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2nd National Training Programme

on

"Installation and Operation of FRP Carp Hatchery"

(7-10 July 2015)

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Centre at

ICAR - Central Institute of Freshwater Aquaculture

(Indian Council of Agricultural Research)

Kausalyaganga, Bhubaneswar- 751002, Odisha, India

Manual

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ICAR - Central Institute of Freshwater Aquaculture
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Sponsored By

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Kausalyaganga, Bhubaneswar – 751 002, Odisha, India

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PREFACE

The 2nd National Training Programme on "Installation and Operation of FRP Carp Hatchery" is a step forward towards skill development in hatchery installation and making the country self-sufficient in quality fish seed production. The ICAR- Central Institute of Freshwater Aquaculture (ICAR-CIFA) formerly as a part of ICAR-Central Inland Fisheries Research Institute (ICAR-CIFRI), Barrackpore and later as an independent institute has given many options for fish seed production in the country. Among them the cemented circular hatchery forms the backbone of the carp seed production. The portable hatchery is a miniature form of the circular hatchery which can be transported, installed and operated with much less cost and time. The fool proof technology after many years of refinement was made commercially available to the end users from 2006. From then onwards, the dissemination and adoption of the technology have been rapid and till date about 300 hatcheries have already been supplied to 26 states. The Portable Hatchery has widely been used for research experiments, demonstrations, instruction as well as for fish seed production.

The National Training Programme comes at an opportune time to assess the current status and to impart knowledge on various aspects of the technology. The programme has been so designed as to give an in-depth exposure to the prospective operators of the hatcheries. Experts in the field of aquaculture technologies will deliver lectures and conduct practical sessions. This compendium is a collection of all those lectures and notes which will be made available to the participants. I am sure this will serve the best interest of the end-users of the technology. I am thankful to all those who have contributed to this compendium.

Bhubaneswar
7 July 2015

(P. Jayasankar)
Director
ICAR-CIFA

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Present Status of Freshwater Aquaculture in India

P. Jayasankar, B.C. Mohapatra and B.R. Pillai

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Introduction

Aquaculture is the fastest growing animal food-producing sector, growing at a rate more than 6% annually and accounting for more than 50% of the world's food fish (FAO, 2009). The global fish production from both capture and culture was 158 million tonnes in 2012 (FAO, 2014). The contribution from aquaculture to the world total fish production was 42.2 percent (90.43 million tonnes including 66.63 million tonnes of food fish, 23.78 million tonnes of aquatic algae and 22,400 tonnes of non-food products like pearls and shells, etc.). With the tremendous increase in demand for fish and stagnation or steady decrease in capture fish production, the importance of aquaculture has increased. A number of studies have pointed a positive scenario for the role of aquaculture in providing the much-needed animal protein to the world population. Recognised as a powerful income and employment generator, aquaculture stimulates growth of a number of subsidiary industries and is a source of cheap and nutritious food, besides being a foreign exchange earner (Ayyappan and Krishnan, 2004).

Aquaculture in India has evolved as a viable commercial farming practice from the level of traditionally backyard activity over last three decades with considerable diversification in terms of species and systems, and has been showing an impressive annual growth rate of 6%. Now, India is the second largest fish producer of the world both in total production and aquaculture production. The total production from aquaculture was 4.2 million tonnes out of this inland aquaculture contributed 3.8 million tonnes, which is more than 90% (FAO, 2014). Indian aquaculture has demonstrated a six and half fold growth over the last two decades, with freshwater aquaculture contributing over 95 per cent of the total aquaculture production. The three Indian major carps, namely catla (*Catla catla*), rohu (*Labeo rohita*) and mrigal (*Cirrhinus mrigala*) contribute the bulk of the production, followed by silver carp, grass carp and common carp forming a second important group. Average national production from still water ponds has increased from 0.6 t/ha/year in 1974 to 2.9 t/ha/year at present, with several farmers even demonstrating production levels as high as 8–12 tonnes/ha/year. Aquaculture contributes substantially to the domestic food security of India which has a *per capita* fish consumption of 11 kg. With freshwater aquaculture being a homestead activity in several parts of the country, besides adding to the nutritional security, it also helps in bringing additional income to rural households.

With huge natural resources like 2.42 million ha of ponds and tanks; 1.07 million ha of beels, jheels and derelict waters; 0.12 million km of canals; 3.15 million ha of reservoirs and 0.72 million ha of upland lakes that could be utilised for aquaculture purposes India has excellent chances of doubling fish production in the next five years. Ponds and tanks are the prime resources for freshwater aquaculture, however, only about 0.8–0.9 million ha is used for aquaculture currently. Ponds in eastern India are typically homestead ponds of less than 1 ha in size. In several parts of the country ponds and tanks are state-owned or communal and are leased out for periods of 3–5 years. All these offers great scope for horizontal expansion of aquaculture.

Rapid expansion of the freshwater aquaculture sector across all parts of the country though has been visibly demonstrated, the increasing role played by the sector in poverty alleviation, livelihood support and nutritional security has often been ignored due to the lack of documentation of the relevant information. This sector provides direct or indirect employment to as many as 14 million people of the country. About 1.3% of the landowning households are reported to be involved in the aquaculture activities and estimated 1.1 million farming households are involved in aquaculture. Aquaculture generates income and employment opportunities across the chain of seed production, fish culture, fish harvesting, input supply, trading, marketing as well as processing. Globally, aquaculture is being seen as antidote to fight poverty and malnutrition. Many developmental programmes like MGNREGS, Watershed development etc. consider aquaculture as a means to enhance the overall impact on the poverty alleviation in rural areas.

The culture systems adopted in the country vary greatly depending on the inputs available in any particular region as well as on the investment capabilities of the farmer. While extensive aquaculture is carried out in comparatively large water bodies with stocking of the fish seed as the only input beyond utilizing natural productivity, elements of fertilization and feeding have been introduced into semi-intensive culture. The different culture systems such as Composite carp culture; Sewage-fed fish culture; Weed-based carp polyculture; Biogas slurry-fed fish culture; Integrated fish farming with poultry, pigs, ducks, horticulture, etc.; and Pen culture have been standardized with optimum achievable production rates of 3–6 tonnes/ha/yr. Intensive culture systems like Cage culture and Running-water fish culture have given productions of 10–15 and 20-50 kg/m^2/yr respectively. The major concern now is that of diversification, at present there are only a hand full of major species being cultured even though the country possesses several endemic potential and cultivable medium and minor carp species having regional demand, such as, *Labeo calbasu, L. fimbriatus, L. gonius, L. dussumieri, L. bata, Cirrihinus cirrhosa, C. reba, Puntius sarana, P. jerdoni.* Efforts are being made to standardize the technology of mass-scale seed production of these species and their inclusion as a component of conventional carp polyculture, based on their regional importance.

Culture of Carps

Carp culture was initially based around the 'polyculture' of the three Indian major carps (catla, rohu and mrigal) as well as 'composite carp culture' of the three Indian major carps with the three exotic carps (silver carp, grass carp and common carp). Standard practices in carp culture include: i) pond preparation and fertilization with organic manures from cattle or poultry as well as inorganic fertilisers like urea and single super phosphate; ii) the stocking of carp at combined densities of between 4,000–10,000 fingerlings/ha; and iii) provision of supplementary feeds mainly in the form of a mixture of rice bran/wheat bran and groundnut/mustard oilcake in equal ratio. However, slowly the progressive farmers in West Bengal and AP moved to two species culture (rohu and catla) with rohu being the main species (80 to 90%) and catla as a minor component (10-20%). The average production is around 4 to 6 tonnes/ha in case of semi-intensive culture and production to the tune of 10 to 12 t/ha has been reported from many parts of the country.

Culture of Catfishes

Due to their unique taste, catfishes are considered a delicacy for fish consumers. The major chunk of catfish, however, comes from capture resources, which includes air-breathing and non air-breathing varieties. Amongst the catfishes, *Clarias batrachus*, an obligatory air-breathing catfish known as magur is the most preferred indigenous catfish in India. The culture of magur obtained impetus by the standardization of its breeding and grow-out farming techniques at ICAR-CIFA, Bhubaneshwar. The fish is currently propagated on a large scale along the north-eastern regions, mainly the State of Assam and Manipur. Twelve hatcheries are in place along the region. In recent years the Government of India has also identified catfish farming as a national priority and has emphasized on diversification of culture practices. Though modern farming techniques for these species advocates monoculture at stocking densities of 20,000–50,000 fingerlings/ha, inadequate availability of juveniles has restricted these as a component in carp polyculture systems. Considering the high market demand for catfish and the availability of a huge potential resource in the form of swamps and derelict waters, commercial farming of these species are being given important attention at present. In recent years, attempts have been made to develop the culture of non-air breathing catfishes like *Pangasius pangasius*, *Wallago attu* and *Ompok pabda*.

Culture of Other Finfishes

The other finfish species of importance include climbing perch (*Anabas testudineus*), murrels (*Channa striatus* and *C. marulius*) and tilapia (*Oreochromis mossambicus* and *O. niloticus*). In India, 13 species of snakeheads (Murrels) have been reported. Among them *Channa striatus*, *C. marulius* and *C. punctatus* are commercially important. Murrels are always in great demand in several states of India. It fetches very high price in the states of Andhra Pradesh, Karnataka, Tamil Nadu, Assam, Bihar, Jharkhand, Uttar Pradesh, Haryana, Punjab and Madhya Pradesh and are considered as popular food fishes with high medicinal value. These fishes are marketed in live condition as they can be kept out of water for several hours in moist condition. Murrels are preferred by consumers due to its flavour, meaty flesh with few intra muscular bones and medicinal properties. The culture practices of murrel has not received much attention mainly due to the non-availability of adequate quantity of seed, difficulties of larval rearing and absence of proper feed for culture practices. The ICAR-Central Institute of Freshwater Aquaculture has developed techniques for developing brooders in concrete tanks, captive induced breeding and seed rearing of striped murrel. At present, the ICAR-CIFA is focusing on development of grow-out culture technology of striped murrel.

Culture of Freshwater Prawn

Among the cultivable freshwater prawns, *Macrobrachium rosenbergii,* the giant river prawn completely dominated the commercial freshwater prawn culture due to its superior cultivable attributes such as very fast growth, high market demand, hardiness, euryhaline nature and its compatibility to grow with cultivable fin-fishes such as Indian major carps, tilapia and catfishes - a viable option for enhancing farm income. The farmed production of *M. rosenbergii* in India has shown phenomenal increase since the mid-nineties until 2005. The production of this species increased from less than 178 tonnes in 1996 to 42,870 tonnes in 2005. Monoculture of *M. rosenbergii* has produced production levels of 1.0–1.5 tonnes/ha in a 7–8 month production cycle. However, the production has been declining since 2006, and in 2010 it was only 3,200 t. A reduction in the productivity in major culture areas due to slow growth and poor survival was the main reason for the decrease in production. The genetic deterioration of brood stock was perceived as one of the major contributing factors to the productivity decrease. Thus a systematic selective breeding program aimed at improving growth rate of this species was very much needed. Therefore, ICAR-Central Institute of Freshwater Aquaculture (CIFA), Bhubaneswar in collaboration with the WorldFish, Malaysia started a systematic selective breeding programme for improving the growth rate of *M. rosenbergii* in 2007. This was the first family based breeding programme for this species in India and it was successful in producing the first genetically improved freshwater prawn through family based selective breeding. With the availability of the improved breed it is hoped to revive the farming of *M. rosenbergii.*

Non-conventional Culture Practices

Sewage-fed fish culture and paddy-cum-fish culture are two important culture systems practiced in certain areas of the country. Sewage-fed fish culture in bheries in West Bengal is an age-old practice. About 5,700 ha is presently utilised for fish culture using the input of primary-treated sewage and produces over 7,000 tonnes of fish per annum, mainly consisting of the major and minor carps. The culture system usually involves multiple stocking and multiple harvesting approaches, with harvest size usually in the range of 300–500g. Though stocking densities of 10,000–20,000/ha are common, densities as high as 50,000/ha has also been reported from several farms.

