Some practices and techniques in cost-effective small and medium-scale aquaculture in West Bengal

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Fish-cum-poultry integrated farming system.

Twenty-two years ago, I attended a presentation by the late Dr S.D. Tripathi on 'Small-Scale Farming Systems for Rural Development' at the Sixth Indian Fisheries and Aquaculture Forum, held at ICAR-CIFE, Mumbai, in December 2002. He discussed low-input, low-cost aquaculture technologies. These included bio-gas slurry-based and manure-based major carp culture, aquatic weed-based aquaculture, catfish farming in small and shallow ponds, low-density monoculture of giant freshwater prawns, and fish farming in paddy fields.

Dr Dilip Kumar, in his article Making Fisheries and Aquaculture More Relevant to Rural Development, argued that integrating aquaculture into agriculture and rural development would have a multiplier effect, including reducing input costs. Dr Radheyshyam noted that nearly 40% of global aquaculture production comes from small-scale extensive systems. In India, most fish production also comes from fish farming in remote rural areas[1].

Padma Shri Dr M. Vijay Gupta stated that development must be sustainable and should not compromise environmental integrity. To achieve this, the survival of smallholder farmers must be ensured, as much of aquaculture is smallholder-based[2]. Dr N. Sarangi and Dr J. K. Jena highlighted that freshwater aquaculture in India is mostly practiced by small and medium-scale farmers. It relies on low to moderate inputs, particularly organic-based feed and fertilisers. They emphasised the use of biofertilisers and processed organic materials, which should be encouraged in aquaculture systems[3].

Over the past decade, several fish farmers have reported that profit margins are gradually declining due to rising input costs. This article discusses various freshwater and brackish water aquaculture practices relevant to small and medium-scale fish farmers in both nearby and remote villages of West Bengal. It focuses on the use of non-conventional feed additives such as date palm molasses, yeast, and the disinfectant and

oxidiser potassium permanganate ($KMnO_4$) in fish culture ponds. These approaches follow organic principles in both agriculture and aquaculture.

These farmer-friendly techniques avoid expensive commercial fish feed, aquaculture products, and high-cost inputs. The farmers use $KMnO_4$ judiciously and do not engage in intensive or industrial aquaculture. The information presented here is based on data collected over the past ten years from fish and shrimp farmers across different districts of West Bengal.

Methods to increase plankton production as food for farmed fish

In villages across West Bengal, many fish farmers use yeast and date palm molasses to enhance zooplankton production in aquaculture ponds. Date palm molasses is a non-crystalline, unrefined, and non-distilled sugar derived from the sap or juice of date palm plants. It contains a high amount of sugar and appears as a thick, sticky, dark syrup. The by-product of commercially produced date palm jaggery is also considered a form of date palm molasses.

Dr B.K. Mahapatra has recommended a formulation to promote phytoplankton growth in fish ponds. For every 40 m^2 of pond area, farmers should apply:

- 100 g mustard oil cake (soaked in pond water for 3–4 days)
- Small amounts of water-soaked diammonium phosphate (DAP) and urea

For increasing zooplankton production in the same area, the following mixture should be used:

- 100–150 g mustard or groundnut oil cake
- 120 g rice polish or rice dust
- 200 g wheat flour
- 100 g date palm molasses
- 10 g Aqua-Yeast

The mixture should be placed in a closed, drum-like container, with pond water added at a ratio of 6–7 times the mixture volume. It should be left to ferment for 4–5 days. To ensure proper fermentation, the liquefied mixture should be stirred daily with a wooden stick after opening the lid.

On the 5th or 6th day, half of the fermented mixture should be diluted with pond water and applied to the pond surface. The remaining half should be applied in the same way the following day.

For every 40 m^2 of fish pond area, a mixture should be prepared in a large plastic bucket using:

- 5 litres of lukewarm water
- 5 g dry yeast

Mixture of GNOC, date palm molasses and yeast.

Mixture of date palm molasses, mustard oil cake and yeast.

Settled fermented mixture for zooplankton growth in pond.

