing to the successful aquaculture.

Objectives of Sampling

- To evaluate rates of survival and mortality.
- To determine fish health status.

- To monitor abnormalities, deformities or signs of stress.
- To assess weight and average size.

Methods of Sampling

- **Random Sampling**: Collecting seed randomly to ensures unbiased results.
- **Time-Interval Sampling**: Regular sampling at set intervals (weekly or biweekly) for generation time-series data for evaluation of growth and health trends.
- **Stratified Sampling**: In this method, the ponds are divided into different sections, and sample collection is done from each section thus ensuring a comprehensive coverage.

Sampling Tools

- **Scoop nets or fry nets**: these are used for collection of fish gently to avoid any physical injuries to fish.
- **Measuring scales and rulers**: Measuring scales and rulers are used for to measure length and weight of fish.
- **Plastic containers or buckets**: For holding sampled fish and observing the fish sample temporarily.
- **Magnifying glass or microscope**: For detecting any deformities and parasites attachment.

Precautions During Sampling

- To avoid stress or injury fishes should be handled gently.
- Avoid doing sampling from same location every time.
- Avoid excess outside water exposure of the fish to prevent mortality.
- Use anesthetics such as clove oil or MS-222, if required to minimize handling stress.

Monitoring Growth and Health

With regular monitoring of fish at farm for its growth and health, ensures early detection of issues and timely intervention for its mitigation. It also assists in feed utilization optimization, enhance survivability and helps in achieving desired production.

Parameters to Monitor Growth

- **Length and weight**: The regular measurement of length and weight helps calculation of feed conversion ratio (FCR) and specific growth rate (SGR) of the fish.

- **Condition factor (K)**: Indicates the overall well-being and robustness of fish. In this, we compare actual weight of fish to the weight that would be expected for its length.

Techniques

- **Biometric Sampling**: In this farmer perform periodic measurement of a fixed number of fish, say 20–30 fishes to estimate average weight and growth rate of fish.
- **Growth Charts and Records**: In this farmer collect and maintain records for comparing with expected growth benchmarks.

Growth Indicators: For monitoring growth, we need certain potential indicator based on which we can monitor and analysis the growth performance of the fish. The indicators which we can use at farm level are mentioned below: -

Monitoring Health: Fish health monitoring involves various strategies for accessing and maintaining the well-being of fish in culture system. It's vital for prevention of outbreaks of disease, optimizing growth, and ensuring healthy fish production.

Health Indicators: Fish health indicators give signal about fish's overall well-being and can be used to assess their health and prevailing environmental conditions. Indicators are the observable characteristics such as behavior, appetite, fin condition and complex assessments like condition indices, histological analysis etc. some of them are explained below: -

- **External appearance**: discoloration, fin rot, Skin lesions, or abnormal swimming behavior.
- **Feeding behavior**: any reduction in appetite signals health issues.
- **Mortality rate**: Sudden mortality indicates possible poor water quality issues or disease outbreak.
- **Gill condition**: Pale or necrotic gills is the sign of oxygen deficiency or infection, whereas healthy gills are bright red.

Diagnostic Tools

- **Microscopic examination**: Microscope are used to detect internal and external parasites, fungal spores, and other pathogens. It's a quick and cheap primary diagnostic tool.

- **Water quality testing kits**: These kits are used for parameters like temperature, TDS, pH, dissolved oxygen, nitrites, hardness, alkalinity and ammonia.
- **Histopathology**: Histopathology is an advanced diagnostic tool wherein tissue samples are examined under microscope observe changes at cellular-level. It's helpful in chronic and systemic diseases diagnosis which affects internal organs and tissues.

Preventive Health Management: Unlike terrestrial animals, it is not easy in case of fish to isolate or inject them. Moreover, effective medications for fish are limited. Many medications due to food safety concerns are also not approved for use. Further, treatment of disease requires accurate diagnosis, labor intensive and expensive. Hence, preventive measures are more feasible and cheaper. Under pond condition both the fish as a host and the pathogen are affected by changes in environment i.e water quality.

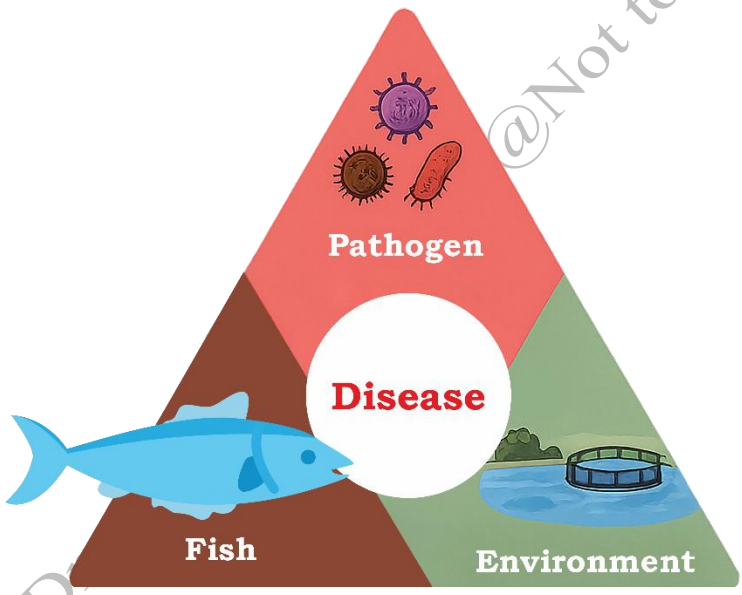
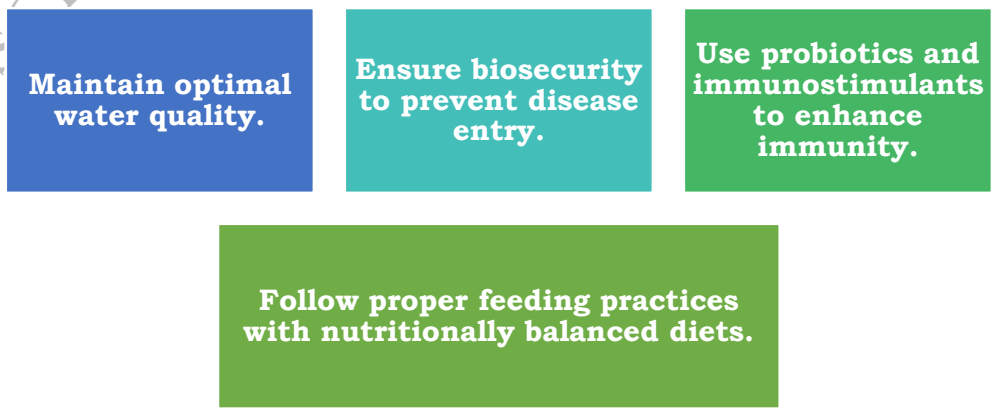


Fig. 2.16: Disease triangle

Following measure need to be taken in order to prevent disease occurrence: -



Monitoring of fish by methodical sampling for growth and health is essential for successful aquaculture. It helps in early abnormalities detection and farmers can take prompt corrective measures. It helps in achieving higher growth performance, survival rates and improves overall profitability. Therefore, it is essential for farmers to adopt a standard monitoring process in order to ensure good health of fish and sustainable aquaculture production.

Common Diseases and its management

The most of disease outbreak in aquaculture occurs due to changes in the environmental fluctuation and water qualities such as pH, temperature, dissolved oxygen, CO_2, transparency, turbidity etc. Waste products cause water pollution thus leading to infection on skin, gills and mouth cavity. Further, the excessive use of fish feed and organic matters produces harmful gases such as methane, H_2S, ammonia, CO_2. This causes fish disease. Any sudden change in water temperature and high stocking density also causes stress to the fish.

Disease Symptoms:

Fish, like any other living organisms, shows some specific signs of infection caused by bacteria, viruses, fungi, parasites or environmental stressors such as poor water quality or inadequate nutrition. Identification of these symptoms early is important for timely treatment and effective management. Monitoring closely these symptoms farmers can prevent the disease spread, minimization of losses and can ensure health and productivity. Some common fish disease symptoms are as follows:

1. Any change in body shape or colour
2. Difference in swimming behavior and isolation from group.
3. Stop feeding or reduction in feed intake.
4. Sheading of scales or any white/red coloration of fin.
5. Water accumulation or reddish fluid on the body.
6. Excess mucous secretion, stomach swollen and gill necrosis.
7. Swelling of fish body with subsequent abrasions, spots, ulcer, furunculous or any wounds with fungal infection.
8. Unfit breathing and movement; sudden movement and jumping out of water; rubbing the body against rough surface; pond dykes; aquatic vegetation etc.
9. Fish showing movements on own axis, forward or backward, tail down or head down, oblong, horizontal or vertical, imbalanced body.
10. Exopthalmous or endopthalmous with swelling/ bulging eyes/ improper vision.

Precautions from disease:

i. **Disinfection of ponds and tanks:** Application of 50–100 kg of bleaching powder per hectare during pond preparation is the foundation of pond management. To get rid of bacteria and pathogens, 400–600 kg/h of quick lime is used in new ponds and 500–800 kg/ h in old ponds. Before fish being stocked in the pond, fish can be treated with a 0.5-2.0% salt solution or 5 ppm formalin.

ii. **Disinfection of instruments:** Instruments before being used in the pond, equipment should be thoroughly cleaned and allowed to dry completely in the sun. Then, it should be disinfected with 5–25 ppm formalin or 250 ppm $KMnO_4$. Never use someone else's pond's instruments.

iii. **Proper diet:** Use fresh, nutritious feed two to three times a day. The feed should contain all the nutritional requirement of cultured fish species. Fish that eat poor-quality food may grow slowly and become weaker.

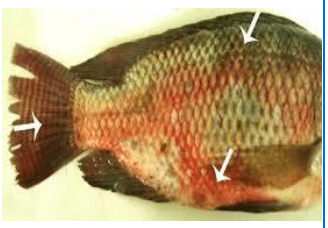
iv. **Grading of fish:** To avoid mortality from food and space competition, fish should be stocked in different types of ponds based on size, species, and stage. There should be separate ponds for fry, fingerling, yearlings and brooders.

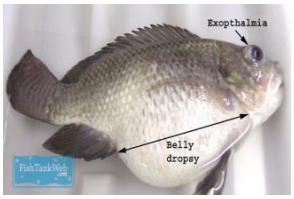
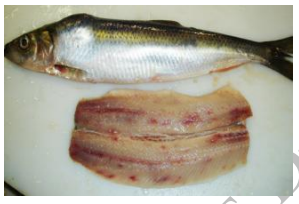
v. **Eradication of diseased and dead fishes:** Dead fish should be removed from the pond and buried far from hatcheries and other ponds. Eliminate sick fish and treat them until they are back to good health.

Common disease and Treatment

Viral Disease			
Disease	**Causative agent**	**Symptoms**	**Treatment**
Viral hemorrhagic septicemia (VHS)  **Fig. 2.17**	*Viral hemorrhagic septicemia virus*	Bulging eyes, bloated abdomens, bruised-looking reddish tints to the eyes, skin, gills and fins.	Sodium hypochlorite bleaching
Infectious hematopoietic necrosis virus	A negative-sense single-stranded,	Abdominal distension, bulging of the eyes, skin darkening, abnormal behaviour, anaemia, and fading of the gills.	No treatment is available

 **Fig. 2.18**	bullet-shaped RNA virus		
Spring viremia  **Fig. 2.19**	Rhabdovirus carpio	Infected fish becomes black and gets legions on the gills and skin. Bleeding from scales, fluid accumulation in the body and alimentary canal inflammation.	No treatment is available
Bacterial Diseases			
Disease	**Causative agent**	**Symptoms**	**Treatment**
Motile Aeromonas Septicemia  **Fig. 2.20**	*Aeromonas hydrophila*	Exophthalmia, skin reddening, fluid accumulation in scales pockets and abdominal cavity.	• Oxytetracycline 2 to 4 g /Kg of feed per day for 10 days. • Sulfamerazine at 264 mg/Kg given in food for 3 days, by 154 mg/Kg/fish/day for 11 additional days is effective treatment.
Columnaris Disease  **Fig. 2.21**	*Flexibacter columnaris*	White plaques, often with reddish peripheral zone leading to haemorrhagic ulcers.	$KMnO_4$ in the fish pond at 3-5 ppm. Fish are bathed in a 5 ppm $KMnO_4$ solution.