Paddy-cum-fish culture is undertaken in medium to semi-deepwater paddy fields in lowland areas with fairly strong dykes to prevent the escape of cultivated fish during floods. Trenches and pond refuges in the paddy fields provide shelter for the fish. The system mostly relies on natural stocking, however, modern farming techniques involving major and minor carps stocked at the densities of 5,000–10,000/ha alongside freshwater prawn are also practiced in several areas. Production levels of 3.5 tonnes of rice and 0.5–1.0 tonne of fish/ha can be achieved in a well-managed paddy-cum-fish farming systems within a year.

Fish Seed Production

Since the latter part of the fifties, Indian scientists have successfully achieved artificial breeding of Asiatic carps (including major Indian and Chinese carps) by application of the hypophysation technique. This achievement has significantly contributed to the methodology of fish seed production and supply of right kind of fish seed to the farmers. The once highly skill-demanding induced breeding technology has been popularized as a more user friendly one which helped it spread across the length and breadth of the country. The easy availability of synthetic hormone formulations further has given fillip to the seed production. At present, more than 1100 fish hatcheries are operating in the country in both public and private sectors. Total carp fry production increased from 409 million during 1973-74 to 36,566 million in 2011-12 making in the fry production of carp. CIFA is also credited with development of technique for offseason breeding of carps ensuring expanded breeding season and round the year availability of right kind of seed.

Present Scenario

The freshwater aquaculture sector in India has undergone rapid changes in recent years. It is slowly and steadily moving away from the Indian Major Carps dominated scenario. As more and more educated men are entering into this field they are evaluating new technologies and bringing in new species from across the state or abroad and rapidly intensifying the culture. It is the economic returns that solely decide the culture species, system and practice. Although IMC continues to be the largest cultivated species group there are several new entrants in the culture sector. Alien or non indigenous species like Pangassius has shown tremendous growth in states like West Bengal and Andhra Pradesh. *Pangasianodon hypophthalmus* (striped catfish) is one of the swift growing catfishes was first introduced into India in the year 1995–1996 in the state of West Bengal from Thailand through Bangladesh. Initially farming was carried out in limited area in the States of West Bengal and Andhra Pradesh. This fish grows to 1–1.5 kg during one year. A minimum of 10–15 tonnes/hectare/year is harvested from the culture of this fish. Due to its fast growth and high production potential farmers got attracted to culturing this species and within a short period the production of Pangassius increased to nearly five lakh tonnes in 2010. This unregulated increase and over production has led to a crash in prices and loss to farmers. Now the production has come down and still farm gate price has not improved and profit margins has comedown drastically. Still the production in 2013-14 was nearly 3,50,000 tonnes. Another such non-indigenous species that is being widely cultured in India include pacu (*Piaractus brachypomus*) and Tilapia and vannamei shrimp. The Government of India has permitted the exotic *Oreochromis niloticus* in aquaculture in late 2012, prescribing certain guidelines as a part of diversification of species for increasing overall fish production levels of the country. In addition, this fish represents lower level in food chain, and thus its culture would be economical and eco-friendly. As per guidelines, farming of only monosex male/sterile (through either hormonal manipulation or cross breeding) is permitted and species recommended is Nile tilapia or improved strains/hybrids of tilapia.

In future, aquaculture will be more technology and input based with greater intensification per unit water bodies to produce more fish per unit area. In this context setting up of more fish feed production units at suitable locations along with mapping the potential agro-based feed ingredient availability in various zones of the country and a database on their nutritive values and nutrient digestibility would be a major step ahead.

Future Prospects:

Growth in population, urbanization and increase in per capita income in a country has always been associated with an increase in consumption of animal product and fisheries products in particular. Therefore, the existing fish eating population at about 60% in our country is all set to increase with the current trend of increase in the per capita income. At present fish constitutes 6% of total food budget in India. Since poor households respond more positively to the higher income, a significant shift in the demand for fish is expected in the coming years. Further, the current income elasticity for fishes being at 1.66 indicates that with the increase in income, people would spend more on fish and relatively less on other types of meat. The projected additional demand for fish in India by 2020 is about 3.21 million tonnes out of which about 90% is expected to be met from the freshwater sources comprising Indian major carps (rohu, catla and mrigal) (52%) and other freshwater fishes (38%). In other words these fishes will play a greater role than even today in meeting the demand of the country. By 2030 it is expected that there will be a need to increase aquaculture production further by three times from the present level to meet the demand. Therefore if supply does not commensurate increase in income of the poorer section there will be rise in the price which will obstruct the consumers and consumption.

Technological backstopping from CIFA for increased food security

For ensuring nutritional and food security through aquaculture, a technology-driven and need based strategy has to be adopted. Enabling technologies developed in research institutions should percolate to the farming community, and once demonstrated in farmers' ponds and convince them, they could easily be adopted. Following technologies have been developed at CIFA, which would hope to help the freshwater aquaculture sector of the country and lead to greater food security.

a. Improved rohu, Jayanti

Jayanti rohu is an improved breed of rohu fish (*Labeo rohita),* the most preferred major carp. It was developed through selective breeding, from five different populations of rohu from of North Indian rivers. Jayanti rohu is the first genetically improved fish in India and was extensively field tested in Kausalyaganga State fish farm (Odisha), Vijayawada (Andhra Pradesh), Rahara (West Bengal) and Ludhiana (Punjab). It has shown a selection response of 17% per generation for growth trait. Dissemination of improved rohu to different parts of India is under progress. Annually about 3 crores of seed of this improved variety are supplied presently to the sector. Mechanism like establishment of more Multiplier hatcheries and the recently formed National

Freshwater Fish Brood bank facility (NFFBB) in Odisha would pave the way for increased dissemination of improved variety of fish seeds to the farming community.

b. CIFAX

CIFAX is a chemical formulation and the first commercialized technology of ICAR-CIFA. It prevents and cures the ulcerative diseases of freshwater fishes. ICAR-CIFA recommercialized CIFAX to M/s Agrawal Trading Company, from Chhattisgarh for Rs.227 lakhs for manufacturing, distribution and marketing the technology throughout the India. CIFAX is popular among the fish farmers and is doing well in the market since last 16 years. CIFAX has become a boon to the fish farmers for preventing and treating ulcer diseases of fishes. It controls the bacterial infections in freshwater fishes. Farmers across India have been benefitted by its application.

c. Immunoboost C

Immunoboost-C is an immunostimulant to improve brood fish health and seed production. It modulates the fish immunity against microbial diseases and has been proven through extensive trials conducted at many aquaculture regions in India. This preparation is marketed by M/s Star Aqua Lab, Medinapore, West Bengal.

d. CIFACURE

CIFACURE is used for controlling bacterial and fungal infections of ornamental fishes. This product can be very well used in the aquarium and other outdoor tanks. It can control many bacterial diseases like hemorrhagic septicemia, ulcers, fin rot, tail rot, eye disease and fungal infections. This product is marketed by M/s Durga enterprises, Bhubaneswar, Odisha.

e. FRP portable hatcheries

Fiberglass Reinforced Plastic (FRP) carp hatchery has proved to be a very effective tool in quality carp seed production which will be beneficial to the farmers. It can be transported, installed and operated in remote places to ensure easy and timely availability of seeds. FRP hatchery is suitable for fish breeding in field conditions for 10-12 kg of female carps in one operation. The portable magur hatchery is a simple device comprising a stand on which are placed a row of plastic tubs (12 cm dia, 6 cm high). It includes egg incubation and hatching. The technology creates a suitable environment for high hatching percentage & maximum 50,000 eggs can be incubated at a time. Both the hatcheries are marketed by M/s M. R. Aquatech, Bhubaneswar, Odisha.

f. CIFACRYO

This is a manually operated handy cryofreezer for gamete cryopreservation of fishes. This is suitable and advantageous in terms of liquid nitrogen use, size of the unit, on-farm utilization and easy operation. It is helpful in maintaining the temperature of the sample up to -196^0 C. This product is marketed by M/s Biotechnika, Bhubaneswar.

g. CIFABROOD™

CIFABROOD™ is an exclusive carp brood stock diet rich in adequate nutrients. It ensures quality of the carp seed, and advances gonad growth and maturation and facilitates early spawning. It is suitable for multiple/repeated breeding in carp and ensures better survival of seed and rapid growth during nursery rearing. It is also economically viable and validated through repeated field trials. Recently this product has been commercialized and is marketed by M/s Aishrya Aquaculture Pvt. Ltd., Naihati, West Bengal.

h. Starter-M

"Starter-M" is nutritionally balanced and highly palatable for baby magur, which ensures faster growth and high larval survival. It is stable in aquatic environment.

i. Spot Agglutination Kit

This kit is useful in the diagnosis of bacterial gill disease, Aeromoniasis and Edwardsiellosis in fish through detection of antibodies. It is quite user friendly for common fish farmers.

j. White Tail Disease Diagnosis Kit for Freshwater Prawn

White tail disease detection kit, based on nested PCR method for RNA segment II is a sensitive and specific diagnostic tool that can detect carriers and early or latent infections. It detects up to four virus particles and is highly sensitive and specific for virus detection. The entire procedure can be completed within a day.

k. Rohu catla hybrid identification kit

Hybridization of principal carp species is counterproductive to industry as well as natural biodiversity conservation. The PCR-based kit developed by the institute can unambiguously detect hybrids of rohu and catla at any life stages.

l. Mechanical Pond Applicator (MPA)

Mechanical pond applicator (MPA) mechanically spread the inputs uniformly in the pond and effectively reduces the manpower requirement for the culture operation. It ensures uniform distribution of inputs such as cow dung, poultry manure, lime, inorganic fertilisers and medicines using mechanical spraying. This is very effective for large ponds of more than 1 ha water area.

m. FRP Demand Fish Feeder

This product is made-up of FRP material. Fish fed by the demand feeder gained an average of 12.61% more weight than hand-fed fish. It is maintenance free and easy to operate. Use of FRP demand fish feeder can save the substantial cost of feed and man hours for feeding.

n. Mobile Aeration Device

Mobile aeration device, run by diesel is useful for large aquaculture ponds to supplement natural sources of dissolved oxygen during culture period. The process of aeration is highly efficient since the dissolved oxygen level of the pond water is found almost double of the initial dissolved oxygen content in just 2 h. The equipment is simple to construct, easy to maintain and cost effective

o. Post-Harvest Technology

Boneless whole carp technology has been developed, resulting in ready to use product. About 60-70% edible portion in table sized carps is retained. This is good fast food item for carry home packs. Similarly value added products, such as fillets, fingers, steaks and chunks are produced from murrels.

p. Breeding and Culture Technologies for Diversified Species

Breeding and culture technologies of diversified groups of freshwater species, such as minor carps, catfish, pabda, freshwater prawn, climbing perch and murrel have been developed to ensure food security.