- 50 g date palm molasses
- 200 g wheat flour or rice bran

The mixture should be thoroughly stirred, covered with a polythene sheet, and left for 24 hours. After this, it should be diluted with pond water and applied to the water surface. On the 12th day, half of this mixture is prepared and applied.

The full mixture is applied again on the 25th day, and this process continues throughout the culture period to maintain sufficient zooplankton production (Courtesy: Shakib Agrotech Ltd.).

Good-quality yeast from a reputable brand can be activated on-site by dissolving it in lukewarm water for 5–10 minutes, along with a small amount of sugarcane jaggery, date palm molasses, or sugar.

Instead of costly, feed-intensive aquaculture used in high-tech systems by resource-rich entrepreneurs, many small-scale farmers focus on maintaining natural plankton populations in culture ponds. This approach reduces reliance on expensive commercial feeds while ensuring a steady supply of planktonic organisms for fish growth.

As a post-stocking grow-out pond management measure, a mixture of urea and triple superphosphate is applied at the correct dosage every 15 days to sustain phytoplankton productivity. For sustained zooplankton production, a mixture can be prepared for every 40 m² of water area using:

- 100 g mustard oil cake
- 150 g rice bran
- 50 g date palm molasses
- 5 g yeast

This mixture should be fermented for 72 hours in a drum and applied in major carp ponds every 12–15 days after dilution (Courtesy: Fish and Fisheries, J. Banik, Upa-Zilla Fisheries Officer, Kumilla, Bangladesh).

Several indigenous formulations used successfully by farmers in West Bengal to enhance plankton production are described below.

Indigenous formulations for plankton enhancement

1. Zooplankton enhancement in grow-out carp culture: For every 1,320 m² pond, mix:

- 4 kg date palm molasses
- 7 kg mustard oil cake
- 150 g yeast

Prepare the mixture in a polythene-lined earthen pit (1.8 m × 1.2 m × 0.3 m) on the pond embankment and add water. Leave undisturbed for five hours, then apply the supernatant fluid to the pond. This significantly enhances zooplankton populations in grow-out carp ponds.

2. Fermented feed application in indian major carp culture: For every 3,840 m² pond, prepare a mixture of:

- 100 kg groundnut oil cake
- 10 kg sugarcane or date palm molasses

Neem cake as organic fertiliser (Courtesy ICAR-CMFRI).


Bags of sundried poultry manure for pond application.


Hygienic poultry litter for application in fish pond.

- 500 g yeast

Allow to ferment and apply in six portions over the first six days after stocking carp fingerlings. Repeat the process on the 13th–18th day in the same manner.

3. Enhancing beneficial bacteria and phytoplankton in *Macrobrachium rosenbergii* farming:

For every 1,000 m^2 pond, mix:

- 250 g yeast
- 3 kg rice polish or rice dust
- 1.5 kg date palm molasses
- 2 kg fish meal

Add 1 litre of water and leave undisturbed in a dark room for three days. Apply one-third of the liquid on the first day of juvenile stocking and the remaining two-thirds on the second day. Repeat every 15–21 days throughout the culture period. This reduces feed and medicine costs in fish, prawn, and shrimp culture.

4. Plankton enhancement in composite fish culture: In a small concrete cistern, ferment a mixture of:

- 25 kg rice bran
- 10 kg date palm molasses
- 250 g yeast

Apply this mixture to 10,000 m^2 of water, repeating three times at one-month intervals for sustained plankton production.

5. "Organic juice" for *Clarias batrachus* broodstock ponds: For every 1320 m^2 pond, prepare:

- 7 kg pulverised whole paddy grains
- 4 kg date palm molasses
- 500 g yeast

Add 4–5 litres of water and ferment for three days. Broadcast the concentrated liquid once every 15–20 days to significantly increase zooplankton populations.

6. Plankton enhancement and ammonia reduction in fish ponds: For every 40 m^2 fish pond with a water depth of 0.9–1.5 m, apply:

- 70–100 g date palm molasses diluted with water
- Apply for two days each week throughout the culture period.