Edward siellosis  **Fig. 2.22**	*Edwardsiella tarda*	Scale expulsion, skin lesions and muscle tissue damage. Numerous gaseous wounds develop on the skin, which results in an unpleasant odor.	With fish feed, use 8–12 mg/kg of tetracycline.
Vibrosis, pike pest, or pike vibriosis  **Fig. 2.23**	*Vibrio parahemolyticus, Vibrio salmonicida and Vibrio harveyi*	Red spots on the ventral and lateral area of fish, swollen and dark skin lesions that ulcerate.	*Vaccines should be used appropriately. Add 8–12 mg of oxytetracycline and sulphonamide or nitrofurazone per kilogram of feed. Use slacked lime to clean the pond.*
Furunculosis  **Fig. 2.24**	*Aeromonas salmonicida*	Appearance of boil like lesions,stomach filled with mucus, blood and sloughed epithelial cells, and fusion of gill lamellae	• Oxytetracycline 50-75 mg/kg fish weight/day for 10 days • Sulfamerazine 150-220 mg/kg fish weight/day for 10-14 days.
Fin Rot or tail Rot  **Fig. 2.25**	*Aeromonas fluorescence* and *Pseudomonas putrifaciens*	As the disease progresses, the tissues of the fins and tail become necrotic, and eventually the fins and tail vanish. The outer edges of the fins become slightly cloudy.	Control methods include putting the fish in a bath of 1:2,000 copper sulphate for one to two minutes or 1-2 ppm benzylokonium chloride for one hour, or swabbing the wound with diluted (1:10) tincture iodine or

			concentrated copper sulphate.
Dropsy  **Fig. 2.26**	*Aeromonas hydrophila and few others fews Aeromonas spp.*	Accumulation of body fluid/ water in the body cavity or in scale pockets, scales become loose, abdomen bulge largely and pressing on it water comes out.	By using tetracycline in fish feed.
Epizootic Ulcerative Syndrome  **Fig. 2.27**	*Aphanomyces invadans*	Cauliflower disease causes the fish's mouth to deform. Fish skin develops a number of red ulcers.	Apply 100–600 kg of lime per hectare of pond. Apply potassium permanganate @4ppm per hectare. Apply 1-2 liters of Cifax per hectare.
Fungal Diseases			
Ichthyosporidiosis  **Fig. 2.28**	*Ichthyosporidium hoferi*	The fungus's growth causes desquamation and the development of small, white necrotic patches where the epidermis has been destroyed.	*A bath in a 3% salt solution works well. Add 1-2 ppm of copper sulfate to the fish pond. Fill the pond with formation at a rate of 15–25 ppm. Give the fish a 20 ppm formalin bath for two to five minutes.*
Branchiomycosis  **Fig. 2.30**	*Branchiomysis sanguinis* and *B. demigrans*	False membrane formation and necrotic patches on the gills are caused by adhesions and proliferation of the gill epithelium.	Add 1 ppm of copper sulfate to the fish pond following by liming. Dip treatment of fish with a 3-5% salt solution.

Other Parasitic Diseases			
Dactylogyrosis  **Fig. 2.31**	*Dactylogyrus spp.*	Gill edges take on a grayish hue. These worms initially target the gill filaments, but as their population grows, they spread throughout the body.	NaCl salt solution bath treatment at 3-5% or formalin bath treatment at 100 mg/liter. 25 mg/ liter formalin for pond treatment or 5 mg liter $KMnO_4$.
Gyrodaclylosis  **Fig. 2.33**	*Gyrodactylus elegans,* *G. medius*	These parasites attack the skin, resulting in radish and inflammatory areas. Flashing is a typical symptom. In extreme cases, blindness causes the cornea of the eyes to become turbid.	
Argulosis  **Fig. 2.34**	*Argulus foliaceus*, *A. pellucidus* and *A. coregoni*	These parasites attack the skin, resulting in reddish and swollen patches. Bacterial hemorrhagic septicemia is a possible secondary infection.	NaCl salt solution bath treatment at 3-5% or 100 ppm $KMnO_4$ bath treatment at 100 mg/liter. Pond treatment with 5 mg liter $KMnO_4$.
Lernaea (Anchor worm)  **Fig. 2.35**	Anchor worms	Nearly every major carp species is regularly attacked by Lernaea, which can occasionally seriously harm rearing and nursery ponds.	Pond treatment with 5 mg liter $KMnO_4$ or bath treatment with NaCl salt solution at 2-3%.

Fish health management is a key factor for sustainable aquaculture. Disease outbreaks endangers fish survival, have devastating impact on fish productivity and economic viability. In order to decrease chances of diseases occurrence, it is important to provide optimal water quality, follow hygiene regulations, apply preventative treatments and use quality feed.

Practical Activity

Activity: Sampling of Fish Seed

Material required: Nets, Buckets or sampling containers, measuring scale, Digital balance, Magnifying glass, clove oil, note book.

Procedure

1. Visit fish pond in nearby area.
2. Use a net to gently collect fish seed samples from different areas of the pond.
3. Anesthetize the fish using clove oil to reduce handling stress.
4. Measure the total length (cm) of 20 sampled fish using a measuring scale.
5. Weigh each fish using a digital balance to record individual weight (g).
6. Calculate the average length and weight.
7. Notice any disease symptoms on fish body.

Check Your Progress

Fill in the Blanks

1. The feed should contain all the _____ requirement of cultured fish species.
2. The excessive use of fish feed and organic matters produces _____ gases.
3. _____is an advanced diagnostic tool wherein tissue samples are examined under microscope.
4. Dropsy in fish is caused by _____.
5. Condition factor Indicates the overall _____and _____of fish.

Multiple Choice Questions

1. Which disease is caused by the *Flexibacter columnaris* bacterium?
   a. Columnaris disease
   b. Spring viremia
   c. Infectious hematopoietic necrosis
   d. Viral hemorrhagic septicemia
2. Which parameter is NOT typically measured during fish growth monitoring?
   a. Specific Growth Rate (SGR)
   b. Weight
   c. Length
   d. Fin shape

3. What is the purpose of using anesthetics such as clove oil during fish sampling??

a. To improve digestion

b. To increase growth rate

c. To minimize handling stress

d. To enhance coloration

4. Which of the following is NOT a primary objective of fish seed sampling?

a. Determining fish health status

b. Estimating oxygen levels in water

c. Evaluating survival and mortality rates

d. Assessing size and weight of fish

5. Which sampling method involves dividing the pond into sections and sampling from each?

a. Biometric Sampling

b. Time-Interval Sampling

c. Stratified Sampling

d. Random Sampling

Subjective Questions

1. Why sampling of fish seed is required?
2. What are the different diagnostic Tools?
3. Describe technique for growth monitoring.
4. Write about some common bacterial fish disease with causative agents and treatment.
5. What basic precautions should be taken for prevention from disease?

Match the Columns

A	B
1. Anesthetics	(a) Anchor worms
2. Spring viremia	(b) MS-222
3. Edward siellosis	(c) Rhabdovirus carpio
4. Lernaea	(d) *Edwardsiella tarda*

Module 3
Harvesting, Packaging and Marketing of Fish Seed

Module Overview

The success of any aquaculture venture hinges critically on the quality and consistent availability of fish seed. The availability of healthy, viable seed that can survive in transportation from hatchery or collecting location to the farmer's pond is crucial to the success of any aquaculture endeavour. These young fish can be obtained either from their natural environments or, more typically, are produced in the fish hatcheries under controlled breeding facilities. Effective collection, packaging, and marketing of this seed are essential components of the sector. The complex process of transporting fish seed from its source to the farmer's pond is critical for widespread availability and sustainable aquaculture growth, necessitating careful attention to harvesting, suitable packaging for live transit, and effective marketing. Essential for reducing mortality during transport is proper packing because fish seed is extremely susceptible to temperature changes, stress, and oxygen loss. A successful marketing plan guarantees that high-quality seed gets to the appropriate location at the right time. Each of these steps plays a vital role in ensuring the seed's viability and the overall success of aquaculture endeavours.

This module introduces students to the practices involved in harvesting, packaging, and marketing of fish seed, ensuring quality and viability during distribution. In Session 1, students will study Harvesting and Packaging of Fish Seed, focusing on appropriate harvesting techniques, grading, handling methods, and packaging practices that minimize stress and mortality. Session 2 covers Fish Seed Marketing and Transportation, highlighting market demand and supply chains, pricing, buyer-seller linkages, and safe transportation methods to maintain seed quality and enhance profitability in aquaculture ventures.

Learning Outcomes

After completing this module, you will be able to:

- Describe the methods of harvesting, handling, grading, and packaging fish seed to maintain quality and reduce mortality.
- Explain the processes of fish seed marketing and transportation, including market linkages, pricing, and safe transport practices.

Module Structure

Session 1: Harvesting and Packaging of Fish Seed

Session 2: Fish Seed Marketing and Transportation

Session 1: Harvesting and Packaging of Fish Seed

Fish Seed

Fish seeds refer to spawn, fry, or fingerlings, they are freshly hatched larvae, juveniles a few days to weeks old and young fish a few months old respectively. This includes fertilized eggs, newly hatched larvae, fry (small, free-swimming young), and fingerlings (juvenile fish resembling an adult's finger). Essentially, they are "baby fish" obtained either from natural aquatic environments or, more commonly, from controlled breeding in specialized fish hatcheries. The quality and consistent availability of good fish seed are paramount for successful fish farming operations. Some important information about the fish seeds is listed below in table 1.

Table 1. Types of fish seeds available in marketing.

Stage of fish seeds	Age of fish seeds	Length of fish seeds	Weight of fish seeds
Spawn	Up to 3 days	up to 8 mm	0.15-0.75 g
Fry	15-20 days	8-40 mm	1.6-3.0 g
Fingerlings	60-90 days	40-150 mm	8-40 g

Harvesting of Fish Seed

Harvesting of fish seed "refers to the process of collecting of spawn, fry, or fingerlings for stocking into aquaculture ponds or other grow-out systems. This crucial step ensures a continuous supply of starting material for fish farming.

Fish seed is harvested from nursery ponds or other sources, typically by netting them and then enclosing them in nets. Before being moved to rearing tanks or containers for raising or shipment, they may also be treated with water or other substances.

Gear Used for Harvesting

a. ***Freshwater Fish:*** Depending on the size and kind of fish, various fishing equipment is used to harvest fish seed. Large-scale egg collecting is only possible if the breeding grounds' locations are known and easily accessible. Eggs are gathered from one to two feet deep water by disturbing the bottom and

scooping them using a 'gamcha,' which is a rectangular spawn collecting net. Large-scale egg collecting is not commonly undertaken in rivers. Commercial collection of spawn (up to 8 mm) is most common in Bihar, West Bengal, and Uttar Pradesh. Fry (8-40 mm) and fingerlings (40-150 mm) are often collected using cast and drag nets. Fry and fingerling gathering, a source of fish seed, is common along the Indus River system in Punjab State. The most common 'shooting net' gears are used for spawn collecting, which is funnel-shaped nets made of tightly woven netting.

b. ***Marine Water Fish:*** Traditional techniques of collecting marine finfish fish seeds in the country's coastal regions rely on tide patterns. Seed collecting is divided into two basic techniques based on location. During low tide, scoop nets are used to collect fish seeds from the mangroves' water pools. Fish seeds are also gathered using drag nets or seine nets in backwaters and seashore regions. During high tide, pole-mounted nets are deployed along the estuary's perimeter. The fish seeds are collected in a net during low tide, and the fisherman collect them when the water recedes more. Seed collection is mostly done from March to May for Asian seabass, March to July for milkfish, and all year for mullet. Asian sea bass and milk fish seed collecting is being carried out on a large scale. Normally, catches seeds are less than 2 cm in size and are stored individually in hapas or dispersed immediately into a pond (1-2 acres). The epiphytic algae and zooplankters that grow there provide food for both milkfish and seabass. Milk fish are typically marketed at a size of 3-5 cm; however, seabass is raised to a much larger size. In addition to finfish seed, mud crab and prawn seed collecting is thriving in coastal regions, and the majority of village households are actively participating in fish seed collection as a part-time profession.

List of Important Gear Using for Fish Seed Collection

1. **Scooping nets:** These are simple nets with a frame and handle, used for collecting fish fry from shallow waters.