Conclusions

It is expected that the fish requirement by 2025 would be of the order of 16 million tonnes, of which at least 12 million tonnes would need to come from the inland sector and aquaculture is expected to provide over 10 million tonnes. Indian aquaculture has to come up with timely strategies to cope with the future challenges of increased fish demand, selective consumers' choices, production of safe and quality fish protein, tapping the export earning, etc. These all have to be done in the face of increased land and water scarcity, competition from other agriculture sector, labour and raw materials shortage, besides satisfying the code of conducts for responsible aquaculture and HACCP in farming. Therefore, the researchers and development machineries in the freshwater sector have their task cut out to maintain pace of the aquaculture development at sound level and to ensure quality fish protein to the increasing populace of the country, which they will do as is being done in last few decades.

Portable FRP Hatchery Technology and Its Adoption in India

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Introduction

The earlier part of 20th century has witnessed the carp seed collection from Bundhs and riverine resources by adopting different devices and collection methods. In India for the first time in 1957, carps were induced bred in captivity by administering carp pituitary extract. The breeding of carps, hatching of eggs and rearing of hatchlings up to spawn stage were carried out in different rectangular hapas made up of cloth. They were fixed in the pond for clear oxygenated water. In hapa system, the entire operations were weather dependent and subject to various environmental hazards. During seventies, glass jar hatching units of various capacities were designed and made to use successfully for hatching. The system had its own drawbacks for commercial seed production. During eighties, the carp eco-hatchery technology got familiar in India. During nineties, different models of hatcheries with different materials (HDPE, PVC, LDPE liner, Ferro-cement, etc. in various shapes and sizes) came to the existence with certain degrees of success at research level, but, they could not penetrate to the grassroots levels. The ICAR-AICRP on Plasticulture Engineering and Technology, centre at ICAR-CIFA, Bhubaneswar has designed and developed the complete set of hatchery system in FRP for carp fish breeding and hatchery rearing of seed (CIFA, 2004 & 2005; ICAR, 2005; Mohapatra *et al*., 2003; 2004; 2005, 2007, 2008 & 2011a). In one operation it can produce 1.0 - 1.2 million carp spawn. In lean season the system can be used for ornamental fish rearing or common carp breeding or water storing. The unit can be operated by unemployed youth, Gram Panchayat and Cooperative Society on self-operational / rental basis. The innovation of this technology is contributing substantially to the blue revolution and biodiversity conservation of the country by producing fish seed at the desired places. Its introduction is reducing the transportation difficulties and uncertainties in getting stocking material from different far off places to the aqua-farm sites.

The developed system has several merits like:

- easy for transportation to different farm sites,
- easy installation and operation,
- low water consumption during fish breeding and spawn production,
- easy to repair,
- less space requirement for installation, and
- less weight and durability of the product for 10-15 years.

Many fish species are in decline and some are going to be endangered due to combination of over-exploitation, contamination of their natural habitats due to pollution, uncontrolled introduction of exotic fish species, habitat modification due to river-valley projects, excessive water abstraction and siltation, etc. In India 320 fish species comes under threatened categories (Lakra, *et al*., 2010). The conservation measures of these species can be achieved through declaration of their habitats as biospheres, zoological parks, and ranching of pure fish seed through artificial or induced breeding. FRP carp hatchery is the best gadget for transportation to the destination in any corner of India for induced breeding of endangered freshwater fish species.

Portable FRP carp hatchery set up

The system (Fig.1) consists of four major parts *i.e.,* breeding/ spawning pool; hatching/ incubation pool; egg/ spawn collection chamber, and overhead storage tank/ water supply system.

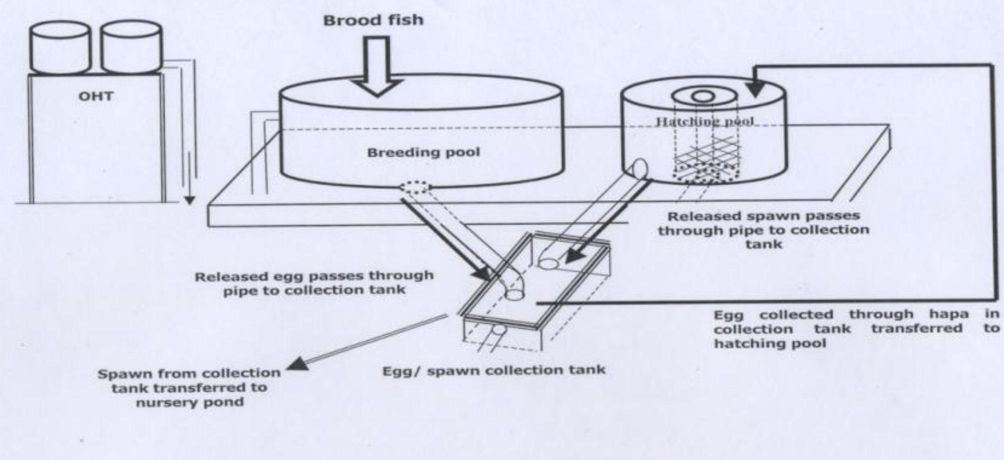

Fig. 1. Diagram of FRP Carp Hatchery

i. Breeding/ spawning pool

The breeding pool is cylindrical in shape with 2.15 m diameter, 0.9 m height and 3409 liter capacity (operation capacity: 2950 liter). The bottom is with uniform slope (1:22) towards outlet at the centre. The wall thickness varies 4.2 – 6.0 mm. To provide water circulation/flow, 5 numbers of 15 mm diameter rigid PVC elbows are fitted at the bottom of the sidewall at equal spacing. Five numbers of rigid PVC nipples 15 x 75 mm are fitted with elbows in the same direction. A single point water inlet of 25 mm diameter is also fitted at the sidewall of the bottom. All the water inlet pipes are interconnected and fitted with individual full-way valves to control the flow of water. One shower is provided at the top of the tank to sprinkle and aerate the water. The water supply to the pool comes from the overhead tank. The system is suitable for breeding 10-12 kg of female carps in field conditions. The breeding success has been recorded at cent percent level in various carp species. The flow rate during egg collection is maintained in the pool at 1-1.5 l/sec. depending on species.

ii. Hatching/ incubation pool

The pool is cylindrical in shape with 1.4 m diameter, 0.98 m height and 1200 liter net egg incubation volume. It consists of egg incubation chamber, FRP inner chamber, water supply system and accessories. The FRP inner chamber of the tank is with 0.4 m diameter and 89 cm height, covered with nylon bolting cloth of 0.25 mm mesh to filter the excess water to the drain. Five numbers of RPVC (15 mm diameter) duck-mouths are fitted at the bottom of the hatchery at 45^o in between outer and inner chamber at equal distances to get required water flow for the eggs. It has drainage outlets fitted at the centre and at the outer chamber for draining and cleaning purposes. The carp eggs are introduced in the outer chamber of the system and water flows continuously through the duck-mouths. The excess water flows continuously through the cloth of the inner chamber to the outlet pipe. The carp eggs hatch out in 14-18 hour and remain in the pool for 72 hour. The spawn is collected from the hatching pool through PVC hose pipes/spawn collection tank. It has the capacity of hatching 1.0-1.2 million eggs per operation. The flow rate in the pool during operation is maintained at 0.3-0.4 l/ sec.

iii. Eggs/ spawn collection tank

This is a rectangular tank of size 1.0 × 0.5 × 0.5 m with capacity of 250 liter. Its wall thickness is 3 mm and is reinforced with MS angle of 25 × 25 × 5 mm at all sides from the bottom in a height of 0.35 m. The water level in the tank is maintained at a height of 0.45 m (net water volume 225 liter). To drain the excess water, PVC pipe of 63 mm diameter and 150 mm length is fitted at a distance of 38.7 cm from the bottom. Cotton inner hapa of the tank size is fixed inside it to collect eggs/ spawn from breeding/ incubation pool, respectively.

iv. Overhead water tank

Water storage tank of minimum capacity 2000 liter is required to operate the hatchery unit. The breeding pool and hatching pool are connected to the water storage tank separately or together in the same water line. One 1.0 HP pump set is required to fill the storage tank periodically to supply water to hatchery continuously.

Release of the technology

His Excellency the Governor of Odisha, Shri Rameshwar Thakur on 14 July 2006 at ICAR-CIFA, Bhubaneswar, Odisha, India released the FRP Carp Hatchery Technology to the nation.

Commercialization of the technology

FRP Carp Hatchery Technology was commercialized by ICAR-CIFA, Bhubaneswar for the first time in 2006 and for the second time in 2013.

Popularization of the technology in India

The graph (Fig.2) shows the number of hatchery units established across the country from the year 2003 to 2014. Till December 2014, there are 293 hatchery units established with as high as 73 units in the year of 2013 alone. There is growing confidence of the technology adopters from the date of commercialization of the technology in 2006. By now 26 states of the country has adopted the technology.

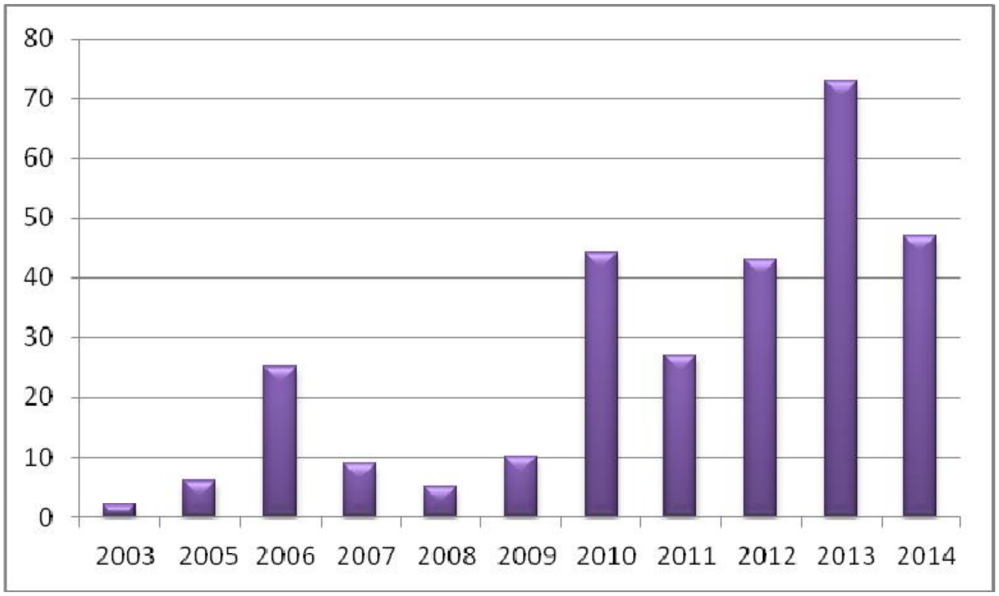

Fig. 2: No. of hatchery units established (year wise) across the country

Geographically, the portable FRP carp hatchery units have been installed and benefited to all regions of the country (Fig.3).