This improves pond productivity, enhances plankton populations, promotes fish growth, and helps reduce ammonia levels.

7. Plankton production in *Penaeus vannamei* culture ponds: For every 1,000 m^2 pond, apply a mixture of:

- 250 g yeast
- 3 kg rice bran
- 1.5 kg date palm molasses
- 2 kg fish meal

Liquefied mixture of GNOC and soyabean dust as feed for carp spawn.

Dust-type home-made feed for major carp spawn.

Fermented fish feed containing GNOC, mustard oil cake, yeast and other ingredients.

Apply every 15 days to maintain plankton levels.

8. Fermented organic slurry for *Macrobrachium rosenbergii* culture: To prepare a slurry for every 1,320 m^2 pond:

- 5 kg date palm molasses
- 10 kg rice bran
- 250 g yeast
- 150 g commercial probiotic bacteria

Add 200 litres of water, artificially oxygenate, and allow partial decomposition for 12–18 hours. Apply before stocking prawn juveniles (3–5 cm size).

9. Fermented feed for *P. vannamei* post-larvae: For every 1,000 m^2 pond, prepare a mixture of:

- 750 g rice polish
- 350 g wheat flour byproduct
- 500 g date palm molasses
- 100 g limestone powder
- 15 ml soy sauce
- 200 g baking soda ($NaHCO_3$)
- 100 g commercially available probiotic

After controlled fermentation, the juice portion is fed to 20-day-old *P. vannamei* post-larvae.

10. Fermented nutrient mixture for major carp culture: For every 1,000 m^2 pond, mix:

- 3 kg groundnut oil cake
- 2.5 kg rice bran or rice dust
- 3 kg date palm molasses
- 500 g yeast powder

Add sufficient water, dilute, cover, and ferment for three days before applying in major carp ponds.

11. Organic juice for plankton bloom in brackishwater shrimp ponds: For every 10,000 m^2 pond during the pre-stocking phase, prepare an organic juice mixture with:

- 60 kg paddy flour
- 20 kg date palm molasses
- 3 kg yeast
- 200 litres of freshwater

Incubate the mixture in an airtight container for 48 hours Apply on the 6th day after bleaching powder application and on the 2nd day after dolomite application to stimulate plankton bloom. Repeat the process three times, at three-day intervals[4].

12. Zooplankton enhancement in composite fish culture ponds: In some composite fish culture ponds, *Cirrhinus mrigala* consumes large amounts of zooplankton, reducing availability for *Catla catla*.

To boost zooplankton production, prepare a mixture of:

- 250–500 g yeast
- 250–500 g sugar
- A small amount of finely pulverised wheat flour
- 15–20 litres of lukewarm water

Let the mixture sit undisturbed for 12 hours, then apply to the pond.

13: Organic juice for *P. vannamei* productivity improvement: Shrimp farmers M. Karuna Raju and Krishnam Raju from Bapatla, Guntur, Andhra Pradesh, use fermented rice bran and soya in *P. vannamei* culture. This practice improves water quality, phytoplankton, and zooplankton production, increasing *P. vannamei* survivability by 20%.

14: Soap and mustard oil treatment in *Pangasianodon hypophthalmus* nursery ponds. A mixture of LifeBuoy soap and mustard oil is used in nursery ponds. The fat content in mustard oil enriches zooplankton populations while the soap kills predatory aquatic insects. Preparation method:

- Soap is first boiled in a large iron vessel over a furnace.
- Mustard oil is then added.
- For every 1,320 m pond, apply a mixture of:
- 5 kg soap
- 15 kg mustard oil
- Apply 48 hours before spawn stocking.

These low-cost, farmer-friendly formulations help improve zooplankton production, pond productivity, and shrimp survival rates, reducing reliance on expensive commercial inputs.

Preparation of farm-made fish feed using yeast and/or molasses

Yeast are microscopic single-celled fungi widely used in aquaculture. Studies suggest that 5% brewer's yeast supplementation serves as a useful protein source for carp aquaculture[5]. It also acts as an immunostimulant and enhances probiotic development in feed. Yeast-based formulated fish feed is highly digestible and is sold in 500–1000 g packets in its dormant state.