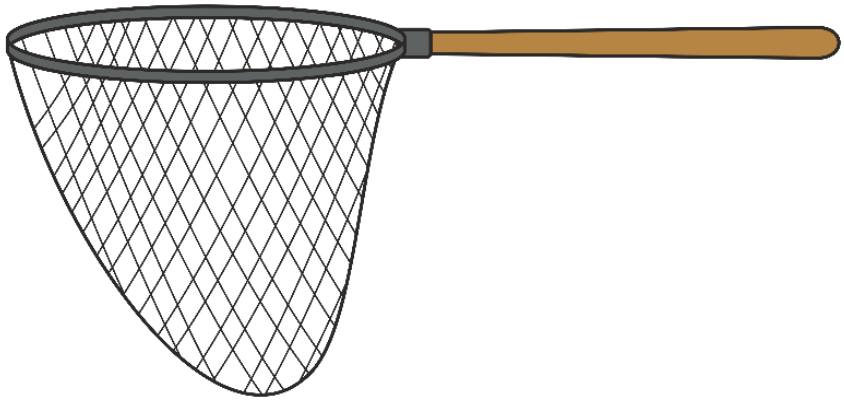


Fig. 3.1: Scooping nets

2. **Cast nets:** These nets are thrown out from a boat or the bank, and the catch is retrieved by pulling the net closed.

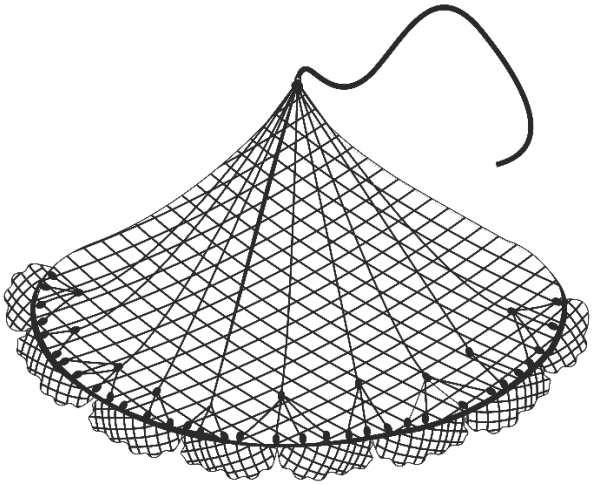


Fig. 3.2: Cast net

3. **Trammel nets:** These are a type of entangling net that can be used for catching fry.

Fig. 3.3: Trammel net

4. **Trawls:** These are the active fishing gears. Trawls are cone-shaped nets towed through the water, capable of capturing a variety of fish. Small trawls are used to catch fish in deeper waters.

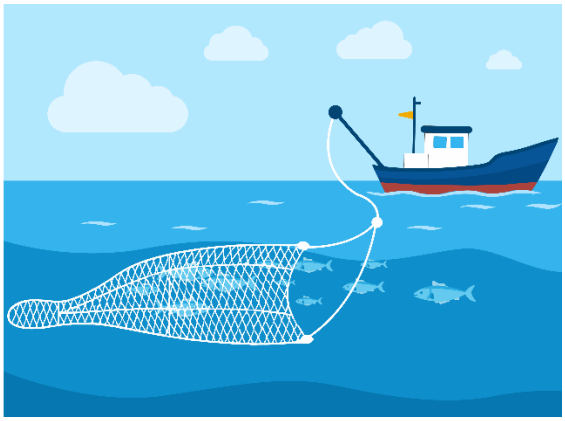


Fig. 3.4: Trawl

5. **Purse seines:** These nets are designed to surround a shoal of fish and then purse the net to prevent escape.

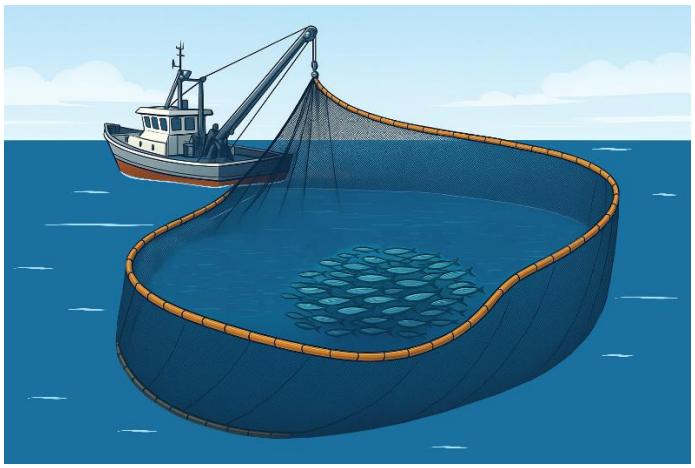


Fig. 3.5: Purse seine

6. **Gill nets:** Gill nets are passive nets that are set in the water, with fish getting caught when they swim into the mesh.

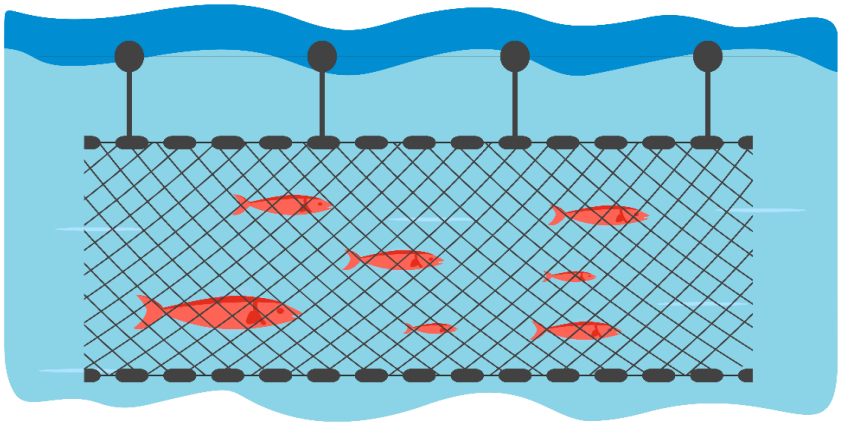


Fig. 3.6: Gill net

7. **Selective fishing:** Some gears are more selective than others, meaning they are designed to catch specific sizes or species of fish.
8. **Passive vs. active gears:** Passive gears like gill nets rely on fish moving into them, while active gears like trawls are towed through the water.
9. **Grading and lifting:** In some cases, fish seed is harvested using mechanized graders and lifting devices to separate and move fish from the water.

Fish seed packaging

Fish seed packaging is essential for successful aquaculture because it ensures that fish seed be safely and efficiently transported from hatcheries to fish farms. Fish seed is fragile and susceptible to environmental changes; thus, suitable packaging practices are critical for keeping its health and vitality. Choosing the right fish seed packing technology is critical for minimizing loss and preserving

quality. The purpose of packing is to maintain water quality, decrease stress, and increase survival rates throughout transport. Different packing methods are utilized depending on the kind and size of the fish seed, the distance to be travelled, the manner of transportation, and the duration of the journey. Continued packaging innovation will help the aquaculture business develop and remain sustainable.

Types of Packaging Techniques

1. ***Oxygenated polythene bag packaging:*** Oxygenated polythene bag packaging system also known as closed system. This is the most common strategy, particularly for long-distance transportation. Fish seed is packed in clean water inside polythene bags, which are then supplied with oxygen (1:2, water and oxygen ratio), carefully sealed, and stored in cartons or insulated boxes. This system ideal for fry and fingerlings of the fish species. This packaging system offers several advantages such as lightweight, cost-effective, and easily transportable by both air and road.

Fig. 3.7: Oxygenated polythene bag packaging

2. ***Open tank or container packaging:*** This packaging system is also known as open system transportation. Fish seed is transported in water-filled tanks, tubs, or containers over short distances. Continuous aeration is supplied through air pumps or mechanical aerators. This method is not ideal for long distance due to the water quality degrades fast. This packaging system's key advantage is that it allows for monitoring during transportation.

Fig. 3.8: Open tank or container packaging (Traditional)

3. ***Rigid container packaging with oxygen supply:*** Large, sealed containers (plastic or fiberglass) are used with an integrated oxygen or air delivery system. These are commonly placed to vehicles for bulk transportation. The key benefits are durability, reusability, and suitability for high volumes. This technique is regularly used for commercial hatchery-to-farm transportation.
4. ***Thermocoal box packaging:*** Polythene bags carrying fish seed and oxygen are placed in thermocoal boxes to keep the temperature consistent to secure against environmental heat. The main role of this packaging system is to relieve heat stress during the summer months fish seed transportation.

Fig. 3.9: Thermocoal box packaging

Practical Activity

Activity – Identification of different types of gears

Material required: Pen, notebook, camera, practical files etc.

Procedure

1. Visits nearby fish harvesting centre and note down following observation:
   - Name of gears
   - Operation of gears
   - Management of gears

2. If any query, please discuss with the centre owner.

Check Your Progress

Fill in the Blanks

1. Fish seed refers to the young developmental stages of fish, specifically used as the starting material for _____.

2. _____ of fish seed is the process of collecting young fish (spawn, fry, or fingerlings) for stocking into ponds.
3. Spawn refers to fish seed up to _____ days old and measuring up to 8 mm.
4. Fish fry are typically _____ to 40 mm in length.
5. _____ nets are used to collect fish seeds from mangroves' water pools during low tide.
6. In oxygenated polythene bag packaging, the water and oxygen ratio is _____.

Multiple Choice Questions

1. What stage of fish seed is usually 60-90 days old?
    a. Fry
    b. Fingerlings
    c. Spawn
    d. Larvae
2. Which net is commonly used in the backwaters and seashore regions for marine seed collection?
    a. Drag net
    b. Shooting net
    c. Cast net
    d. Scoop net
3. Fish seeds are typically less than _____ cm in size during marine collection.
    a. 5
    b. 4
    c. 3
    d. 2
4. The most common packaging system for long-distance fish seed transportation is:
    a. Rigid containers
    b. Thermocoal box
    c. Oxygenated polythene bags
    d. Open tanks
5. The packaging method that allows for easy monitoring during transport is:

a. Oxygenated bag packaging
b. Open tank packaging
c. Thermocoal box packaging
d. Rigid container packaging

Match the column

S. No.	Column A	Column B
1.	Open tank	Passive netting
2.	Thermocoal box packaging	Active fishing gears
3.	Gill nets	Container packaging
4.	Trawls	Polythene bags

Subjective Questions

1. What do you mean by fish seed, harvesting and packaging of fish seed?
2. Discuss about the gears used for the fish seeds harvesting.
3. Discuss about the different packaging techniques

Session 2: Fish Seed Marketing and Transportation

Fish seed marketing and transportation are essential components of the aquaculture business, with considerable benefits for food security, rural employment, and economic growth. Fish seed, which consists of fry, fingerlings, or juveniles, is used to stock ponds, tanks, and other water bodies for fish farming. The effective distribution of healthy, stress-free seed has a direct impact on aquaculture production and success. Fish seed marketing includes selling and distributing fish seed to farmers and cooperatives via government and commercial hatcheries. It works through a variety of channels, including seed growers, wholesalers, retailers, and, in certain cases, middlemen. The need for fish seed is determined by species preferences, seasonal patterns, and regional habits.

Indian major carps (*Catla catla, Labeo rohita and Cirrhinus mrigala*), exotic major carps (*Hypophthalmichthys molitrix Ctenopharyngodon idella and Cyprinus carpio*), catfishes (Magur *Clarias magur*, Singhi *Heteropneustes fossilis* and Pangasius *Pangasius pangasius*) and shellfishes (prawns such as *Macrobrachium rosenbergii* and shrimps such as *Penaeus monodon*) are some of the most commonly sold species through transportation. Accurate demand forecasting, reasonable pricing, and clear communication are necessary for successful marketing; they are frequently aided by digital platforms or extension services. Transporting live fish seed requires extreme care due to its delicate nature; this careful handling is crucial for its survival. High survival rates depend on proper pre-transport conditioning, which includes stress control and packing. To avoid the mortality in the transportation, the maintain ideal water quality, oxygen levels, and temperature are the main management practices. The efficiency of transportation is being improved by contemporary developments like climate-controlled containers and mobile delivery units. However, there are many different types of marketing systems, ranging from unofficial local networks to legal cooperatives and syndicates. Their efficiency guarantees on-time delivery, quality control, and lower losses, which makes ongoing public-private sector collaboration and development essential to the industry's viability and growth.