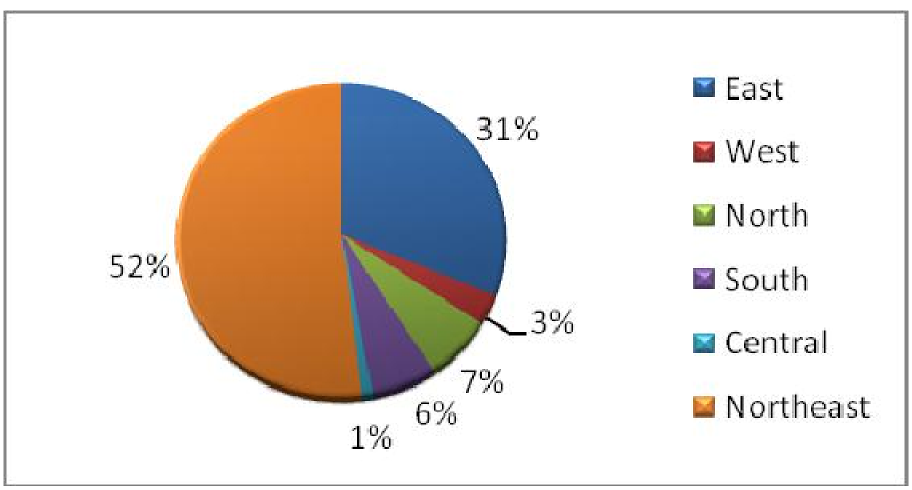

Fig.3. Dissemination of portable hatchery technology across the regions

Around 52% of the total installations were done in Northeast region of the country, where fish is in high demand. The next important region to which the technology penetrated is Eastern region, where 31% of the installation was done.

Species suitable for breeding

The system is suitable in field conditions for breeding of most of the cultured carps in India *viz.,* Rohu (*Labeo rohita*); Catla (*Catla catla*); Mrigal (*Cirrhinus mrigala*); Kalbasu (*Labeo calbasu*); Fimbriatus (*Labeo fimbriatus*); Silver carp (*Hypothalmichthys molitrix*); Grass carp (*Ctenopharyngodon idella*); Common carp (*Cyprinus carpio*); etc (Mohapatra *et al*., 2011b & 2013). With some modifications, this system has been used for breeding of Magur (*Clarias batrachus*); *Pangasianodon hypophthalmus*; Pabda (*Ompok bimaculatus*); Tengra (*Mystus vittatus* & *M. gulio*); Silver barb (*Puntius* sp.), etc. In lean season the system can be used for ornamental fish rearing or common carp breeding.

Operations and Economics

Based on the number of hatching pool, the hatchery system is either one, two or three million capacity of spawn production per operations of hatchery (four days). In the hatchery the spawn (final product from hatchery) is harvested on 4th day during operation. Fertilized eggs are kept in hatching pool for incubation and it takes 14-18 hours for hatching, and then after 72 hours for transformation to spawn. Thus, four days are required for spawn production from one million capacity unit. It can produce two and three million spawn in four days with the two and three breeding pools, respectively.

The economics of hatchery operations is dependent on many factors like capacity of hatchery, level of use of the gadget, price of inputs and outputs, availability of brood stock, regions of operations, season of operations, etc. The average cost and benefits of the operations of hatchery is presented in Table 1.

Table 1. Economic of hatchery operation (Price in Rupees)

Sl. No.	***Items***	***1.0 million spawn capacity***	***2.0 million spawn capacity***	***3.0 million spawn capacity***
I.	***Expenditure***			
A.	***Fixed Capital***			
1.	*FRP Carp hatchery*	*1,00,000*	*1,45,000*	*1,90,000*
2.	*FRP water storage tank*	*15,000*	*22,000*	*30,000*
3.	*1 HP single phase mono block pump set*	*10,000*	*10,000*	*10,000*
4.	*Miscellaneous accessories*	*5,000*	*6,000*	*7,000*
	Sub-total	***1,30,000***	***1,63,000***	***2,33,000***
B.	***Variable Cost per Cycle***			
1.	*Brood fish (@ 50/kg)*	*1,000*	*2,000*	*3,000*

2.	*Electricity and fuel*	*200*	*300*	*400*
3.	*Inducing agent*	*325*	*650*	*975*
4.	*Wages (@ Rs. 100/day for 8 man-days per operation i.e., 4 days)*	*800*	*800*	*800*
5.	*Miscellaneous*	*175*	*250*	*350*
	Sub-total	***2,500***	***4,000***	***5,525***
C.	***Total Costs***			
1.	*Total variable costs (20 cycles)*	*50,000*	*80,000*	*1,10,500*
2.	*Depreciation on fixed cost @ 10% yearly*	*13,000*	*16,300*	*23,300*
3.	*Interest on fixed capital @10% per annum*	*13,000*	*16,300*	*13,000*
	Grand Total	***76,000***	***1,12,600***	***1,46,800***
II.	*Gross Income (per Cycle)*			
	Sale of spent brood (@ Rs. 40/kg)	*600*	*1,200*	*1,800*
	Sale of spawn (avg. @ Rs. 600/ lakh)	*6,000*	*12,000*	*18,000*
	Sub-total	*6,600*	*13,200*	*19,800*
	Gross Return (for 20 cycle)	***1,32,000***	***2,64,000***	***3,96,000***
III.	***Net Income*** *(Gross income - Total costs)*	***56,000***	***1,51,400***	***2,49,200***

Acknowledgement

The authors are thankful to the Indian Council of Agricultural Research for financial assistance through AICRP on Plasticulture Engineering and Technology. The authors are also thankful to the Director, ICAR-Central Institute of Freshwater Aquaculture, Bhubaneswar for support to carry out the work.

Installation Guidelines for FRP Carp Hatchery

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ICAR-AICRP on Plasticulture Engineering & Technology formerly known as Application of Plastics in Agriculture at ICAR-CIFA, Bhubaneswar has designed and developed a complete unit of hatchery system in FRP for carp fish breeding and hatchery rearing of seed. The FRP carp hatchery technology got commercialized and released to the nation during 2006. To make aware the users of the technology, for its easy installation and dismantling, operation and precautions to be taken, this chapter has been prepared and placed in this training manual for the benefits of the users of the technology.

Proper installation of the FRP hatchery unit at one place for a longer period requires a platform. The platform should be strong enough to withstand the pressure of the hatchery unit placed over it. The height of the platform should be such that eggs/spawn are collected in collection tanks through pipes by gravity flow only. For stability construct the periphery wall with bricks/stones masonry (1:4) from 2 feet below the earth surface up to 1.5-2 feet above the ground level. Fill the platform with coarse sand up to 2 feet to give the strength. The top surface of the platform may also be provided with 4 inch concreting (1:4:8) to make more durable and strong. If the hatchery needs repeated shifting, platform construction is not required. Sand filling below the breeding pool is required to provide base strength to the pool.

Essential Components of a FRP Carp Hatchery

The complete unit of FRP carp hatchery is mainly made of fiber reinforced plastics, consisting of:

- Breeding/ spawning pool
- Hatching/ incubation pool
- Egg/ spawn collection chamber, and
- Overhead storage tank/ water supply system

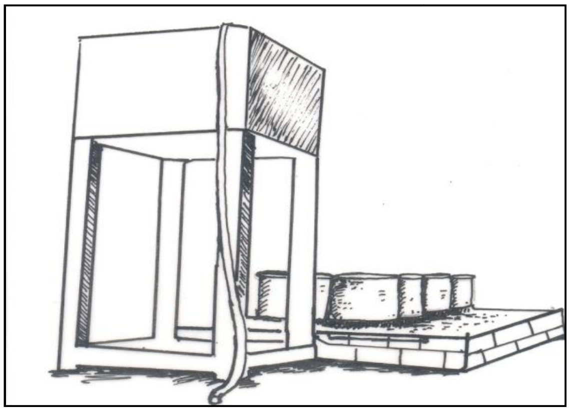
PLATFORM CONSTRUCTION

For stability construct the periphery wall with bricks/stones masonry (1:4) from 2 feet below the earth surface up to 1.5-2 feet above the ground level. Fill the platform with sand up to 2 feet to give the strength.

The platform should be strong to withstand the pressure of the hatchery unit placed over it. The height of the platform should be such that eggs/spawn are collected in collection tanks through pipes by gravity flow only.

The top surface of the platform may also be provided with 4 inch concreting (1:4:8) to make more durable and strong. The size of the platform is to be decided as per the size of the hatchery unit. It is essential to keep at least 0.5 m distances around each pool as a working space. For example a hatchery unit (breeding pool 2.15 m diameter and incubation pool 1.4 m diameter) requires a platform of size 6.0 x 4.0m.

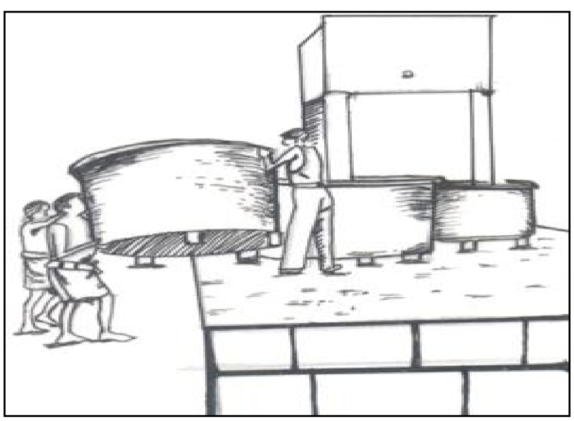
OVERHEAD TANK



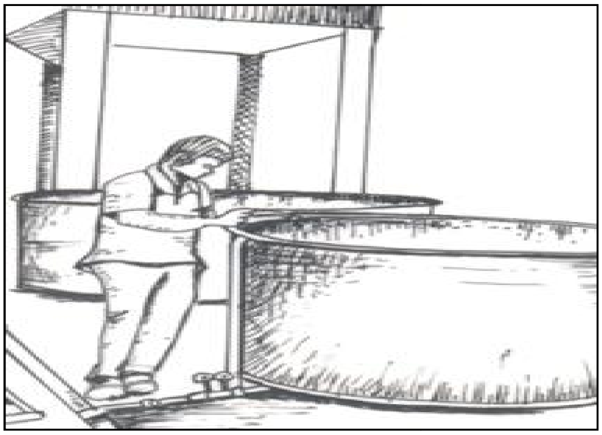
The water retention capacity of over-head tank should be 2,000l or more for one set of hatchery (one breeding pool + one hatching pool). These tanks can be made of any material like PVC, RRC, bricks, etc. and it can be rectangular or circular in shape. The height of the tank should not be less than 10 feet to provide required flow and velocity in the hatchery for its efficient operation.

FITTING OF FRP HATCHERY

Place the breeding pool near to the overhead tank. Place the hatching pool next to breeding pool.



If you need more hatching pool then place next to the hatching pool. The hatching pool is slightly declined towards the spawn collection pipe. Keep all the breeding and spawning pools in a straight line.



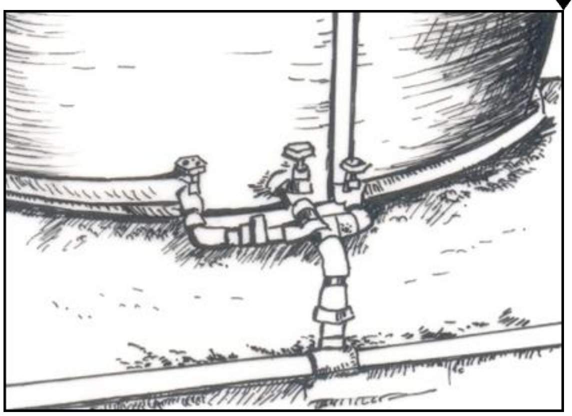
Fit the inlet pipe of the pool to the overhead tank. Place the egg/spawn collection chamber to the side of egg/spawn collection pipe.