Farmed air-breathing catfish (*Clarias batrachus*) are typically fed a mix of animal- and plant-based ingredients. Common animal-based ingredients include fish meal, small trash shrimp meal, semi-boiled chicken entrails, mussel meat, and dried silkworm pupae. Plant-based ingredients include rice bran, soybean dust, and groundnut oil cake. These ingredients are combined in different ratios depending on the stage of culture: a 1:3 animal-to-plant ratio in the first month, 1:1 in the second month, and 3:1 from the third to the sixth month.

An improved *C. batrachus* feed formulation has been developed that includes 60% fish meal, 15% roasted soybean meal, 10% groundnut oil cake, 3% baker's yeast, 2.5% sunflower oil, 2.5% cod liver oil, 4.5% starch, 2.5% vitamin-mineral mix, and 0.5% feed attractants such as methi (*Trigonella foenum-graecum*) and root dust of Ekangi herb (*Hedychium spicatum*). This mixture is partially decomposed under controlled conditions before being applied in ponds.

Fermentation enhances the nutritional value of feed ingredients. Instead of using dry formulated feed, some farmers prefer to mix yeast into feed to facilitate controlled fermentation, which improves digestibility and enhances probiotic activity. Dr Dilip Kumar has identified the development of cost-effective and efficient fish feed with minimal reliance on fish meal as a priority for aquaculture. He also emphasised the need for detritus- and primary productivity-based low-cost aquaculture systems for rainfed, undrainable ponds[6].

For pond applications, fish farmers may use 500–1000 g of high-quality yeast along with molasses or jaggery. For direct feed application, yeast can be used at a rate of 2–3 g per kilogram of fish feed (Courtesy: R. Kumar, PVR Aqua Farm). Fermented feed should not be applied daily or weekly to major carps and other fish in culture ponds. Instead, it should be used once or twice a month.

To prepare a fermented feed supplement for a pond where 10 kg of supplementary fish feed is scheduled for daily application, farmers add 1,000–1,500 g of date palm molasses and 100–150 g of yeast to the feed. The yeast, purchased in its dormant form, is first mixed with lukewarm water and left undisturbed for 30 minutes to activate. Once activated, an equal amount of pond water is added, and the mixture is stirred thoroughly. It is then left uncovered for 48 hours to allow fermentation before being applied over the pond surface (Courtesy: AM Aqua Farm).

Sample farm-made pelleted feed for major carps.

Fish farmer applying fish feed as moist dough ball.

Farmers in West Bengal have developed various low-cost, farm-made feed formulations that have been successfully used in major carp and finfish culture. These formulations enhance fish nutrition while reducing dependence on expensive commercial feeds.

1. Feed for *Pangasianodon hypophthalmus* seed rearing

A mixture of 50 kg groundnut oil cake, 40 kg finely pulverised shrimp feed, and 40 kg Agri-Min feed supplement is partially composted in cement cisterns. It is applied at 7–8 kg per 2,600 m^2 nursery pond.

2. Indian major carp feed

The feed contains 8–10% powdered green leaves of *Leucaena leucocephala*, *Terminalia arjuna*, blackberry, and *Heritiera fomes* (dried under shade), along with 15% paddy dust, 15% wheat flour or rice dust, and 30–35% oilcake (from coconut, sunflower, linseed, flaxseed, or mustard).

15–20% fish meal, 5–10% husk of *Lathyrus sativus* or moong pulses, 2% turmeric powder, 2% neem (*Azadirachta indica*) leaf powder, and 1% common salt are also added.

Rice bran, mustard oil cake, date palm molasses, and baker's yeast powder are mixed, pulverised to 100-micron particle size, and fed to growing spawn and fry.