Fish Seed Markets

Fish seed markets are primarily to the aquaculture industry and supplying fish farms with the juvenile fish essential for their production and growth. These marketplaces may be found in a variety of locations, including waterways, hatcheries, and specialized trade sites. These markets exist in a variety of locales and are driven by factors such as demand, supply, quality, price, and supply chain efficiency. West Bengal's Naihati is a well-known fish seed market that supports producers, buyers, and dealers and is essential to the region's aquaculture sector.

Types of fish seed markets

- **Riverine Sources:** Fish seed has traditionally been collected from rivers, a laborious process that might produce a mixture of good and unwanted fish.
- **Hatcheries:** Many hatcheries now produce huge amounts of carp seed, making them a more regulated and effective source of fish seed.
- **Specialized Markets:** A specialized fish seed market refers to a segment of the aquaculture industry focused on the production and distribution of specific types of fish seeds that cater to particular farming needs, environmental conditions, or consumer demands such as Naihati.

Factors affecting to the fish seed markets

- **Demand:** The demand for fish seed varies depending on the season and the type of fish being cultivated.
- **Supply:** The availability of fish seed is impacted by various factors such as weather, water quality, and the number of licensed seed sellers.
- **Quality:** Fish seed quality, which encompasses both genetic and non-genetic factors, is essential for aquaculture success.
- **Pricing:** Depending on the type, size, and quality of the seed, fish seed costs might differ.
- **Supply Chain:** The timely delivery of high-quality seeds to farmers depends on the effectiveness of the fish seed supply chain.

Different Marketing Channels

Marketing channels refer to the methods organizations use to communicate with their target audience and to promote or distribute their products or services. These channels can be categorized into two types:

- **Channel 1**: In this channel, fish seed is marketed directly from the producer to the consumer.

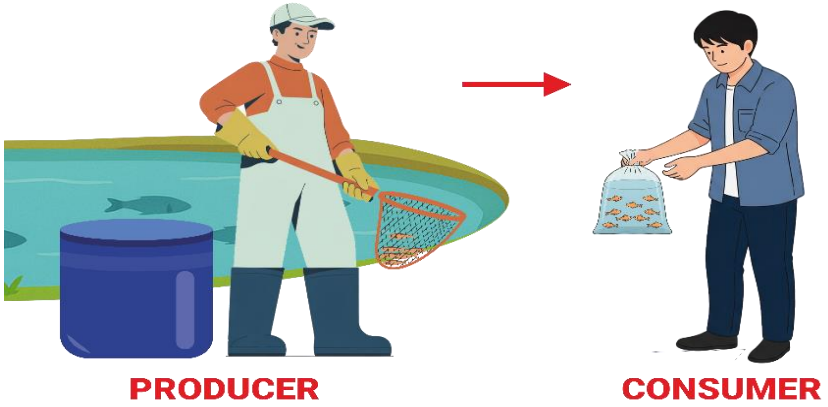


Fig. 3.10: Channel 1 (Producer – Consumer)

- **Channel 2**: In this channel, fish seed is marketed through three steps — the producer sells the fish seed to the consumer through Mediator.

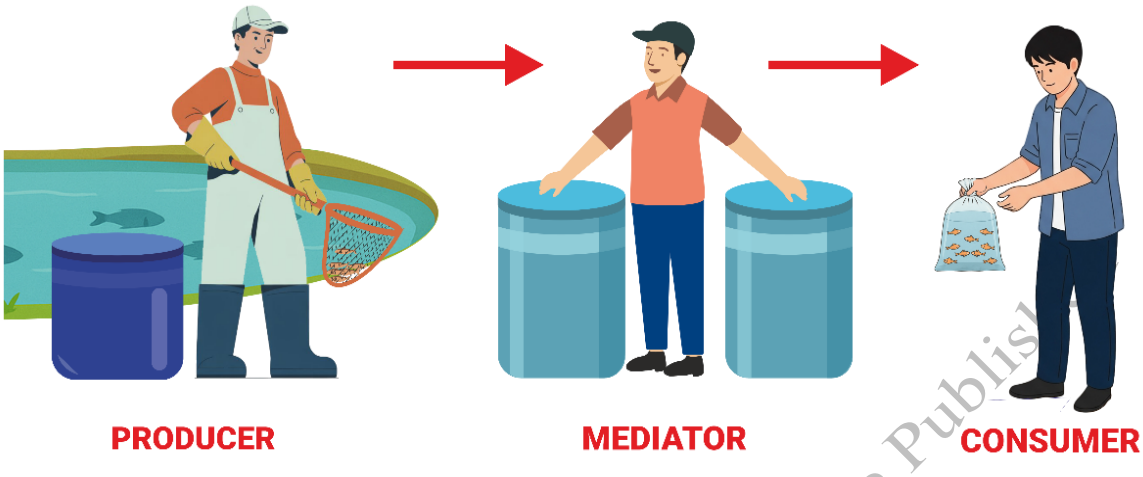


Fig. 3.11: Channel 2 (Producer – Mediator- Consumer)

Each channel has its own strengths and limitations, catering to varying audience behaviours and preferences.

Transportation of Fish Seed

Transporting of fish seed is an important part of aquaculture, since it directly affects the survival, development, and overall success of fish farming operations. Fish seed, usually in the form of fry, fingerlings, or juveniles, must be supplied from hatcheries to farms in a healthy and stress-free environment. Effective transportation ensures that excellent seed reaches farmers on time, preserving viability and lowering death rates. Pre-transport training is critical for reducing stress and increasing survival. This involves fasting the fish for a minimum 24 hours before to packing, using clean, oxygen-rich water, and occasionally administering sedatives or salt to reduce handling shock. During transportation, factors like as oxygen saturation, carbon dioxide levels, and temperature must be carefully monitored, especially on longer journey when delays or temperature variations might result in significant mortality. To transport fish seeds successfully, good planning, management, and infrastructure are required. It is critical to the aquaculture value chain because it ensures that healthy seed is delivered to farmers on time and safely. Reducing fish seed mortality during transportation not only boosts output, but it also improves the aquaculture industry's sustainability and profitability.

Division based on transportation facility

1. **Open system of fish seed transportation:** The open system of fish seed transportation is one of the most frequent techniques for moving fish seed over short distances, particularly in rural and semi-urban aquaculture environments. This approach involves transporting fish seed in open containers such as aluminium, plastic, or fiberglass tanks mounted on trucks, boats, or

carts. To keep the fish alive during travel, the water in these containers is refilled or aerated on a regular basis. This technique is commonly used to transport hardy species like as Rohu, Catla, and Tilapia for short periods of time (less than 6 h), as it provides direct access to the water for monitoring and modifications. Fish seed transportation via the open system is a cost-effective and useful option for short-distance deliveries. To preserve the quality of the water and reduce mortality while in transportation, it has to be handled carefully and closely monitored.

Major benefits

- Use of short distances perfect for distribution locally in adjacent fish farming regions.
- Real-time monitoring simplifies the observation and adjustment of fish behavior and water conditions
- Aeration must be maintained by the use of air compressors, mechanical aerators, or manual techniques.
- Low price comparatively cheap since it requires less equipment.

2. ***Close* system of fish seed transportation:** Traditional fish transportation often exposes fish to environmental changes, pollution, and physical stress, leading to high mortality and disease. To address these issues, the closed system of fish seed transportation has evolved as a contemporary, efficient, and bio-secure option. A closed transport system is a self-contained unit in which water and ambient conditions are meticulously maintained and totally separated from the surrounding environment during the transport process. To keep fish seed in optimal conditions, these systems often employ insulated containers, oxygen-rich environments, and temperature management. This approach improves fish longevity by reducing water exchange and limiting exposure to diseases and contaminants. The significance of closed systems has grown with the rise of aquaculture, particularly when shipping high-value or fragile species across long distances. Furthermore, with growing concerns about biosecurity, environmental protection, and sustainable aquaculture methods, closed systems offer a dependable option that adheres to legal and ecological norms. The closed system of fish seed transportation is critical for improving fish seed quality, increasing farm performance, and ensuring the aquaculture industry's long-term viability. Closed systems are particularly effective for transporting delicate fish species and are ideal for long-distance journeys. Closed fish seed transport systems provide a dependable, environmentally sustainable, and secure approach to moving fish seed. When effectively designed and carefully monitored, these systems greatly contribute to the success of aquaculture by preserving the health and survival of the transported stock.

Major components

- Fish are transported in oxygenated plastic bags or insulated, leakproof vessels that preserve internal conditions.
- Fish survival-appropriate dissolved oxygen levels are maintained using compressed oxygen cylinders or air pumps with diffusers.
- The proper temperature may be maintained with ice packs or refrigerated units, which lowers fish metabolism and lessens stress.
- Ammonia binders, pre-treated water, and occasionally activated carbon are used to maintain ideal water characteristics.
- There is less chance of disease transmission since there is no water interaction between the environment and the transport container.
- Maintains ideal circumstances while reducing stress and mortality.
- Stops the transfer of diseases and parasites between locations.
- There is no release of potentially tainted water into natural environments

Division based on stage of Fish

1. **Transportation of brooders fish:** Transporting brooder fish, also known as broodstock, involves moving mature, sexually active fish intended for breeding purposes. Unlike the smaller and more delicate fish seeds, broodstock are larger, heavier, and can experience significant stress if not handled correctly. The primary objective is to minimize physiological stress and physical injury to preserve their reproductive health and viability. Key considerations include:
    - Broodstock are often fasted for 24-48 hours before transport to reduce waste production, which can foul water quality.
    - Transport tanks or specialized bags are filled with high-quality water, often enriched with oxygen. Parameters like temperature, pH, and dissolved oxygen are carefully monitored and maintained to prevent metabolic stress. Buffers may be added to stabilize pH, and sometimes mild sedatives are used to calm the fish.
    - Gentle netting and transfer techniques are crucial to avoid scales loss, fin damage, or internal injuries. Fish are typically moved in darkness or low light to reduce agitation.
    - Stocking density is carefully managed to prevent overcrowding, which increases stress and waste accumulation.

- Transport containers are well-insulated to maintain stable temperatures, and robust aeration or oxygenation systems are essential for longer journeys.

2. **Transportation of spawn fish seeds:** Transporting spawn, which represents the earliest and most delicate larval stage of fish seeds, requires extreme care to ensure high survival rates. These newly hatched fish are typically very small, often planktonic, and highly susceptible to environmental fluctuations and physical shock. The paramount concern during spawn transportation is maintaining pristine water quality and stability. This involves:

- Due to their fragile nature, spawn must be handled with utmost gentleness, avoiding any sudden movements, jarring, or excessive agitation during transfer.
- Maintaining high levels of dissolved oxygen is critical, often achieved through sealed bags with pure oxygen overlay, or very gentle aeration for larger volumes.
- Even minor temperature fluctuations can be lethal. Insulated containers are essential, and sometimes temperature-controlled environments are used for longer hauls.
- Spawn are transported at significantly lower densities than fry or fingerlings to reduce oxygen demand and minimize the accumulation of metabolic waste products, which they are highly sensitive to.
- Unlike larger fish, spawn may not be fasted for extended periods, or if they are, it's for a very short duration immediately prior to transport, as they have limited energy reserves.

Uses of the digital services in fish seed marketing

Digital services are revolutionizing the aquaculture sector by improving transparency, efficiency, and connection between suppliers, hatcheries, and fish farmers through the distribution of fish seeds. Historically, the selling of fish seeds was mostly dependent on local networks, middlemen, and manual processes; this frequently resulted in delays, restricted access to high-quality seed, and higher prices. Nowadays, the procedure is becoming more accessible and structured thanks to internet platforms. Online markets, mobile applications, and websites allow for the real-time display of species information, seed availability, costs, and delivery choices. In order to assure fair pricing and improved access to a variety of seed alternatives, farmers may now use their cell-phones to browse listings, compare offers, and place orders-reducing their reliance on middlemen. Farmers are kept updated on seed quality, stocking times, and transportation schedules by means of communication systems such as WhatsApp groups, and specialized

applications. By ensuring that fish seed is distributed in ideal circumstances and increasing transparency, GPS tracking systems lower stress and death rates. Secure cashless transactions are made possible by digital payment mechanisms like UPI and mobile wallets, which encourage financial inclusion, especially for small-scale farmers. Hatcheries can estimate demand, track trends, and improve supply chain management with the use of data analytics technologies. Through webinars, online videos, and digital extension services, digital platforms have also improved farmer training by providing advice on handling procedures, disease control, and seed selection. All things considered, the productivity, accessibility, and sustainability of aquaculture are being greatly increased by the use of digital services in fish seed marketing. The supply chain for fish seeds will become even more robust as digital use increases, bolstering the long-term growth of the sector. Customers can get product through E-commerce channels.