Fix the shower on the top of the pool to the pipeline connected to central inlet assembly

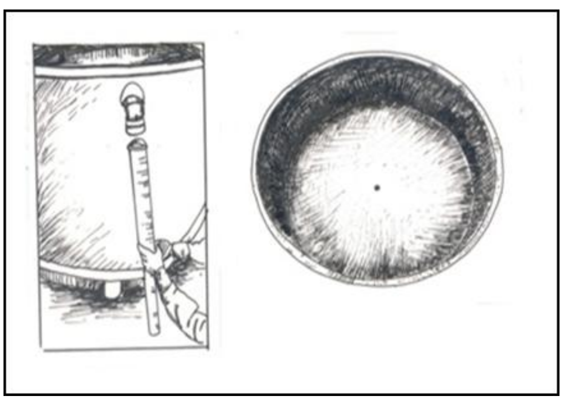
BREEDING POOL ASSEMBLY

Keep the breeding pool on the platform (possibly to the left side of the platform). Its bottom outlet pipe should face towards the egg/ spawn collection tank.

A single point water inlet of 25 mm diameter is also fitted at the sidewall of the bottom



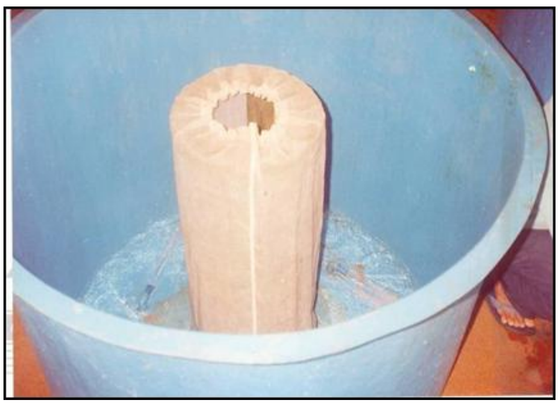
Fit all the water inlet pipes (duck mouth and single point water inlet) with individual full-way valves to control the flow of water.



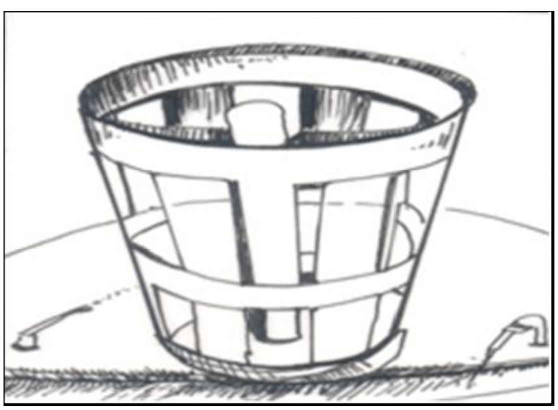
Fix the central inlet water connection lines for duck mouth, 25mm pipe line and to shower. There are two outlet system *i.e.* Overflow pipe and central outlet.

The eggs are collected from the breeding pool through PVC pipe falling to spawn collection tank.

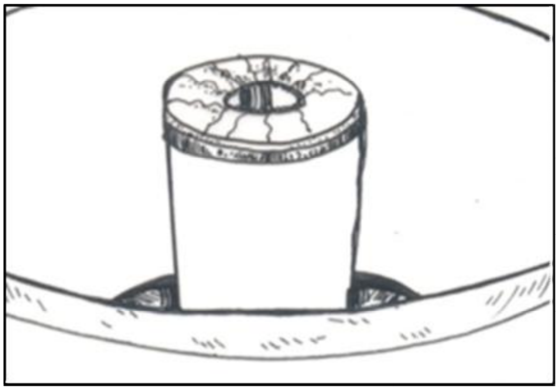
Hatching/ Incubation Pool



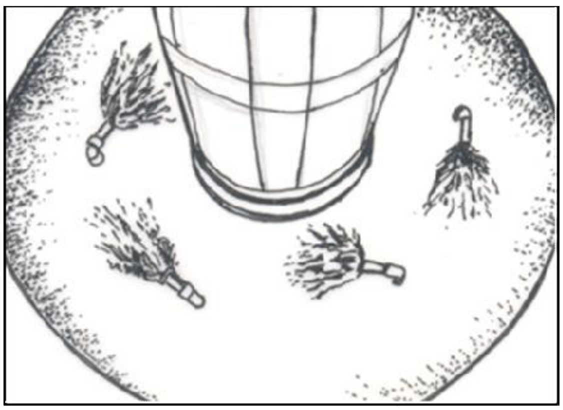
The pool is cylindrical in shape with 1.4 m diameter, 0.98 m height and 1200 liter net egg incubation volume.



Outlets fitted at the center and at the outer chamber for draining and cleaning purposes.



FRP inner chamber, covered with nylon bolting cloth of 0.25 mm mesh to filter the excess water to the drain.



Five numbers of RPVC (15 mm diameter) duck-mouths are fitted at the bottom of the hatchery at 45o angle in between outer and inner chamber at equal distances to get required water flow for the eggs.

The excess water flows continuously through the cloth of the inner chamber to the outlet pipe.

Carp Brood-stock Husbandry Management

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Mature parent fish is the foremost and essential material basis and a key factor for artificial propagation of cultivable fishes. There are available some standard brood fish rearing practices including pond management, nutrition to fish and health care for enhancing the breeding efficiency of the fish. In the traditional system, it is limited to produce brood stock only for monsoon breeding. But, the scientific brood husbandry provide the parent stock during pre-monsoon, monsoon and post monsoon months of the year for seed production.

Condition of rearing pond

Ponds should be sited in places which are free from drought and flood with sufficient water of good quality (hard water should be avoided), soil with strong ability of water conservation, sufficient sunshine and good communication facilities. For easy catching and management, it is proper have ponds each with an area of 0.2-0.5 hectare retaining a minimum of 1.2-1.5m average depth of water during summer season. The bottom of the pond should be flat for easy catching. The bottom should be of loam with some humus for regulation of fertility of water. Grass carp are fit for stocking in sand-soil pond. Catla, rohu, silver carp require fertile water in which large amount of plankton and benthos can be reproduced.

Pond preparation

Excessive mud should be removed from the ponds before stocking. At high temperature poisonous substances such as organic acids, hydrogen sulphide, methane, etc. are easily generated from the decomposition of the sediments. Ponds in which fish diseases have occurred should be sterilized in sunny days. Lime is also used for such purpose. The ponds should be free from aquatic weeds, weed fishes and predators. Suitable piscicides are mohua oil cake (200-250 ppm) or bleaching powder (20-30 ppm chlorine level). The quantity of bleaching powder can be reduced to half if combined with urea at 10 ppm level. The urea should be applied a day before the application of bleaching powder.

Various kinds of green manure are applied as base fertilizer for the regulation of water quality of the ponds after pond cleaning. Generally 3-5 tonnes of green manure are applied per hectare. The green manure is applied into the pond (at a water depth of 30-40 cm), exposed to sun for 3-5 days and after decomposition of the manure the pond is filled with water. Otherwise apply raw cowdung 5-8 tonnes, single super phosphate 100-250 kg, urea 75-100 kg and muriate of potash 50kg per hectare per year. The initial dose is one fourth of the total and the rest are splitted doses. The lime in applied based on the pH of the medium. With fertilization the plankton in brood fish pond should always be above 2ml per 50 l of water.

Sources and conditions of parent fish

The brood fish may be grown in the farm or collected from rivers, reservoirs and lakes. Healthy ones should be selected to ensure production of healthy progenies. Transportation of brood fishes from distant places for induced breeding involves difficulties such as transportation, injury and subsequent mortalities. Therefore it is better to raise them at the composite fish-seed farm itself. Parent fish should be of maturity age (2-3 years of age). The care of the brood stock is to start nearly 5-6 months earlier to the breeding season. If there are no suitable matured fish, younger fish can also be selected for further culture.

Stocking density

Reasonable stocking is one of the important measures for assuring the culture of parent fish. The gonads of parent fishes are to be completely developed and the water body is to be fully exploited. The culturable carps (major Indian and Chinese) may be stocked together at 1500-2000 kg/ha. The common carp for which no hypophysation is necessary, may be grown separately in the farm itself as a donor fish for pituitary glands. Spent breeders of preceding breeding season are reared as 'prospective brood' It is always preferred as the initial stock for multiple breeding programme. The stocking ratio may be catla 3: rohu 2: mrigal 2: grass carp 2: silver carp 1.

Rearing management

The prospective brood is to be reared in a separate pond rich in plankton. They should be treated with potassium permanganate solution (5 ppm) at regular intervals to avoid secondary infections. 20-25% water replenishment is advisable from a pond in a month. One or two months before reproduction period, water filling should be done 3-4 times each month with slight flow lasting 3-5 hours each time. The fishes should be examined periodically for their condition and for progress in maturity and freedom from parasitic condition. If the brood fish condition is not satisfactory and they are emaciated, the stock should be thinned out or the rate of supplementary feeding increases suitably. Replacement of water, re-circulation and aeration of the standing water periodically, preferably during summer months is highly desirable. Particular care should be taken to prevent the surfacing of the parent fish.

Supplementary feeding

In the pond the natural food production may not be sufficient to hold the parent stock for maturity. The brood fish have to be adequately fed with supplementary feed daily, at 1-3% of the body weight to start with. For grass carp suitable water weeds *Hydrilla, ceratophyllum* and *nechamandra* or fodder grass are to be provided 20-30% of body weight. The addition of feed should not spoil the water condition in the pond. Under optimum feeding condition, the fishes reach proper maturity and produce large number of eggs. Surplus feeding may lead to deposition of fat in the body affecting maturity adversely. A protein rich standardized formulate feed is as follows: groundnut oil cake (48%), soyabean cake (40%), rice bran (5%), fish meal (5%), calcium dibasic phosphate (1.5%), sodium chloride (0.3%), multivitamin mixture 0.1% (Sarabhai chemicals). Trace elements (0.1%) and vitamin C and E (30 mg and 200 mg/kg) daily @ 3% body weight. The other feed compositions are groundnut oil cake (70 kg), rice bran (28 kg), common salt (1.5 kg), trace elements (0.1 kg), vitamin supplement (13g/100 kg feed), vitamin C (10 g) and vitamin E (3 g). For grass carp feed ingredients required are soyabean cake 50 kg, Ground nut oil cake 25 kg, rice bran 20 kg and fish meal 5 kg.

Health care

Avoid over crowing and intensive carp culture practices to avoid stress and disease outbreak in culture ponds. In diseased condition, in situ medication may be avoided as far as possible. It is fatal to brood fish during pre-spawning and spawning period. It is better to isolate the diseased fish from the main pond. A routine prophylactic is required to avoid secondary infection during management practices. Overaged, diseased and unproductive brood if any, are replaced by the new stock. The water quality, feeding and feed quality, prophylactic measures should be monitored regularly for better parental stock.

Carp Breeding in FRP Hatchery

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Steps of Hatchery Operation

Clean the breeding and hatching pools by potassium permanganate ($KMnO_4$) solution and then by water before the hatchery operation.

⬇

Close the outlet valve of breeding pool and then fill it with water. Fix a clean cotton hapa inside it for brood fish conditioning.

⬇

Collect fish breeders male to female ratio in 1:1, transport them to breeding pool, place them in hapa and run the shower(s) for conditioning.

⬇

After 1-2 hours of conditioning, inject the breeders with suitable inducing hormone (Ovatide, Ovaprim, Ova-FH) and release them to the breeding pool, remove the hapa, cover the pool with net clothing to prevent the escape of brood fish by jumping out from it and run the shower(s).

After 4-5 hours of injection, allow the flow/ circulation of water in the breeding pool, open the outlet valve, allow the water to pass from breeding pool through the hapa of the eggs/ spawn collection tank to the outside. If eggs released from the fishes, they are collected and removed by the hapa in the eggs/ spawn collection tank. The water current and whirling effect is created in the breeding pool by regulating the water flow through the inlets and outlet.