3. Supplementary feed for *Penaeus monodon* in brackish-water ponds

The formulation includes 325 g molluscan meat, 325 g trash shrimp meal, 1,335 g maize dust residue, 1335 g wheat starch (gluten protein), and 20 g each of date palm molasses, palm oil, cod liver oil, and vitamin-mineral mix.

4. Fermented feed for Indian major carps

For every 10,000 m^2 water body, a feed mixture of 20 kg mustard oil cake and rice bran (combined), 10 kg date palm molasses, and 500 g baker's yeast is partially fermented for three days and applied once every 15 days.

A low-cost major carp feed is also prepared using black gram pulses, rice bran, wheat bran, pulverised mustard oil cake, flaxseed oil cake, vitamin-mineral mix, and date palm molasses.

5. Farm-made feed for *Pangasianodon hypophthalmus* in grow-out ponds

This formulation consists of partially insect-affected gram and peas, deoiled rice bran, broken rice, broken wheat grains, maize dust, inferior-quality pulses, sugarcane jaggery, and fat-eliminated pulverised silkworm pupae, all boiled before application.

6. Indian major carp feed with date palm molasses

This feed includes 25% wheat bran, 30% rice bran, 25% pulverised mustard oil cake, 10% fish meal, and 10% date palm molasses.

7. Alternative feed for major carps

Another method, prepared using deoiled rice bran, pulverised groundnut oil cake, maize dust, soybean dust, and date palm molasses in a 20:4:2:1:0.5 ratio, with a small amount of vitamin-mineral mix.

8. Partially decomposed feed for composite fish culture ponds

For every 1320 m^2 pond, a mixture of 15 kg wheat flour byproduct, 5 kg groundnut oil cake, 10 kg mustard oil cake, 2 kg inferior-quality soybean dust, and 50 g yeast is used.

The mixture is liquefied in earthen cylindrical containers (0.6 m diameter) by adding four bucketfuls of water and left to decompose for 7–8 days before application. This method has been reported as beneficial by a fish farmer.

Compost manure, vermicomposting, and integrated fish farming

Padma Shri Dr S. Ayyappan, in his article Fish for All Forever, highlighted the integration of freshwater aquaculture with other farming systems and the recycling of organic matter as key potential areas. In many villages across West Bengal, fish farmers prepare compost mixtures to enhance pond fertility. A standard 100 kg compost pile consists of 25 kg cow dung, 5 kg mustard oil cake, 20 kg water hyacinth ash, 25 kg agricultural lime, 10 kg submerged aquatic weeds, and 15 kg thick pond bottom sediment (silt). The materials are placed in a rectangular pit on the pond embankment under anaerobic conditions, ensuring that sunlight does not enter. After 30 days, water is added, and the pit is covered for another 3–4 days before the compost is liquefied and applied to fish ponds at a rate of 600–800 kg per 10,000 m^2 per month.

This method improves pond bottom soil fertility by supplying organic carbon, nitrogen, phosphorus, and potassium. The decomposition process eliminates harmful microorganisms, making nutrients readily available. Application of water hyacinth ash has also been observed to increase populations of *Moina* sp. zooplankton in ponds.

Pit for compost preparation on pond embankment.

Good quality compost fertiliser for pond application.

A view of poultry house built partially over pond.

In some cases, compost is prepared in small pits (1.5–1.8 m deep) dug on the pond slope. Over a 20-day period, a mixture of finely chopped green grass, leaves, vegetable peel-offs, fresh water hyacinth, submerged aquatic weeds, and raw cow dung (in equal proportion to water hyacinth) is used. A small amount of mustard oil cake is added, while common salt is included to kill fungus and lime to neutralise acidity. Water is added every 2–3 days to maintain proper moisture levels.

Composted water hyacinth has shown good results in newly excavated deep ponds created using JCBs and dredgers. The water becomes greenish due to increased plankton abundance. Before stocking carp fingerlings, 60–70 kg sun-dried water hyacinth (dried for 6–7 days), 10–20 kg cow dung or mustard oil cake, and 2–3 kg urea are layered in a rectangular pit under anaerobic conditions for 15–25 days. This process yields high-quality compost, which is then applied to the pond.