E-commerce is the process of buying and selling goods and services over the internet. On an e-commerce platform, customers can order goods or services from anywhere at any time, and those goods and services will be delivered to the consumer. It has various advantages, such as being easy for buyers to select a wide range of products, the right consumer can be targeted, and no physical store is required to run a business which depends completely on networking. The digital marketing of the fish seeds has become the foundation of current marketing techniques. Channels like social media platforms, email marketing, and content marketing (blogs, videos, webinars) provide focused and quantifiable outreach.

Practical Activity

Activity - Visit nearby hatchery and observe the process of packaging marketing.

Material required: Pen, notebook, camera, practical files etc.

Procedure

1. Visits of nearby fish seeds hatchery and note down following observation:
    - Identification of brooders fish
    - Precaution for packaging of fish seed
    - Packaging of fish seed
    - Transportation of fish seed
    - Observe and note down marketing channel
2. If any query, please discuss with the hatchery owner

Check Your Progress

Fill in the Blanks

1. The fish seed market of _____ in West Bengal is a major hub in the aquaculture sector.
2. Open system of fish seed transportation is suitable for _____ distance deliveries.
3. Fish are transported in closed systems using _____ containers to maintain internal conditions.
4. The use of _____ binders helps maintain water quality in closed transportation systems.

Multiple Choice Questions

1. Which of the following is not a type of fish commonly sold in fish seed marketing?
    a. Catla
    b. Rohu
    c. Hilsa
    d. Magur
2. What is the primary benefit of digital platforms in fish seed marketing?
    a. Increase cost
    b. Ensure transparency and accessibility
    c. Reduce demand
    d. Decrease farmer income
3. What is a major challenge during fish seed transportation?
    a. Oxygen saturation
    b. Packaging cost
    c. Feed availability
    d. Fertilizer usage
4. What is fasted before transport to reduce waste production?
    a. Fingerlings
    b. Spawn
    c. Broodstock
    d. Hatchlings
5. The open system of transportation is best suited for:

a. Long-distance journeys

b. Air travel

c. Export fish

d. Short-distance deliveries

Subjective Questions

1. Describe about the open system of fish seed transportation.
2. Describe Fish seed markets and enlist various marketing channels.

Module 4
Health, Hygiene and Safety Procedures

Module Overview

Aquaculture, which involves the farming of aquatic organisms such as fish, molluscs, crustaceans, and aquatic plants, is the world's fastest-growing food-producing sector. As in other sectors, proficient labour is essential for fish farming, influencing production efficiency, sustainability, and overall performance. Fish farm workers, ranging from fundamental jobs to specialised positions, are tasked with many responsibilities, including fish breeding, feeding, water quality management, disease control, and equipment maintenance. Despite the rapid growth, there is still an overall lack of policies and regulations in the aquaculture sectors. There has been little attention to the occupational health and safety hazards/risks faced by fish farm workers, particularly in low- and middle-income nations.

This module emphasizes the importance of maintaining health, hygiene, and safety standards in fish seed production and nursery management. In Session 1, students will learn about Safety Protocols and Safe Handling of Equipment, including the correct use of tools, protective measures to prevent accidents, and good hygiene practices to ensure both worker and fish health. Session 2 focuses on Emergency Procedures and Disposing of Dead Fish, covering first aid responses, handling of hazardous situations, and safe, environmentally friendly methods of disposing of dead fish to prevent disease outbreaks and maintain a healthy nursery environment.

Learning Outcomes

After completing this module, you will be able to:

- Apply safety protocols and demonstrate the safe handling of equipment used in fish seed production.
- Describe emergency procedures and explain proper methods for disposing of dead fish to prevent disease outbreaks.

Module Structure

Session 1: Safety Protocols and Safe Handling of Equipment

Session 2: Emergency Procedure and Disposing of Dead Fish

Session 1: Safety Protocols and Safe Handling of Equipment

Hazard: Hazards are typically defined as sources of possible damage, harm, or negative health impacts to individuals or entities.

Risk: Risk involves a combination of probability and consequence, specifically regarding adverse outcomes (injury, mortality, disease) resulting from exposure to the hazard.

Common hazards in agriculture

In agriculture and livestock practices, several types of hazards may be present. These include:

- Mechanical hazards due to fall, slipping, heavy machinery, and moving parts of machinery resulting in entanglement, crushing, pull-in, and burn injuries.
- Occupancy of confined spaces such as grain bins and silos resulting in suffocation and engulfment.
- Chemical hazards due to pesticides and toxic vapour exposure through oral, skin, eye, and nasal routes resulting in irritation, vomiting, diarrhoea, and death in extreme cases.
- Ergonomic hazards due to repetitive motion and physically demanding work resulting in injuries and adverse long-term health effects.
- Environment-related hazards due to prolonged exposure to extreme heat, cold, and sunlight resulting in sickness, sunburn, etc.
- Biological hazards such as poisonous insects, snakes, allergens, and pathogens.

Hazards and risks in fish farm

Besides the physical safety and chemical hazards, the farmworker may also have the risk of zoonotic diseases from untreated water and sick or apparently healthy fish (Table 1). Inadequate biosecurity measures may not only result in production loss due to frequent infectious disease outbreaks in fish farms but also put the health of fish farm workers and consumers at risk. Thus, risk assessment and management as well as the establishment of standard operating procedures (SOPs) are important parts of a farmworker's responsibilities. Besides, the fish farm worker should also have the knowledge of the removal and proper disposal of moribund/dead fishes. This unit comprehensively covers the various risks and required remedial measures for successful fish farming.

Table 1: Various types of Hazards in Fish Farming

Safety & Physical	Chemical	Biological
• Slips, trips and fall • Unprotected machinery and electricity • Confined spaces • Heat, cold and sun exposure • Heavy lifting and overexertion	• Exposure to harmful pesticides and insecticides • Exposure to skin irritants, antibiotics and toxic gases	• Spines and allergens • Poisonous insects and snakes • Pathogenic microbes and zoonotic diseases

General cleanliness and safety procedures to be followed in fish farm

In fish farming, maintaining cleanliness and safety is crucial for protecting fish health, preventing disease outbreaks, ensuring the production of high-quality food, and mitigating the health risks for farm workers. This involves regular cleaning, disinfection, biosecurity measures, and safe handling practices. The general activities should include the following:

- Uncontrolled growth of shrubs and weeds in and around the fish farm should be controlled to avoid infestation with rodents and snakes. Floating, submerged, and emergent aquatic weeds hamper the primary productivity and promote the growth of pathogenic microbes and parasites in the water.
- Tanks and equipment must be routinely cleaned to eliminate organic debris and avert the accumulation of biofilms that may host pathogenic microbes.
- All the farm areas should be properly labelled. Broodstock, seed, feed, and medicine areas should be marked with restricted entry. Harmful chemicals/pesticides/insecticides should be appropriately labelled with access control. Updated safety data sheets (SDS) for all hazardous substances should be kept.
- The farm area should have proper lighting arrangements with non-slip surfaces. Use of barriers or railings around high-risk open water or other areas can also be followed.
- The electric equipment and wiring should be routinely checked for any defect. Special attention should be paid to aerators, feeders, and water quality monitors installed in the pond water (Fig. 4.1).
- First aid kits and fire extinguishers at the key locations should be installed. Emergency response plans should be established and practiced.

- Throughout the farm, safe lifting techniques should be enforced with the use of mechanical aids to prevent physical strain injuries.

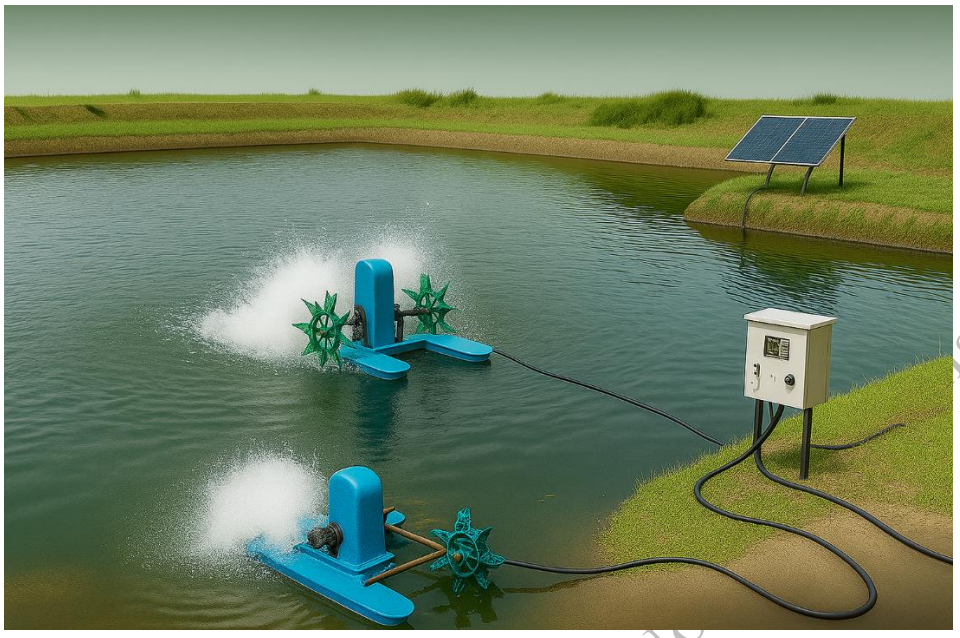


Fig. 4.1: A well-managed aquaculture farm with properly installed aerators

Safe use of chemicals in fish farm

Various types of chemicals are used in fish farms. For example, herbicides, insecticides, pesticides, and piscicides are used during pond preparation to remove unwanted herbs, insects, and weed fishes. Potassium permanganate and bleaching powder (calcium hypochlorite) are used during routine disinfection and sanitation operations on the farm. Improper handling of chemicals in fish farm may have adverse effects on human health, such as irritation, dizziness, vomiting, and diarrhoea. Long-term exposure to toxic chemicals can cause severe damage to body organs and increase the risk of cancer. Thus, the following precautions are recommended for safe use of chemicals in the fish farm.

- As far as possible, potentially harmful chemicals must be purchased from a licensed supplier with a valid bill.
- Bulk purchasing and storing in the premises should be avoided. One should purchase only the quantity for one-time use in the required area.
- During transportation, harmful chemicals must not be carried along with fish feed and other eatables.
- Harmful chemicals must be stored in a safe area, away from the reach of the children.
- The safety warning and label information should be carefully studied to understand the risks (Fig. 4.2).

- During application, the farmworkers should wear appropriate personal protective equipment (PPE).
- Any equipment or buckets used for chemical spray should be thoroughly washed with clean water.
- Persons handling toxic chemicals should follow personal hygiene measures such as hand washing, showering, cleaning of nails, washing of contaminated clothes, etc.
- All chemicals should be used only as per the recommended dose.
- Any leftover chemical, after application, should not be discarded near the water source.
- The empty chemical containers should not be used for storing other items. The container should be disposed of as per instructions on the label.
- In case of unintentional exposure to a toxic chemical, one should immediately take the applicable first aid and contact the qualified health professional, if needed.

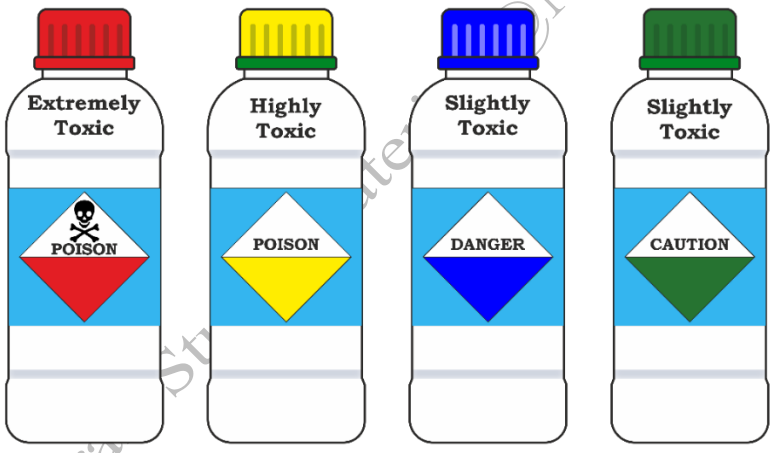


Fig. 4.2: Toxicity labels on pesticide containers

Protective equipment for farm worker

Working in a fish farm can pose significant health and safety risks to farm workers if proper precautionary measures are not taken. Thus, the following safety measures should be followed to mitigate the safety and disease risks:

- The workers should wear comfortable one-piece or two-piece clothing for farm operations.
- Fish farm workers must wear personal protective equipment (PPE) as needed (Fig. 4.3). Important PPE are:
    - **Safety goggles** – eye protection from splash and debris
    - **Respirators** – protection against hazardous chemicals

- **Gloves** – High quality gloves for chemical, injury, and pathogen protection
- **Boots** – Protection from slip and cut injuries
- **Hard hats** – Head injury and extreme sunlight protection
- **Life vests** – Essential while working near high water depth areas

Fig. 4.3: Common PPE required for farm workers

- Utmost care should be taken to maintain personal hygiene while working in a fish farm. Proper sanitary practices help to minimise the infectious disease risks to aquatic animals and farm workers.
- The farmworkers should have basic knowledge of zoonotic diseases and their impact on health.
- Hand wash stations with antiseptic soap/gel should be available at various locations throughout the farm.
- Regular health check-ups of farm workers are advisable, and vaccination should be promoted wherever required.