In hatching pool fix the FRP inner socket and then fix the screen on the socket, fix the PVC drain pipe in the center of the tank to drain excess water, the height of the drain pipe in the pool is maintained at 0.9m so that, up to that height water level can be maintained, give water circulation in the egg incubation chamber through duck-mouths (inlets).

Collect the released eggs from the egg/ spawn collection tank by hapa time to time, measure them and release to the egg incubation chamber of the hatching pool. The egg release generally stops within 8-10 hr from injection to breeders.

Remove the breeders from breeding pool once the spawning is over. They may be released to the pond after dipping them in 5 ppm $KMnO_4$, clean the breeding pool by $KMnO_4$ solution and then by water.

On release of eggs maintain the flow rate in the hatching pool in such a way that the eggs float in the water (can be checked by putting light from a torch from the top of water), periodically check the eggs/ spawn, clean the filtering mesh by a brush with long handle from the side of inner chamber to avoid water choking.

On 4th day collect the spawn through hapa in the eggs/ spawn collection tank by opening the outlet valve connected to the outer wall of the hatching pool. Provide mild water circulation in the pool during spawn collection.

After spawn removal the hatching pool and the eggs/ spawn collection tank are cleaned by $KMnO_4$ solution and then by water.

To avoid direct sun light to the pools and tank, over the hatchery unit a shed may be erected.

Larval Development in Carp

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Embryological Development in Indian Major carps

The outer envelope of the ovulated egg is known as chorion. After fertilization eggs swell 5 to 6 times within 10 to 15 minutes of shedding in water. The space between vitelline membrane and chorion is the previtelline space. The fluid of this space is previtelline space, gives protection against the mechanical shock to the embryos. A fertilized egg passes through various stages and hatches out as a yolk sac larvae. Development stages (Fig 5-7) are as follows.

a) Blastodisc:
Blastodisc stage is the first stage in development sequences. It indicates the animal pole of the zygote and retains the active cytoplasm with chromatin materials. Blastodisc is seen as a protuberance within 30 min of fertilization (fig.1). Unfertilized ovulated eggs also develop blastodisc but, regress soon.

b) Cleavage:
Carp egg is macrolecithal. Cleavage is confined to the blastodisc without splitting the yolk mass and termed as the discoidal meroblastic cleavage. The first cleavage starts towards the equatorial plane and divides the egg into two blastomeres. Depending upon the water temperature (24-31^{0}C) , the first segmentation may commence within 30-50 minutes after fertilization. During the early development stage, blastomeres appeared in an arithmetic sequence *i.e.* 2,4,8,16 (Fig.1 b-). The same sequence is not maintained during later stages of development.

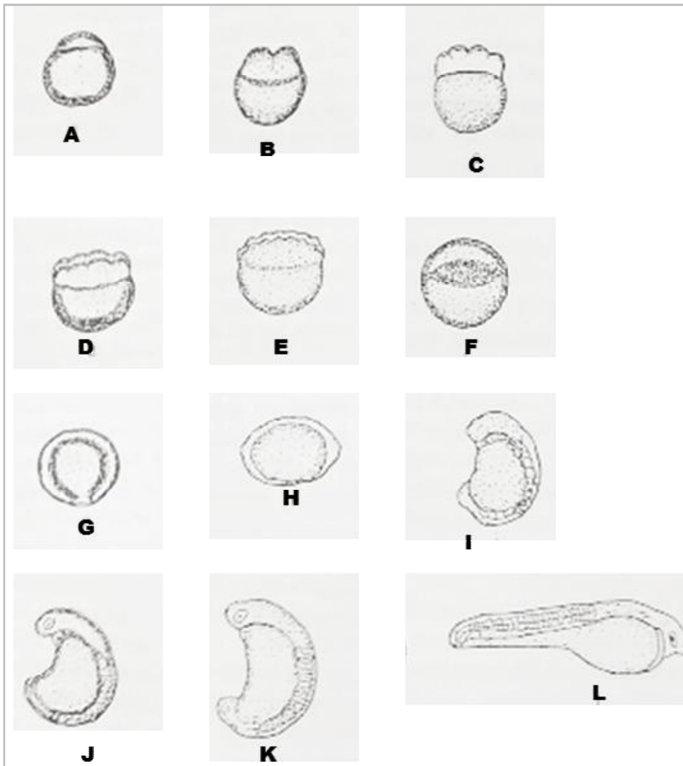
c) Morula stage:
Morulation is the process of aggregating the loosely clustered blastomeres into hemispherical cap at the animal pole. The blastomers are then arranged in the process of fertilized eggs enter into the process of blastulation.

d) Yolk plug stage:
Stage with complete invasion of the yolk by gradual spreading over the blastomers leaving only a small pore known as blastopore. Such stage appears 5 to 5 hours, after fertilization. The blastopore is made within 3-4 hours after fertilization. Within the next 30-40 minutes, the invagination is completed and the blastopore is almost closed.

e) Embryo development:

The embryonic sheath, appears within 4-6 hours of fertilization. This stage indicateds initiation of embryo formation. The end of the streak near the blastodisc is the tail and the other end of the steak is future head of the larvae. The round embryo then starts elongating the takes an oval shape. The embryo takes more or less a pea shape appearance within 5-6 hours of fertilization. The head and tail regions of the embryo are not differentiated yet. Next stage is the somite appearance within 6-7 hours of fertilization.

Head and tail regions are clearly differentiated, the posteriors parts of the yolk sac start narrowing and the embryo takes more or less a bean spaed appearance. 9-12 segmentation is visible. After an hour of this stage, tails get differentiated from the embryo mass and segmentations also increase in number (14-17no.). Next stage of the embryo is "comma shape" appeared within 8-10 hours of fertilization. A pair of otocyst is found, Kuffers, visicle are visible at the hind end of the embryo and fully elongated embryo appeared within 10-14 hours of fertilization. The number of myotomal segmentation increases gradually. Slow feeble myotomal movement is observed, followed by tail lashing movement.



Fertilized eggs : (A) blastodisc j just formed, (B) 2 celled stage, (C) 4 celled stage, (D)8 cell stage, (E) 16 celled stage, (F) morula stage, (G) yolk plug stage, (H) elongation of yolk mass, (I) with 6 somites, (J) appearance of optic cups ((K) elongation of tail from Kupffer's vesicle, (L) about 2 hours before hatching

f) Twitching stage:

The head and tail rudiments are completely free from yolk mass, optic rudiment and embryonic fin folds are appeared. Yolk mass is differentiated into a yolk bulb and a slender extended portion. No mouth and operculums are seen. Embyo is found active and shows continuous twitching movement. Rate of twitching movement increases gradually till it hatches out. Twitching movement exerts mechanical pressure on the chorion and embryo hatches out within 16-18 hours of fertilization.

All the fertilized eggs do not hatch out simultaneously, because the spawning and fertilization of same brood does not occur at a time.

g) Larval development:
The characteristic feature of the developing larvae till 72 hours is as follow (fig. 2). The newly hatched larvae are transparent, non pigmented without mouth and pectoral fins. It possesses the yolk sac and shows wriggling movement. The 24 hour hatchling has chromatophores on the head above the eyes, anal is distinct. Auditory constriction is clear pectoral fins without rays. Notochord turned upwards at the very end. The 48 hours hatchling has distinct air bladder and prominent gill and pectoral fin. The air bladder is elliptical. 72 hours larvae are free swimming and ready to accept feed.

Embryological developments in Chinese carps

The embryonic development processes of big head, silver carp, grass carp, mud carp and black carp are almost the same. Here the embryonic development of silver carp in enumerated (fig. 2).

a) Fertilized egg and its cleavage:
The matured egg is spherical in shape, yellowish and bluish, and semi-pelagic. Its diameter is 1.3-1.5 mm. The perivitelline space is very narrow. In contact with water the fertilized egg membrane absorbs water and swells within 15-20 minutes to a diameter of about 4.8-5.3 mm. The egg membrane is transparent and unsticky film.

Egg plasm, 25 minutes after the fertilization begins to concentrate towards the animal pole of the egg from the state of even distribution and forms a hat-shaped protuberant blastoderm. The favourable temperature of water is 28.5-29.5^{0}C . After 35 minutes of fertilization, it undergoes the first cleavage, after 45 minutes second cleavage; after 55 minutes third; after 60 minutes fourth; after 80 minutes fifth and so on. The blastomere accumulate on the top end of the yolk and appear to the mulberry shaped. This is morula state.

b) Blastula stage:
Two hours and twenty minutes after fertilization, blastodermal cell splits continuously. The boundary of the cell can still be seen but indistinctly and forms a semi-circular high blastula. After that, a cavity is gradually formed in the center of the blastula the blastacoel. Three hours and thirty two minutes after fertilization, the blastoderm becomes flat. It is the flat blastula stage.

Gastrula stage:
Three hours and fifty five minutes after fertilization, the blastomere wrap downwards the equator of the egg, with some blastomeres wrapping into inside of the embryo. This is the beginning of the gastrula. An embryonin ring can be seen from the external appearance. Another fifty minutes later, the embryonic shield is formed. This is midgastrula stage. Five hours and fifty minutes after fertilization, the blastoderm wraps downward above 4/5 of the yolk sac. Neural plate begins to form on the dorsal part of the embryo. Column-formed notochord appears in the center line of the neural plate. In the front of the neural plate appears to head position. Two pairs of body segments occur in the mid-part of the embryo. At this time, embryo already has 3 blastodermal layers

and gastrocoel. Various kinds of organ-primordia re differentiated from these blastodermal layers.

c) Organogenesis stage and hatching:

Six hours and forty five minutes after fertilization, optic vesicles appear on the two sides of the fore-brain and the body segments increase from two pairs to five. Seven hours and fifteen minutes after fertilization, olfactory p0late appears, and primordial of fore-brain, mid-brain and post-brain appear successively. The body segments increase to ten pairs.

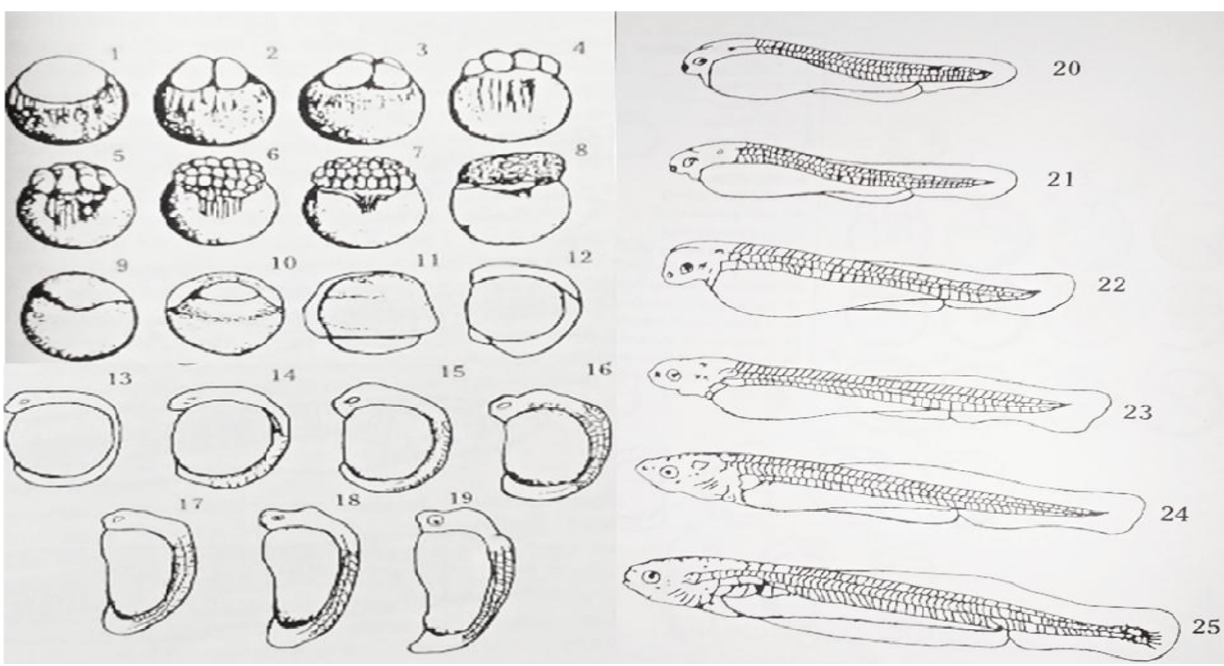
Eight hours and ten minutes after fertilization, auditory vesicles appear on both sides of the post brain. There are 17 pairs of body segments.