In grow-out major carp culture, *Labeo rohita* and *Cirrhinus mrigala* feed on partially decomposed plant-based organic matter, decomposing algae, detritus, and high-quality compost fertiliser from the pond. Compost should be provided in controlled amounts to promote proper fish growth.

Scientific discussions on integrated fish farming have extensively covered livestock-fish integration, vermicomposting, paddy-cum-fish culture, and treated domestic wastewater-based fish farming. These methods form the livelihood base for small- and medium-scale fish farmers in West Bengal. Many farmers have successfully adopted economically viable, scientifically validated, and refined techniques suited to their conditions.

Fish farmers possess strong indigenous technological knowledge, which, when combined with modern aquaculture principles, has proven to be highly effective. Elderly fish

Small poultry house on the bank of fish pond.

farmers engaged in small- and medium-scale aquaculture have developed innovative stocking, pre-stocking, and post-stocking methods, often leading to new, productive practices.

As a low-cost input, vermicompost has been used for fertilisation in shrimp culture ponds. It is prepared using hay, leaves of mangrove plants, kitchen waste, neem (*Azadirachta indica*) leaves, pre-composted (aged) manure, and the earthworm species *Eisenia foetida*. It is applied at 200–500 kg per 10,000 m^2, with additional doses if necessary[7].

Approximately one million earthworms of selected varieties can convert 120,000 kg of organic matter into high-quality manure within 25 days. Typically, 1 m^3 of waste weighs around 500 kg and requires 4,000–5,000 epigeic earthworms for composting. The role of earthworms in sustaining soil productivity through organic waste recycling as vermicompost has been extensively studied[8].

Integrated farming systems involving fish and other livestock provide optimal resource use while generating continuous and increased income. Demonstrations and practical experiences indicate that farmers adopting integrated systems have seen income increases of 4–6 times[9]. Recycling by-products from farmed animals, including poultry and ducks, reduces costs and improves fish production efficiency.

In a fish-cum-poultry integrated farming system, 100 poultry birds consume 9 kg of dry *Azolla* daily, reducing poultry feed costs by 25%. From an initial 5 kg *Azolla* seed stock, up to 2,500 kg can be harvested in one month from every 1,320 m^2 pond. *Azolla* functions as both green manure and a nutritious feed for birds and fish.

In every 1,320 m^2 composite fish culture pond, 25 grass carp (*Ctenopharyngodon idella*) weighing 250–500 g are stocked to supply organic manure. These fish are fed 10–20 kg of green leaves or submerged soft aquatic weeds daily. Their faeces enhance pond fertility and serve as direct food for common carp (*Cyprinus carpio*) and *Labeo bata*, supporting nutrient recycling within the pond ecosystem.

Poutry-cum-fishery integrated farming system.

Small house for ducks on pond embankment.

Vermicompost chambers at ICAR-CIFA, Bhubaneswar.

Vermicast produced with epigeic earthworms.

Major carp and giant prawn polyculture for increased income

Giant freshwater prawn (*Macrobrachium rosenbergii*) has been successfully integrated into major carp grow-out culture systems in the Indian Sundarbans region, particularly in South 24 Parganas district. This polyculture system is practiced in ponds and canals in village areas. Post-larvae and juvenile prawns, used as stocking material, are readily available in tidal rivers across Kakdwip, Canning, and Diamond Harbour sub-divisions. These natural populations are harvested sustainably.

The introduction of *M. rosenbergii* into carp culture improves production, as the prawns, being bottom-dwelling, help clear unwanted residues from the pond bottom. This keeps pond conditions more favourable for carp growth. Market demand and pricing for *M. rosenbergii* in local markets are significantly higher than for *Cirrhinus mrigala* and *Cyprinus carpio*, which are not included in these polyculture ponds. Farmers reported that income from this system was more than double that obtained from major carp culture alone (Courtesy: Ramkrishna Ashram KVK, Nimpith). Prawns can be fed home-made feed prepared using green coconut flesh and other locally available ingredients.