Disinfection and disposal of tools and equipment

In aquaculture farms, disinfecting equipment is essential to preserving biosecurity and stopping the spread of illnesses. To get rid of germs, surfaces,

water, and equipment must be cleaned and disinfected. Common techniques include physical techniques like ultraviolet irradiation or chemical disinfectants like hydrogen peroxide or chlorine. If not cleaned properly, submerged surfaces and routinely used tools in fish farming may have depositions of organic matter and microbes. Such formations of organic matter and microbes on inanimate surfaces are called biofilms. In biofilm, bacterial cells are held together by layers of organic extracellular polymeric substances. Biofilm may harbour and promote the growth of potentially pathogenic bacteria. Microbes in biofilms are very difficult to destroy, as biofilms offer protection against chemicals, antibiotics, desiccation, and environmental conditions. Thus, physical scrubbing followed by disinfection should be an important part of a farm's routine biosecurity programme.

The selection of disinfection methods is contingent upon the dimensions, classification, and characteristics of the materials and facilities requiring disinfection, as well as the disinfectants legally available. Surfaces requiring disinfection may encompass fabrics (apparel, nets), rigid substrates (plastic, concrete), or porous materials (soil, gravel). Disinfection is more challenging on permeable surfaces and necessitates additional time.

The general cleaning and disinfection process should consist of at least the following steps:

i. Scrubbing and removal of visible solid waste

ii. Deep cleaning with scrubbing and detergent (if required) and washing

iii. Application of appropriate disinfectant at prescribed concentration for recommended duration

iv. Rinsing with clean water and drying

During the cleaning and disinfection, required PPE must be worn by the worker. Besides, monitoring of the entire process and record keeping by a technically qualified person are also essential.

General guidelines for cleaning and disinfection in fish farm

i. All equipment required for feeding, cleaning, and the disposal of deceased aquatic organisms must be distinct for each culture unit. Unless absolutely needed, equipment and tools from one farm unit should not be used in another farm unit. The equipment used in another farm unit must be washed and disinfected before reentry.

ii. Different types of nets of varying mesh size are often used in fish farms. After use, all nets should be invariably washed and dried. Previously used and unwashed nets should never be reused in another facility (tank, pond, etc.) before cleaning.

iii. All pipes and tanks must be routinely cleaned and disinfected. Before each seed production cycle, all broodstock maturation, spawning, larval rearing, and indoor nursery tanks should be thoroughly cleaned.

iv. All corrosion-resistant and non-porous materials like air stones, air pipes, screens, and sampling containers must be soaked overnight in calcium hypochlorite solution (200 ppm free chlorine) followed by rinsing with clean water the next day.

v. After initial cleaning to remove loose debris, large tanks should be sprayed with concentrated calcium hypochlorite solution (~1,600 ppm free chlorine) and allowed to stand for several hours before rinsing with clean water.

Disinfection of source and effluent water

Disinfection of water being used in fish farm (source water) and wastewater generated by the farm (effluent water) is required to maintain an optimum level of biosecurity. The disinfection plan may vary depending upon the water source. For example, underground borewell water may not require any disinfection before use in aquaculture facility. In the case of community water resources (lake, river, etc.), source water should be filtered with coarse bar screens and fine mesh of 150-250 µm mesh size before pumping into the storage reservoir. In a storage reservoir, water should be disinfected with 20-50 ppm free chlorine for 12-24 h. After treatment, the water should be dechlorinated to remove the free chlorination. Vigorous aeration and sunlight help in effective dechlorination. Ozone filters and UV can also be used for the disinfection of source water. For treatment of effluent water, a free chlorine concentration of 25-50 ppm is recommended. However, higher concentrations may also be used depending upon the pathogen risk in the effluent water.

Biosecurity

Biosecurity is a sets of practices that will reduce the probability of a pathogen introduction and its subsequent spread from one place to another. Besides preventing the entry of infectious pathogens into the farm, biosecurity measures also minimize the risk of infectious pathogen being carried by farm worker to susceptible individuals. Physical, chemical, and biological methods to prevent the spread of infectious pathogens are important components of biosecurity programme (Fig. 4.4 and 4.5).

Fig. 4.4: Common biosecurity practices to followed in a fish farm

Dog fencing

Tyre wash

Footbath

Handwash

Fig. 4.5: Typical components of biosecurity infrastructure in a fish farm

Practical Activity

Activity -Identification of the items of a First Aid Kit

Materials required:

Pen, pencil, notebook, First Aid Kit

Procedure:

1. Open the first aid kit and observe all the items inside.
2. Identify and list each item found in the kit.
3. Group the items into categories:
   - Bandages, gauze, adhesive tape.
   - Pain relievers, antiseptics, ointments.
   - Scissors, tweezers, thermometer.
   - CPR mask, first-aid manual, gloves.
4. For each item, note its purpose and how it should be used in an emergency.

Check Your Progress

Fill in the Blanks

1. _____ are typically defined as sources of possible damage, harm, or negative health impacts to individuals or entities.
2. Exposure to _____ in confined spaces like silos can result in suffocation and engulfment.
3. Biofilms are formed by bacterial cells held together by layers of organic _____ substances.
4. Pathogens and zoonotic diseases in fish farms can spread due to inadequate _____ measures.
5. The source water from lakes and rivers should be filtered with mesh size of _____ microns before use.

Multiple Choice Questions

1. Which of the following is a mechanical hazard in agriculture?
   a. Sunburn
   b. Pesticide exposure
   c. Slipping on wet floors
   d. Snakebite
2. Which one of the following is a biological hazard in fish farms?

a. Pathogenic microbes
b. Antibiotics
c. Toxic gases
d. Heat exposure

3. Which of these PPEs is used to protect the eyes from splash and debris?
   a. Boots
   b. Gloves
   c. Respirators
   d. Safety goggles
4. What chemical is commonly used for disinfection in aquaculture farms?
   a. Ammonium nitrate
   b. Calcium hypochlorite
   c. Ethanol
   d. Potash alum
5. Which disease risk can occur from untreated water in fish farming?
   a. Zoonotic diseases
   b. Mechanical injury
   c. Nutritional deficiency
   d. Oxygen toxicity
6. What is the recommended disinfectant concentration for soaking nets overnight?
   a. 50 ppm
   b. 100 ppm
   c. 500 ppm
   d. 200 ppm

Subjective Questions

1. What protective equipment and its importance used by farm workers.
2. What safety precautions should be followed for the safe use of chemicals?
3. Describe the process of disinfection and disposal of tools and equipment in fish farms?

Session 2: Emergency Procedure and Disposing of Dead Fish

Chemical poisoning and first aid measures

Poisoning is the lethal disruption of the body's physiological mechanisms by the consumption/inhalation, ingestion, injection or surface absorption, etc. of toxic chemicals. Immediate first aid measures are very important in these kinds of emergencies. Sources of poison may include insecticides, pesticides, fungicides, herbicides, etc. It can be diagnosed by blood test, Urine test, and also by physical examination of the sufferer.

Chemical poisoning may result from continuous contact or absorption through skin, inhalation of toxic vapour or swallowing it directly. Common symptoms of pesticide poisoning are headache, nausea, vomiting, tremors, convulsions, and difficulty in respiration. A first-aid kit with necessary antidotes should be available at the work site for each type of poisoning. Antidotes are always mentioned on the pesticide containers.

Standard procedures to deal with accidents and emergencies

Standard procedures to deal with accidents and emergencies include preventive measures, immediate response, and ongoing safety protocols. The following are the important components of safety procedures and emergency response.

- Risk assessment for identification of potential hazards such as disease outbreaks, environmental changes, chemical spillage, equipment malfunction, etc.
- Once the hazards have been identified, an emergency response plan must be devised with well-defined roles and responsibilities for each team member.
- In case of accidents, the immediate response should be
    - Prioritize the safety of all affected persons and animals
    - Secure the area to prevent further injury or damage
    - Provide first aid and seek the further medical help, if necessary
    - Notify the authorities
- A root cause study should be conducted to avoid the further recurrence of the accident.
- Conduct frequent training for all personnel regarding safety measures, emergency procedures, and appropriate equipment usage.

First aid kit and measures

Despite following the SOPs and taking the required precautions, accidental injuries may occur in a fish farm. Thus, every farm should have well-stocked first

aid kits at easily accessible locations. Some of the basic components of first aid kits are gloves, antiseptics, gauges, dressings, tourniquets, and eyewash (Fig. 4.6). Depending upon the location and anticipated risks, antidotes against venomous insects and snake bites could also be part of the first aid kit. Besides, the farmworkers should be well-trained in first aid measures in case of cuts and bleeding, burn injuries, fractures, eye injuries, snake bites, etc.

- In case of minor cuts, lacerations, and abrasions, the irrigation bottles containing purified water should be used to flush and clean the injury site, followed by the application of antiseptics and a bandage.
- In the event of severe injuries like crushed or amputated limbs, the immediate focus should be on the prevention of blood loss through the application of direct pressure and specialized tourniquet. If a tourniquet is not available, the limb can be held in an elevated posture.
- If skin gets contaminated due to chemical exposure, the affected areas should be washed with soap and water.
- In case of eye injury, plenty of clean water should be used to flush the eye repeatedly.
- Ingestion of poison could be very dangerous. In such cases, vomiting should be induced immediately. For this, a glass of warm water with mustard oil or table salt works well. Vomiting can also occur when a finger is touched internally to the throat. Continue vomiting until a clear liquid begins to emerge from the stomach.
- Unless the snake is confirmatory identified as nonvenomous by an expert, all snake bites should be treated as venomous and life-threatening. The snakebite should be gently cleaned with soap and water to prevent infection and to remove residual venom. Any tight jewellery or bands from the affected area should be removed. The patient should remain calm and must avoid unnecessary movement. One should neither cut the wound nor try to suck out the venom. The use of a tourniquet must be avoided.
- In case heart beat stops due to electrocution, asphyxiation, or sudden heart attack, cardiopulmonary resuscitation (CPR) is an important life-saving skill. CPR should only be administered after proper training.

Fig. 4.6: first aid kit

Process of removing and disposing the dead and moribund fishes

During the culture period, fish mortality may happen due to disease outbreaks, poor water quality parameters, and sudden changes in the environmental conditions. The mortality rate may vary from nominal to very high. Sudden high mortality in a fish farm can be an environmental hazard and may also pose significant risk to biosecurity. Besides the putrefaction and foul smell, dead fish carcass also attracts dogs, birds, and other wildlife. Thus, dead fish must be disposed of properly and swiftly to reduce soil and water contamination, hence mitigating the potential of disease outbreaks and transmission. Fish farms are advised to strategies and establish disposal measures for deceased stock before such incidents arise.

1. Recycling

Reuse/recycling of dead fish is an eco-friendly option with the potential to generate some economic returns. Several useful products like fishmeal, fish silage, and fertilizers. The methods used for recycling should not be harmful to the environment. Besides, reuse/recycling may not be appropriate in case fish mortality occurs due to infectious disease outbreak.

2. Composting

During composting, organic waste is transformed into useful biological end products by microbes under aerobic conditions. Except for the spore-forming bacteria, other pathogenic microbes (viruses, bacteria, fungi, and parasites) are destroyed to a large extent during the composting. The end product of composting can be used as organic fertiliser. During composting, a distance of at least 100 meters should be maintained from the water source. The volume of fish carcass in the compost pile should not surpass one-fourth of the overall volume of the compost pile.