Nine hours and forty five minutes after fertilization, caudal bud appears. With the development and extension of the caudal bud, yolk sac is elongate. There are 20 pairs of body segments.

Ten hours and thirty five minutes after fertilization, crystalline lenses appear in the optic-vesicles and the oval gill plates appear below the optic-vesicles. There are now 25 pairs of body segments. Embryonic body begins to wriggle slightly.

Fifteen hours and fifteen minutes after fertilization, the otoliths appear in the auditory vesicles and the wriggle becomes violent. There are 35-36 parts of body segments. Sixteen hours and thirty-five minutes after fertilization, some embryos begin to break the membrane and come out. The 72 hours larvae are free swimming and ready to accept outside feed.

Embryonic Development of Silver Carp



1. Protuberant blastoderm, , 2. 2 cell stage, 3. 4 cell stage, 4. 8 cell stage, 5. 16 cell stage, 6. 32 cell stage, 7. 64 cell stage, 8. Morula stage, 9. Mid-blastula stage, 10. Early gastrula stage, 11. Late gastrula stage, 12. Blastopore closing stage, 13. Body segment appearance stage, 14. olfactory plate appearance stage, 15. caudal vesicle appearance stage, 16. Audictory vesicle appearance stage, 17. Caudal vesicle appearance stage, 18. Eye crystalline lenses formation stage, 19. Muscle functioning stage, 20. Hatchling, 21. Pectoral fin enlarge, 22. Gill arch appearance stage, 23. Eye yellow pigment stage, 24. Air bladder formation stage , 25. Eye yolk complete absorption stage

Environmental Management for Carp Brood and Seed Rearing Ponds

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Water quality management

Some water quality parameters and their management have strong influence on growth and reproduction of brood-fish and carp seed rearing.

pH: Water pH affects metabolism and physiological process of fish. A pH range of 7.5 to 8.2 is optimum for brood fish production.

For carp seed rearing, a pH range of 7.2 to 8.2 could be very good. The increase of pH could be done by the application of lime. Calcium carbonate ($CaCO_3$), calcium hydroxide ($Ca(OH)_2$), calcium oxide (CaO) or dolomite is used to rectify the acidic water depending upon the pH. The decrease of pH could be attained by the application of agricultural gypsum, elemental sulphur or acid forming fertilizers viz., ammonium sulphate, ammonium chloride etc.

Dissolved oxygen: The optimum dissolved oxygen (DO) content of pond waters should be in the range of 4 to 8 mg/L for good growth of fish. Oxygen depletion in water is rectified by the different types of aeration.

For brood-fish ponds and carp seed rearing, other steps taken to control the oxygen level are:

i. Care should be taken to feed fish in the afternoon or evening in heavily stocked pond systems as oxygen requirement in fish after feeding increases and dissolved oxygen is minimum in pond during early morning.
ii. Organic manure application in a water area should be done carefully as organic material consumes oxygen during decomposition. Therefore, the quality of manure to be applied without the risk of oxygen depletion can be calculated taking into consideration the availability of dissolved oxygen during the 24 hr period.

Temperature: Temperature sets the pace of metabolism by controlling molecular dynamics (diffusibility, solubility, fluidity) and biochemical reaction rates. Under favourable conditions, the optimum temperature range for many coldwater and warm water fishes are 14–18°C and 24–30°C, respectively. Water temperatures can be adjusted to optimum levels in controlled system such as hatcheries. It is difficult to adjust water temperature in large water bodies. Operation of aerator during calm and warm afternoon helps to break thermal stratification by mixing warm surface water with cool subsurface water. Planting of trees on pond banks to give shade will reduce stratification but at the same time, reduces the beneficial effects of wind mixing and restricts solar energy for photosynthesis.

Turbidity: Optimum Secchi disk visibility in brood-fish ponds is considered to be 40–60 cm. Turbidity resulting from plankton is generally desirable. Pond waters turbid with suspended soil particles can be controlled by application of 500–1,000kg/ha organic manure, 250–500 kg/ha gypsum or 25–50 kg/ha alum. Too much turbid water or muddy water is also not good for seed rearing.

Ammonia: The total ammonia concentration in water comprises two forms, namely:
NH_3 = unionized ammonia (Free ammonia) and NH_4^+ = Ionized ammonia

They maintain equilibrium as per the equation:

$$NH_3 + H_2O \rightarrow NH_4^+ + OH^-$$

The un-ionized ammonia fraction is more toxic to fish and the amount of the total ammonia in this form depends on the pH and temperature of the water. As a general rule, the higher the pH and temperature, the higher is the percentage of the total ammonia present in the toxic un-ionized form. The un-ionized ammonia fraction is more toxic to fish. A free ammonia level of 0.02–0.05 mg/L is safe concentration for carp brood fish. However, this concentration should be less in carp seed rearing ponds.

There are a number of measures to maintain safe ammonia concentration in pond water. Normally at high dissolved oxygen and high carbon dioxide concentration, the toxicity of ammonia to fish is reduced. Some recommended measures to reduce the effects of ammonia are:

Aeration will increase the dissolved oxygen concentration and decrease the increasing pH thereby reducing toxicity.

Healthy phytoplankton populations remove ammonia from water. Care should be taken while using fresh manure with high ammonia content. The manure should be dried to allow ammonia gas to escape before application to the pond.

A high quality feed that contains no more nitrogen (crude protein) and phosphorus than actually needed by fish should be used in ponds and also over-feeding should be avoided.

Excessive liming should be avoided as it raises pH and high pH favours ammonia toxicity to aquatic animals.

Water exchange can reduce ammonia concentrations in fish and prawn ponds. From both economic and environmental perspectives, water exchange should only be used when necessary.

Nitrite: In most natural water bodies and in well maintained ponds, nitrite concentration is low. A level of trace to 0.002 mg/L of nitrite is optimum for brood fish pond. In seed rearing ponds it should be traced in amount.

Nitrate: A range of 0.2 to 0.5 mg/L of nitrate is optimum for brood fish ponds. This concentration should be less in seed rearing ponds.

Correct stocking, feeding and fertilization practices should be maintained properly to control ammonia, nitrite and nitrate levels in water.

Total Alkalinity: Brood fish pond should have an alkalinity of more than 80 mg/L as $CaCO_3$. A level of 80–120 mg/L alkalinity is ideal for brood fish. For spawning and seed rearing, alkalinity in the range of 60 to 80 mg/l as $CaCO_3$ is desirable. Low alkalinity can be rectified by treatment with lime. Higher alkalinity could be reduced by mixing with low alkalinity water either from rain or from the canal, reservoir or river. High alkalinity water could also be reduced by the treatment with alum. Experiments have shown that 1.6 mg/L of alum can remove 1.0 mg/L of total alkalinity of water.

Total Hardness: Water hardness more than 60 mg/L is satisfactory for pond productivity and helps to protect fish against harmful effects of pH fluctuations and metal ions. Ponds with low hardness can be treated with lime for rectification.

Carbon Dioxide: A carbon dioxide value in the range of 4 to 12 mg/L is optimum for brood fishponds. Increasing the pH of water by hydrated lime can control high carbon-dioxide concentration. Experiments have shown that 1.0 mg/L of hydrated lime can remove 1.68 mg/L of free CO_2.

Water exchange: There are reasons to exchange water in specific instances, such as to reduce salinity, to flush out excessive nutrients and plankton or to reduce ammonia concentrations. However, daily water exchange usually does not improve water quality in ponds, and pumping costs are a liability. From both economic and environmental perspectives, water exchange should only be used when necessary.

Bottom Soil Management and Pond Fertilization

The production of various primary food organisms depends largely on the availability of different nutrients. Dynamics of availability of most of these nutrients, in turn, is determined by the condition prevailing in the bottom soil. Proper fertilization could help to produce plankton. Inorganic fertilizer, urea @ of 20 kg/ha/15 days and Single superphosphate @ 30 kg/ha/15 days should be applied while 200 to 300 kg cow dung/ha/7 days should be applied to a brood fish pond till the fish is used for breeding purposes. The soil pH should be around 7.0. Lime should be applied to maintain the total alkalinity level of 80 mg/l, if it is less in any brood fish pond.

Fertilization schedule of nursery ponds: The natural productivity of nurseries is often unsatisfactory due to a deficiency of one or more of the nutrient elements in soil and water, which may be caused by other environmental conditions. Correction of deficiencies by application of manures or fertilizers containing these nutrients in suitable form and in optimal amount is necessary to accelerate biological production and enhance productivity. Accordingly, small shallow ponds are preferred for nurseries for easy management and manipulation of environmental conditions.

Use of organic manures: Both organic manures and chemical fertilizers are widely used for improving the productivity of nurseries. Cow dung is the most widely used organic manure in many areas and is typically applied at a rate of 5,000-15,000 kg/ha in one installment well in advance of stocking with spawn, preferably at least a fortnight prior. The amount is reduced to 5,000 kg/ha when mohua oil cake is used as a fish toxicant in shallow nursery ponds. Sometimes, to hasten the process of decomposition of added manures, limes ($CaCO_3$) are applied at a rate of 250-350 kg /ha in nurseries after the application of manure. Sometimes spaced manuring with cow dung at a rate of 10,000kg/ha 15 days prior to stocking followed by subsequent application of 5,000 kg/ha seven days after stocking has been practiced for sustainable production of zooplankton in nurseries. When more than one crop is raised, nurseries may be manured with cow dung at 5,500 kg/ha immediately after the removal of the first crop. Besides the cow dung, a combination of mustard oil cake, cow dung and poultry manure in the ratio of 6:3:1 at 1,100 ppm have been successfully used for the culture of zooplankton for carp spawn.

Inorganic fertilizers: Inorganic fertilizers containing a fixed percentage of individual nutrient elements or a combination of more than one element are also able to enhance the productivity of nurseries. A ratio of nitrogen: phosphorus ration (N:P) of 4:1 is considered most effective for increased production in nurseries. Weekly application of nitrogen: phosphorus: potassium mixture (N: P: K) in the ratio of 8:4:2 ppm is suitable for increased production of fish food organisms. Use of N: P: K in the ratio of 18:8:4 at 500 kg/ha after liming at 200 kg/ha is quite effective in enhancing the production of slightly acidic and unproductive soils used for nurseries. Nitrogenous fertilizers containing different forms of nitrogen (amide, ammonium-cum-nitrate and ammonium) are suitable for management of nurseries. These three forms of fertilizers (e.g. urea, calcium ammonium nitrate and ammonium sulfate) are effective for slightly acidic to neutral, moderately acidic and alkaline soils respectively and a rate of 80 kg nitrogen/ha are most suitable for rearing of rohu spawn in nurseries.