Relevance of potassium permanganate to inland aquaculture

The severe cyclonic storms Amphan (May 19–20, 2020), Bulbul (November 9–10, 2019), and Yaas (May 25–26, 2021) caused significant damage to aquaculture in the coastal districts of West Bengal, including South 24 Parganas. Many freshwater and brackishwater ponds were affected due to tree branches falling into the water, fish deaths, and organic matter decomposition, leading to severe water quality deterioration.

As an immediate remedial measure, the District Magistrate of South 24 Parganas and the West Bengal Department of Fisheries distributed potassium permanganate and lime to affected fish farmers in brackishwater and marine zones.

Apart from controlling harmful microorganisms in pond water, potassium permanganate can also destroy phytoplankton and zooplankton populations, a phenomenon known as “plankton crush.” Due to this effect, it should be applied carefully in recommended doses over pond water, particularly in grow-out fish ponds during winter. Application is done in highly diluted form as a disinfectant or microbicidal treatment, typically in the early morning or late evening after sunset. The general dosage is 0.8–1 mg/litre or 8–10 kg per 10,000 m^2 as a prophylactic treatment.

The different uses of potassium permanganate in aquaculture are presented in the adjacent table.

A probiotic formulation enriched with effective microorganisms has been developed for use in major carp culture ponds. It helps eliminate ammonia buildup, reduces toxic gas accumulation at the pond bottom, and prevents oxygen depletion. The formulation also promotes fish growth and stabilises pH levels during both summer and winter months.

Application of duckweed in pond as fish feed.

To prepare the probiotic mixture, a 50-litre water drum is filled with 3 kg ripe papaya, 3 kg ripe pumpkin, 3 kg ripe banana, 1 kg date palm molasses, and one poultry egg. After thorough mixing, 10 litres of water is added, and the drum is sealed airtight. It is left undisturbed for 22 days, with the lid briefly opened for five minutes daily to release accumulated gases and allow beneficial bacteria to grow. This preparation is intended for every 4,000 m^2 water body.

After 22 days, the fermented mixture is diluted with 100 litres of water and 3–5 kg of date palm molasses, then applied to the pond surface during the daytime (Courtesy: Dr S. Bala, Iti Katha Research Centre).

For a 400 m^2 pond, a separate probiotic mix can be prepared using 3 kg mustard oil cake, 1 kg urea, 1 kg single super phosphate (soaked overnight), 1 kg wheat flour, 2 kg wheat flour byproduct, 500 g sodium chloride, and date palm molasses. After 24 hours of fermentation and dilution, it can be applied in freshwater finfish culture ponds. This is a low-cost and effective method for producing natural fish food organisms (Courtesy: Bala Fisheries, Jessore, Bangladesh).

End Note

On 16 August 2024, the Government of India announced the launch of Kisan ki Baat, a monthly radio programme aimed at disseminating scientific knowledge to farmers. The initiative is designed to modernise agricultural practices and equip farmers with the latest scientific information. Since the Indian farming community largely consists of small and marginal farmers, participatory research can help them generate and adapt appropriate technologies on-farm[10].

To ensure long-term sustainability, aquaculture must follow extensive or semi-intensive farming methods. These approaches are low-cost, sustainable, and economically viable[11]. Rural fish farming in West Bengal relies heavily on natural plankton production and home-made feed, reducing dependence on expensive commercial products. Farmers have transitioned towards modified-extensive, environment-friendly fish and prawn farming, which provides satisfactory to highly satisfactory returns.

Table 1. Applications of potassium permanganate in aquaculture.