3. Rendering

Rendering is the process of heating the carcass under pressure to extract safe products and byproducts such as protein, meat, and fat, etc. Rendering has been used for animals for several years, and it can be a carcass disposal option immediately after mortality. Rendering of putrefied carcass should be avoided, and effluents generated during rendering should be treated with chlorination for disinfection.

4. Onsite burial

The subsurface disposal on-site burial method is a cheaper, quicker, and easy-to-execute method. It is also a preferred method to dispose of small quantities of dead fish. In case of death due to an infectious agent, burial is appropriate from a biosecurity point of view. Burial pits should be dug away from water sources and drainage. The soil of a burial pit site should be of low permeability. In the

burial pit, the carcass should be covered with a thick layer of soil followed by lime and a final cover. The integrity of the final cover on the burial pit should be maintained and inspected regularly.

5. Incineration (burning)

During incineration, the carcass is subjected to high-temperature combustion to convert it to gases and sterile ash. Open-air burning with the help of timber, straw, and other fuel additives is one of the most common methods of incineration. Gas, diesel, or electricity-powered incinerator machines are also available. The process of incineration should not create air pollution and environmental nuisance. Poor, incomplete burning of carcass may result in an unpleasant smell.

Practical Activity

Activity: Demonstrate the personal safety and biosecurity procedures being implemented in a fish farm and hatchery.

Material required: Pen, pencil, notebook, gloves, goggles, masks, earplugs, reflective vests.

Procedure:

- Visit a nearby fish farm and hatchery.
- Observe the overall cleanliness and maintenance of the fish pond.
- Note down the available personal protective equipment, first aid, fire safety, and electrical safety measures.
- Write about the biosecurity steps being taken at the fish farm.
- Demonstrate the protective measures followed at fish farm.

Check Your Progress

Fill in the Blanks

1. During burial, carcass should be covered with a layer of soil followed by a layer of _____
2. Formations of organic matter and microbes on inanimate surfaces are called _____
3. The full form of the term SOP is _____
4. _____ is the process of heating the carcass under pressure to extract safe products.
5. The _____ method is preferred to dispose of small quantities of dead fish.

Multiple Choice Questions

1. What should be done first in the event of an accident?

a. Notify the media
b. Secure the area
c. Conduct a survey
d. Wait for ambulance

2. What is used to flush eyes in case of injury?
   a. Antiseptic cream
   b. Soap and water
   c. Clean water
   d. Cotton pads
3. What is the safest method to dispose of dead fish after an infectious disease outbreak?
   a. Composting
   b. Incineration
   c. Recycling
   d. Onsite burial
4. Which of the following is not a symptom of pesticide poisoning?
   a. Vomiting
   b. Headache
   c. Fever
   d. Tremors
5. What should be used to stop blood loss in severe limb injuries?
   a. Antiseptic powder
   b. Cotton gauze
   c. Tourniquet
   d. Ice pack
6. Composting site must be at least how far from water sources?
   a. 50 meters
   b. 100 meters
   c. 25 meters
   d. 10 meters

Mark 'True' or 'False'

1. Treatment and disinfection of effluent water from a fish farm is not required.
2. Infectious agents cannot transmit from animals to humans.
3. Onsite burial is a cheaper, quicker and easy-to-execute method of carcass disposal.
4. The composting process should not be done near the water source.
5. For disinfection of source water, free chlorine can be used.

Match the Columns

A	B
1. Personal protective equipment	a) Fishmeal
2. Composting	b) Biosecurity
3. Rendering	c) Gloves
4. Recycle/Reuse	d) Heating the carcass
5. Footbath	e) Fertilizer

Crossword

			[3]C								
	[1]B		O					[4]R			Y
								Y			
[2]B			I		L			E			

Across

1. Practice of keeping the farm free from pathogen entry and spread.
2. Method of carcass disposal when death occurs due to infectious agent.

Down

1. Microbial decomposition of organic material under aerobic conditions.
2. Preparation of useful products from dead carcass.

Success Story

Success Story -1: Empowering Shrimp Farmers through Affordable Feed– The Journey of Sai Aqua Feeds

Mr. Krishnam Raju and Mr. M. Karuna Raju, B.Tech graduates from Guntur, Andhra Pradesh, established *Sai Aqua Feeds* company in 2015 in order to deal with rising shrimp feed costs for their 88-hectare shrimp farm. To lessen reliance on commercial feed, they set up a shrimp feed mill with a 2 tons per hour capacity along with feed quality control laboratory by investing ₹3.0 crores. The feed produced were branded under the name of *"Vasanthi Premium"* and was initially used on their own farm, this resulted in 20% decrease in cost of production. Inspired by the outcome, they began selling the feed to neighboring farmers at ₹55–₹65/kg, which was much less than the going rate of ₹88/kg at that time.

"Vannamei Plus," developed by the Central Institute of Brackish water Aquaculture (ICAR-CIBA) and acquired by Sai Aqua Feeds, is an affordable, high-quality feed produced using indigenous feed manufacturing technologies and ingredients that are obtained locally. This feed helped small farmers earn an additional profit of ₹50,000–₹60,000 per crop per hectare. Inspired by Sai Aqua Feeds' success, small and medium-scale farmers established five more feed mills in Andhra Pradesh, Kerala, Gujarat, Haryana, and West Bengal. With an annual turnover of ₹20 crores and employment generation for 70 individuals, the firm was honoured with the "Best Fisheries Enterprise" award by the Government of India on World Fisheries Day, 2020. (Source: Indian Fisheries' 100 Super Success Stories, NFDB 2022).

Success Story -2: Amal Medhi – From Marginal Farmer to Assam's Leading Fish Seed Entrepreneur

Mr. Amal Medhi, a graduate in Arts (B.A.) from Sondha village in Nalbari district of Assam, was formerly engaged in low-return paddy farming on 50 % of land, his family's livelihood remained uncertain until 2008, when he took a bold step to convert his farmland into a fish pond. He invested ₹20,000, for purchase of 10 lakh spawn and began its culture. His first attempt helped to earn ₹50,000 and inspired him to scale up his farm. He took a loan of ₹1.95 lakhs to buy two ponds of one-acre each and started rearing spawn to fingerlings. Mr. Medhi to adopted innovative practices after attended training in 2012 on the breeding of indigenous species like magur, koi, singhi, and pabda. This resulted in enhancing of his earning by times of his investment. Driven by this success, he purchased 10 acres and leased 15 more across neighboring villages, expanding into mass fish culture and seed production. Today he is leading fish seed enterprise in Assam.

The firm focuses on producing high-quality seed of desi magur, singhi, pabda, IMC, and exotic carps, achieving an impressive annual fish seed production of 1 crore and a turnover of ₹3.5 crores. His enterprise currently provides direct employment to 15 individuals. Mr. Medhi's contributions have earned widespread recognition. He was awarded the titles of “Best Fish Farmer” and “Best Quality Fish Seed Producer” in 2016 and was honoured as the “Fisheries Brand Ambassador of Assam” in 2019 by the Department of Fisheries (Source: Indian Fisheries' 100 Super Success Stories, NFDB 2022).

Success Story -3: Empowering Island Farmers through Fish Feed Production – The Journey of Mrs. Jaya Lakshmi

Mrs. Jaya Lakshmi, a retired South Andaman Government employee with a higher secondary degree, started her own business, M/s. Meyor Nature, in 2022. Her integrated farm at Garacharma produces organic manure, freshwater aquaculture, poultry, vegetables, and a nursery. Realizing the high cost of aquaculture feed and its scarcity in the area, she collaborated with ICAR-CIARI, Port Blair, which had created the "Dweep Carp Grower Feed" and established a pilot-scale feed mill (80–100 kg/hr) under NABARD's Farm Sector Promotion Fund. Her facility also serves as an incubation center to support startups in fish feed production. Mrs. Lakshmi was given practical instruction in the creation and formulation of fish feed during a three-month incubation program. Her team produced 1,025 kg of feed, generating a turnover of ₹51,250 and created employment for 4 people. Inspired by this achievement, Mrs. Lakshmi now intends to start her own fish feed mill in order to expand her business and give the young people of the island a means of provide livelihood and employment opportunities (Source: Indian Fisheries' 100 Super Success Stories, NFDB 2022).

Success Story -4: The Fish Doctor of Bundelkhand – Late Mr. Gulab Singh Raikwar

Late Mr. Gulab Singh Raikwar, a famous fish farmer from Uttar Pradesh's Jhansi district, was a visionary who significantly advanced aquaculture in Bundelkhand. He graduated in Arts (B.A.) and began his fish farming journey in 2006 by borrowing money from a relative. He used this money to travel to Kolkata, purchase fish seed, and dig a pond on his land to start his fish farming venture. With technical guidance from the Department of Fisheries, Jhansi, and with financial assistance under Government schemes like the Davs yojana (2008–09) and the Pradhan Mantri Matsya Sampada Yojana (PMMSY) in 2017–18, he expanded his enterprise into a successful fish hatchery and farming unit. He cultured a various of fish species including Indian Major Carps (IMC), exotic carps, desi magur, pangas, tilapia, and kalbasu. His efforts led to an annual turnover of ₹20 lakhs and the generation of employment for 15 unemployment youths. He was known for his deep knowledge and hands-on experience, which

led him to earn the title of “Machhliyon ke Doctor” (Fish Doctor) amount the fish farmers. He was also widely recognized among fish farmers of Madhya Pradesh, Uttar Pradesh, and Rajasthan, who use to visit his hatchery to buy quality fish seed and learn fish farming techniques. His reputation continued to grow as he share his knowledge and train others. He also took specialized fish breeding training from various states like Andhra Pradesh, West Bengal, and Maharashtra. For his exemplary work in promoting fish farming in the region, he was honored on the occasion of World Fisheries Day, celebrated on November 21, 2023, at the College of Fisheries, Rani Lakshmi Bai Central Agricultural University (RLBCAU), Jhansi. Late Mr. Raikwar’s journey is as a best example in aquaculture sector that of how passion, determination, and the right kind of support can transform someone life. Unfortunately, in 2025 he passed away in a road accident, now his son has taken over his business and carrying forward his legacy.

Glossary

Aerators: Devices that inject air into the water by spraying or circulating it, enhancing oxygen transfer and improving surface mixing. They also help disperse toxic gases and support uniform water temperature.

Algal Bloom: The rapid proliferation of algae, triggered by excess nutrients (e.g., nitrogen, phosphorus). Though algae are fundamental to the aquatic food web, a dense bloom can lead to oxygen shortage, fish kills, and water discoloration.

Ammoniacal Nitrogen: A form of nitrogen present as ammonia (NH_3) and ammonium (NH_4^+) in water. High levels, especially of NH_3, can be toxic to fish and are influenced by pH, temperature, and waste decomposition.

Aquaculture: The cultivation of aquatic organisms such as fish, shrimp, or plants under controlled conditions for commercial, recreational, or conservation purposes.

Aquatic Vegetation: Plants that grow in or near water bodies. While some provide oxygen and shelter, excessive growth can deplete oxygen and interfere with pond management.

Brooders (Broodstock): Sexually mature fish selected for breeding. Healthy, well-conditioned brooders are essential for producing high-quality eggs and fry.

Bundh: A traditional, shallow rain-fed pond used in India for natural fish breeding during the monsoon season.

Conditioning: The process of preparing fish, especially brooders or fry, before handling, spawning, or transport. It may involve fasting, medication, or acclimatization.

Closed Transport System: A fish transport method using sealed containers or oxygen-filled plastic bags, minimizing stress and water contamination.

Composting: The microbial breakdown of organic waste like fish remains or manure into nutrient-rich fertilizer for reuse in agriculture or pond preparation.

Crumble Feed: A granular feed form created by breaking up pellets, suitable for small fish that require finer particle sizes for consumption.

Dechlorination: The removal of chlorine from treated water to prevent harm to fish, commonly done using aeration or chemical agents like sodium thiosulfate.

Desilting: The removal of accumulated silt from pond bottoms to restore depth, improve water quality, and support better fish growth.

Detoxification: The process of neutralizing harmful chemicals used to eliminate unwanted fish species before restocking ponds with desirable fish.

Dyke: An earthen or concrete embankment built around a pond to retain water and prevent flooding or seepage.

Effluent: Wastewater discharged from ponds or hatcheries that may contain nutrients, chemicals, or pathogens requiring proper treatment before release.

Endogenous Feeding: The early life stage when fish larvae rely on yolk reserves for nutrition, prior to feeding externally.

Epiphytic Algae: Algae that grow attached to surfaces like plants or rocks in water, often contributing to the natural food base for small fish.

Exogenous Feeding: The stage when fish larvae begin feeding on external sources after absorbing their yolk sac.

Fasting (in Transport): The practice of withholding feed from fish 24–48 hours before transport to reduce metabolic waste and stress.

Feed Conversion Ratio (FCR): A measure of feed efficiency, calculated as the amount of feed required to gain a unit of fish weight. Lower FCR indicates better efficiency.

Feeding Frequency: The number of times fish are fed per day. Increased frequency supports faster growth, especially in juvenile stages.

Fertilization (Manuring): The application of organic or inorganic materials to a pond to stimulate natural food production like plankton.

Flake Feed: Thin, floating feed particles used primarily for small or surface-feeding fish species.

Foliar Spray: A method of applying herbicides directly onto plant leaves, commonly used to control aquatic weeds.

Formalin: A solution of formaldehyde used in aquaculture to treat parasites, fungi, and bacteria. It must be handled with care due to toxicity.

FRP Pool: A fiberglass-reinforced plastic tank used for rearing, breeding, or holding fish under controlled conditions.

Gamcha: A traditional cloth used in some regions to filter fish spawn or separate debris from water during seed collection.

Groundnut Oil Cake: A protein-rich byproduct from groundnut oil extraction, often used as an ingredient in fish feed or pond fertilization.

Herbicide Residue: Chemical remnants from weed control agents. High residues can harm aquatic life and must degrade before stocking ponds.

Histopathology: The microscopic study of fish tissues to diagnose diseases, organ damage, or effects of toxins.

Induced Breeding: A technique where hormones are administered to fish to stimulate spawning under controlled hatchery conditions.

Insulated Container: A temperature-controlled container used to safely transport fish seed over long distances with minimal stress.

Larvae: The early, post-hatch developmental stage of fish. Larvae require high-protein live or formulated feeds for proper growth.

Live Food: Natural organisms like rotifers, daphnia, or Artemia used as nutritious feed for fish larvae and fry.

Metabolic Waste: Waste products such as ammonia and carbon dioxide excreted by fish, which must be managed to maintain water quality.

Moribund: A term describing fish that are near death or in a state of irreversible decline, often due to disease or stress.

Mycotoxin: Harmful compounds produced by fungi in improperly stored feed. These can cause illness or reduce fish growth.

Nursery Pond: A specially prepared pond where hatchlings are reared into fry or fingerlings under protective conditions.

Nutritional Requirement: The specific dietary needs of fish based on their age, species, and production goals, including protein, lipids, vitamins, and minerals.

Open Transport System: A fish transport method using open containers where water is regularly replaced. Less efficient than closed systems.

Osmotic Stress: Stress caused by sudden changes in water salinity or ion balance, affecting fish health during handling or transport.

Pathogen: A disease-causing microorganism such as bacteria, viruses, fungi, or parasites.

Pellet Feed: Compressed feed particles designed in various sizes and buoyancies for different fish species and growth stages.

Personal Hygiene / PPE: Practices and equipment like gloves, masks, and gowns used to prevent contamination and protect both handlers and fish stock.

Phytoplankton: Microscopic aquatic plants that form the base of the food chain and support fish growth through natural feeding.

Planktonic: Describes organisms that drift freely in the water column, including many forms of algae and zooplankton.

Pond Disinfectants: Chemicals such as lime, formalin, or potassium permanganate used to clean and sterilize ponds before stocking.

Predatory Fish: Fish species that prey on smaller fish, fry, or eggs. Their presence in culture ponds must be controlled to avoid losses.

Quick Lime: Also called calcium oxide, used to disinfect pond bottoms, adjust pH, and improve soil and water conditions before stocking.

Raceway: A long, narrow pond or tank where water flows continuously. Used for high-density fish rearing with good oxygenation.

Spawn: Newly hatched fish that still depend on yolk sac nutrients and require careful handling and appropriate feeding.

Starter Feed: A finely ground, high-protein feed given to fish larvae after they begin feeding externally.

Stocking Density: The number of fish introduced per unit area or volume of water. Proper density ensures good growth and water quality.

Supplementary Feed: Additional feed provided to fish beyond what's available naturally in the pond to meet nutritional needs.

Toxic Gases: Harmful gases like ammonia, hydrogen sulfide, and methane produced by decaying matter in water. These can kill fish if not managed.

Toxicant: A chemical substance that can cause harm or death to fish when present in excessive amounts in water or feed.

Transparency (Water): A measure of water clarity that affects light penetration and photosynthesis, typically checked using a Secchi disk.

Trypsin Inhibitor: A naturally occurring compound in some plant-based feeds that interferes with protein digestion in fish.

Ultraviolet Irradiation: A method of sterilizing water by using UV light to kill harmful microorganisms without chemicals.

Uprooting: Manual removal of aquatic weeds by pulling them from their roots. Effective but labor-intensive.

Weed Fish: Unwanted fish species that compete with cultured species for food or prey on their young.

Zoonotic Disease: A disease that can spread between animals and humans. Biosecurity and hygiene are key to prevention in aquaculture.

Answer Keys

Unit 1: Nursery Management

Session 1

Fill in the blanks

1. Grass Carp
2. 6.5, 9.0
3. Nursery pond.
4. Lime
5. Predatory fishes.

Multiple Choice Questions

1-c, 2-b, 3-d, 4-b, 5-a

Match the following

1-D, 2-C, 3-B, 4-A

Session 2

Fill in the blanks

1. Conditioning
2. 0.05
3. 3–4
4. Acclimatization
5. Bati

Multiple Choice Questions

1-b, 2-c, 3-a, 4-c, 5-d

Match the following

1 –D, 2-A, 3-B, 4-C

Unit 2: Feeding and Monitoring of Fish Seed

Session 1

Fill in the blanks

1. starter feeds
2. gonadal
3. 44–48%
4. canning
5. Pearson Square

Multiple Choice Questions

1-c, 2-b, 3-a, 4-d, 5-b

Match the following

1-B, 2-D, 3-A, 4-C

Session 2

Fill in the blanks

1. nutritional
2. harmful
3. Histopathology
4. Aeromonas hydrophila
5. well-being, robustness

Multiple Choice Questions

1-a, 2-d, 3-c, 4-b, 5-d

Match the following

1-B, 2-C, 3-D, 4-A

Unit 3: Harvesting, Packaging and Marketing of Fish Seed

Session 1

Fill in the blanks

1. Aquaculture
2. Harvesting
3. 3
4. 8
5. Scoop
6. 1:2

Multiple Choice Questions

1-b, 2-a, 3-d, 4-c, 5-b

Match the following

1-C, 2-D, 3-A, 4-B

Session 2

Fill in the blanks

1. Naihati

2. short
3. insulated
4. ammonia

Multiple Choice Questions

1-c, 2-b, 3-a, 4-c, 5-d

Unit 4: Health, Hygiene and Safety Procedures

Session 1

Fill in the blanks

1. Hazards
2. grain
3. extracellular polymeric
4. biosecurity
5. 150–250

Multiple Choice Questions

1-c, 2-a, 3-d, 4-b, 5-a, 6-d

Session 2

Fill in the blanks

1. Lime
2. Biofilm
3. Standard Operating Procedure
4. Rendering
5. onsite burial

Multiple Choice Questions

1-b, 2-c, 3-d, 4-c, 5-c, 6-b

Mark 'True' or 'False'

1. False
2. False
3. True
4. True
5. True

Match the following

1-c, 2-e, 3-d, 4-a, 5-b

Crossword

- Across**:** 1- Biosecurity, 2- Burial
- Down: 1- Composting, 2- Recycle

List of Credits

Dr. Abhishek Srivastava
CoF, RLBCAU, Datia
Fig. 1.1
Fig. 1.2
Fig. 1.3
Fig. 1.4
Fig. 1.7
Fig. 1.8
Fig. 2.12

DAAH, PSSCIVE, Bhopal
Fig. 1.5
Fig. 1.6
Fig. 2.10
Fig. 2.11
Fig. 2.13
Fig. 2.14
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Dr. Anuj Tyagi
CoF, RLBCAU, Datia
Fig. 2.1
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Fig. 2.32
Fig. 2.33
Fig. 2.34
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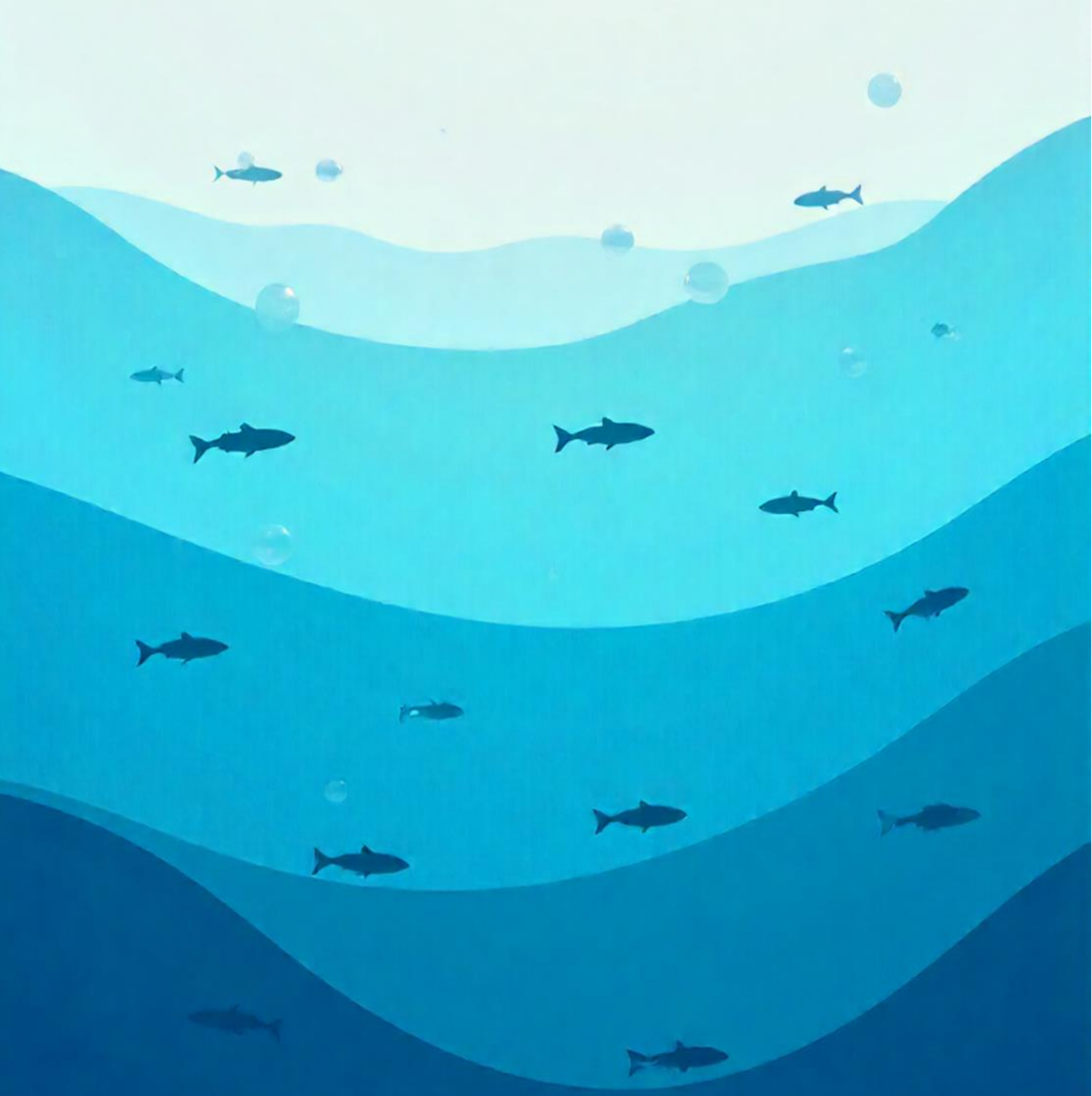
Fig. 4.6



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PSS CENTRAL INSTITUTE OF VOCATIONAL EDUCATION
(a constituent unit of NCERT, under MoE, Government of India)
Shyamla Hills, Bhopal- 462 002, M.P., India
www.psscive.ac.in