Aim of Use	Dosage of $KMnO_4$	Duration of Treatment	Method
Cure ulcer-type bacterial disease in major carps	1 ppm or 10 kg per 10,000 m^2	-	Applied in pond water (depth: 1.0–1.2 m)
Kill crustacean ectoparasites *Argulus* sp. and *Lernaea* sp. in pond	4 ppm or 40 kg per 10,000 m^2	-	Applied in pond water
Cure dropsy disease in carps at its initial stage	5 ppm or 5 mg/litre	Dip treatment for 1–2 minutes	Used in a 1,000-litre cement tank
Cure ichthyophthiriasis and kill protozoan parasite *Ichthyophthirius multifiliis* in carps	10 ppm or 10 mg/litre	Bath treatment for 5 minutes	Used in a 1,000-litre cement tank
Kill crustacean ectoparasites *Argulus* sp. and *Lernaea* sp. on fish body	10 ppm or 10 mg/litre	Dip treatment for 40 seconds	Used in a 1,000-litre cement tank
Kill fungus *Saprolegnia* sp. and cure fungal disease in carps	10 ppm or 10 mg/litre	Bath treatment for 15 minutes	Used in a 1,000-litre cement tank
Quick increase in dissolved oxygen content in pond	15–20 g $KMnO_4$ + 5–7 kg soil + 50–100 g common salt	Every 1,000–1,320 m^2 pond (depth: 1.0–1.2 m)	Applied at 3–4 places in the pond
Treatment of unhygienic pond bottom soil	Sand + 700–750 g $KMnO_4$ + 5 kg limestone powder	Every 1,000 m^2 pond	-
In conditions of dissolved oxygen scarcity	175–200 g	Every 1,320 m^2 pond	Solution prepared and applied over the water surface
Eradicate smell of rotten eggs from pond bottom	250–350 g	Every 1,320 m^2 pond	-
Cure ulcer-type bacterial disease in major carps	20 g $KMnO_4$ + 20 g copper sulphate + 2 kg garlic + 2 kg common salt	For diseased fish in every 1,320 m^2 pond	Paste prepared, 35–45 litres of water added, spread in all parts of the pond
Prophylactic treatment of apparently healthy major carps	250–300 g	For fish in every 1,320 m^2 composite fish culture pond, once in 30–45 days	Fish drag-netted to one side, $KMnO_4$ solution poured over fish, released after 2–4 minutes

Fish farming is no longer considered a subsistence-level activity but a profitable small- to medium-scale venture. While some elderly villagers continue using backyard ponds for secondary income or household nutrition, most small- and medium-scale fish farmers in West Bengal have moved away from traditional, non-scientific methods. Over the past 10–12 years, they have adopted improved aquaculture techniques, actively seeking technical guidance from trainers and experts.

Young entrepreneurs and new entrant farmers, as termed by Peter Edwards, are increasingly interested in farming high-value freshwater and brackishwater fish in both indoor and outdoor systems. Their preference for major carps is decreasing, and when they do stock them, they prefer stunted fingerlings of 100–200 g instead of the traditional 15–40 g fingerlings.

Experienced fish farmers aged 45–70 years, either independently or as part of primary fishermen cooperative societies, strictly follow scientific, hygienic, and improved grow-out farming methods. They focus on reducing production costs by supplementing plankton-rich pond environments with farm-made formulated feed. Unlike older practices that relied solely on natural plankton, they now use moist dough balls and pelletised farm-made feed, avoiding the need for expensive factory-manufactured pelleted feed.

A cost-saving practice in village aquaculture involves allowing cooked rice to ferment overnight in water stored in aluminium vessels. A slightly sour aroma develops by morning, and cone-shaped dumplings obtained from local Santhal tribal households are added to the soaked feed as a feed attractant. The mixture is fed to major carps within 24–36 hours. Since profit margins in small-scale aquaculture are narrow, such cost-cutting measures significantly improve economic viability, as observed across Asia.

Regardless of scale, fish farmers must adhere to Good Aquaculture Practices to ensure that only healthy, unadulterated fish reach consumers. Whether farming Indian major carps, all-male tilapia, *Pangasianodon hypophthalmus*, or air-breathing catfish, fish must be grown, harvested, transported, and marketed in a safe and hygienic manner.

Consumers today are well-informed and highly conscious of food safety. They expect to purchase pure, high-quality fish from trusted local markets. Maintaining consumer confidence is essential to ensuring continued demand and profitability in the sector.

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Small-scale feed production unit at home of fish farmer.