Combination of organic and inorganic fertilization: The combine use of both organic and inorganic fertilizers is another strategy for increased production of either fish food organisms or fry. The combination of mustard oil cake and 6:8:4: N: P: K inorganic fertilizer on equivalent nutrient basis (at 12 kg nitrogen/ha) is suitable as compared to either organic to inorganic for nutrient management of nurseries. However, on an equivalent nutrient basis (N: P: K) organic manure (cow dung) is the most suitable fertilization strategy for management of carp nurseries compared to either inorganic fertilizer or combined use of organic and inorganic fertilizer.

Conclusion

The best method for preventing soils and water quality problems in seed rearing and brood fish ponds is to select a site with good soils and an adequate supply of high quality water and to maintain moderate levels of brood fish/spawn stocking. If this is done, liming, fertilization and aeration can prevent most soil and water quality imbalances. However, in some instances, sedimentation basin may be needed to prevent ponds from filling in and water exchange may be required periodically. In intensive ponds, bottom soil treatment such as drying and liming between crops, phosphorous precipitation, turbidity removal and oxidation of bottom soils with sodium nitrate may be beneficial.

"CIFABROOD™": A Proven Carp Brood Stock Diet For Quality Seed Production

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Background

The freshwater aquaculture production of the country has been dominated by carps constituting up to 95% of the total production of the country and the three Indian major carps *viz*. catla (*Catla catla*), rohu (*Labeo rohita*), mrigal (*Cirrhinus mrigala*) contribute as much as 1.8 million tons. Fish seed is the most critical and prime factor and considered the main lever of the aquaculture development in the country. Generally the average survival rate in the fry rearing of carp seed hardly exceeds 30-40% under pond condition and thus even though country produces at present over 30 billion carp fry, non-availability of desired size and quality of stocking material still remains a constraint. To maintain the quality of fish seed it is important to follow good brood husbandry. This clearly needs immediate attention to address the inherent problems in the seed production. In oviparous animal like fish the embryonic development is completely dependent on the stored energy provided in the eggs following fertilization. The nutrient necessary for embryonic development is transferred from female brood during egg formation. Since millions of eggs mature simultaneously and derive all the essential nutrients from the brood mother, there is always chance of deficiency in one or other component either due to lack in mother's diet or due to malnutrition. Therefore adequate nutrient source through exogenous diet containing indispensable amino acids (IAA), long-chain fatty acids (PUFAs), selected vitamins and trace elements must be provided to the brood prior to maturation in such a way that voluntary dietary intake becomes optimum.

What was the necessity?

- We are almost self sufficient in quantity of carp seed produced in the country, but quality is compromised
- Non-availability of suitable feed for brood stock
- Hatcheries suffer from frequent failure in gonad maturation, breeding response, reduced fecundity, fertilization and spawn recovery
- Irregularities in the developmental stages
- Survival of larvae during nursery rearing hardly exceeds 30% in spite of best possible management measures in pond
- Hatchery owners constrained to maintain large number of brood stocks to produce seed due to uncertainty of larval survival resulting in high cost

Objectives

- To improve reproductive performances of brood fish specially of Indian major carps by dietary manipulation
- To improve the quality of seed, and larval survival and growth
- To spread the benefit of CIFABROOD throughout the country, and beyond
- To make carp seed production more assured and profitable

Feeding trials

At CIFA

- The feeding trial conducted in ponds under Institute based collaborative project between Nutrition Section and carp breeding unit of CIFA (1996-98)
- At KVK Khordha ponds as per the instruction and supervision of the then Director, Dr. S. Ayyappan (1998-99)
- Tested for efficacy on gonad maturation in offseason breeding experiment under institute project during 2007-2009 in Physiology Section

At farmers' field

- Ramsagar,Bankura, West Bengal 2012
- Sarkana, Khordha, Odisha,2013

Salient observations of feeding trials

- Egg, sperm and larval quality superior in test diet over control group
- Therefore it is possible to change the egg and larval quality by suitable dietary manipulation of brood carp
- Brood stock diet has strong influence on breeding performances
- It can influence early maturation of the gonad
- Spawn recovery is directly dependent on brood diet composition

Salient features of CIFABROOD™

- Nutritionally balanced and validated through monitored field trial
- Provides essential nutrients generally lacking in conventional feed or natural fish food organisms
- Advances gonad growth and maturation and facilitates early spawning
- Ensures higher production of viable eggs.
- Suitable for multiple/repeated breeding in carp
- Enhances spent fish recovery
- Promises higher recovery of quality seed per unit body weight of female
- Ensures better survival of seed and rapid growth during nursery rearing

Successful trials in West Bengal and Odisha on CIFABROOD™

Re-maturation and breeding of spent brood at Ramsagar, Bankura, West Bengal, in August-September2012.

- ❖ Asha Fish Breeding Farm,(Mr. Badan and Rajiv Biswas),
- ❖ Pre-monsoon(Feb-May) breeding preferred over post monsoon (August-September)
- ❖ Spawn production a routine activity but spawn survival and recovery (<30%) still a chronic and regular problem particularly in non-spawning season.
- ❖ Besides, feed cost accounts major input share in such farm business due to compulsory maintenance of large number of brood stocks throughout the year.
- ❖ Feeding started on 18th July2012 fed @ 2% of body wt. to spent carps.
- ❖ First breeding conducted on 23rd August 2012,and continued in September.

Technological benefits (Bottleneck removed and farmer made confident)

Benefits stated by the farmer

- ❖ They don't need to maintain a large number of brood stocks.
- ❖ This feed is very much suitable for early breeding.
- ❖ The eggs produced are 100 times better than what they had produced so far.
- ❖ Farmer got more than double the number of viable spawn from same amount of eggs.
- ❖ They never expected that spent brood (twice bred earlier) will mature again within 45days.
- ❖ Now they believe that fish can be matured and bred at any time they want.

Early breeding of Indian Major carps in April and May 2013 at Sarkana, Odisha (Mr. Batakrushna Sahoo)

- ❖ IMCs are bred in June-August in farmer's pond in Odisha.
- ❖ Batababu producing seed for last 20 years but never thought of early breeding of IMCs.
- ❖ Feeding started on 18th February2013 and fed @ 3% of body wt.
- ❖ Fishes were matured by 6th April2013 (48days), without water exchange.
- ❖ First breeding conducted on 22nd April 2013 with mrigal broods, 2nd breeding on catla on 13th and 28th May and rohu bred on 31st May 2013.
- ❖ There was initial problem of selling the spawn in April but subsequently, almost all the spawn were sold on the respective spawn lifting days and taken by the regular buyers.

Technological benefits

- ❖ The maiden success in early breeding of IMCs during hot summer has developed confidence in the farmer.

- ❖ Co-operation from fellow spawn buyers has motivated him for taking up and scale up early breeding program in February-March in coming year.
- ❖ Early bred (April) spawn has already grown up to fingerling size by June 15^{th} 2013 which is fetching Rs.1 per piece to the nursery growers.
- ❖ According to the spawn buyers survival rate of fingerling is in between 50-70% as compared to 30% normally observed during spawning season in previous years.
- ❖ Fingerlings are ready for stocking for grow out culture from June middle to October allowing an extra period of near about 3 months for growth purpose.
- ❖ Farmer feels that success in early breeding with the help of CIFABROOD^{TM} will lead to a surge in the number of spawn buyers even in peak summer of coming years, and is most likely to have many positive impacts in the aquaculture sector.

Farmer successfully conducted early and repeat breeding of Java punti (*Puntius gonionatus*) in 2014 at Kuliagarh, Naihati in N-24 PGs district of West Bengal under CIFABROOD^{TM}

Mr Tapan Patra son of Late Mr Bijoy Kr Patra aged about 46 years is a well known and established breeder in Kuliagarh, Naihati area in N-24 PGS district of West Bengal. With his 15years of experience he generally conducts breeding on rohu, catla, mrigal(IMCs), silver carp, grass carp, common carp(exotic carps),as well as pungus, bata and to some extent on Java punti in his farm called Durga Enterprise. His farm consists of 19 numbers of hatching pools and 7 nos of ponds of total 7.2 ha water area. He used to feed the brood stock with his own formulated feed comprised of boiled rice mixed with ground nut oil cake, mustard oil cake, soybean meal and vitamin-mineral mixture. However, early breeding was never a easy job and being at Naihati he knows about the stiff competition among the hatchery owners. As soon as he heard about the new feed CIFABROOD^{TM,} in January 2014, immediately applied in a particular pond of 2.5 bighas @2% b.wt. starting from 7^{th} February2014. Initially the pond was stocked with the three IMC species (total body mass of 850kg) along with 400 numbers of Java punti(total body mass of 200kg). He observed that within March, 15th2014, females of IMCs were matured and ready for breeding while very few males of respective species were oozing. He was completely disappointed not being able to utilize the early matured females with so much gonadal development not seen earlier in his pond. On the other hand, while netting in the same pond by chance it came to his notice that both male and females of Java punti were mature and ready for breeding program. So, he chose to start breeding program with Java punti on 21^{st} March2014, which went on for next three months and he was able to produce about 12 billion puntius spawn during March to May2014. The demand for Java seed was more prominent in Naihati area due to nearby fish seed market in the locality also, and the rate in the season was Rs 400/- for each cup (125ml containing ~1.2 lakh of spawn). Subsequently he removed all the IMC broods to another pond keeping only Java punti in it and continued feeding with CIFABROOD^{TM}. To his utter surprise he found that the spent fishes were maturing again and again with a time gap of about 7-10 days and described it as his maiden experience in his life. While in control pond (without CIFABROOD^{TM}), Java punti matured later (20 days) with lesser development and spent fishes were very weak as compared to experimental pond. Although his observation of rematuration of Java punti requires scientific analysis and confirmation, this has not only built his confidence in puntius breeding but also showed an alternative source of income in fish breeding business. He is thinking to do puntius breeding in larger scale in coming year.

Farmer conducted early breeding of Indian Major Carps in March 2014 in Murshidabad district of West Bengal by feeding CIFABROOD™

Mr Debsaran Ghosh (45years), a biology graduate is the elder son of a traditional agriculturist Mr Kush kumar Ghosh of a remote village- Rashbeluria, PO-Dohali under Sagardighi PS,of Murshidabad district in West Bengal. With lot of difficulties he could establish a small unit of hatchery now known as Ghosh Hatchery in 2010. It comprised of two Chinese breeding pools, seven hatching pools and six ponds of 12bighas total water area. Farm operations mainly consist of brood stock rearing during September to March and breeding operations and selling of seeds during April to August each year. The species includes catla, rohu, mrigal(IMCs), grass carp, silver carp, common carp, bata and paccu. A new entrant in the business, he immediately faced tough competition from the nearby old & established hatcheries of home district as well as from the Ramsagar hatcheries of neighbouring district Bankura where early breeding of carps is already a traditional business. Initially he used to purchase the broods for breeding purposes but repeated failure taught him to rear & develop own brood stock for timely start of hatchery operation particularly for early breeding. He also understood the importance of feeding a brood diet and tried a commercial feed during 2013 in his ponds instead of normal traditional feed. In November2013, he came to know about CIFABROOD™ and immediately applied in a two bigha pond @ 3% of body wt. on experimental basis from 3rd March 2014, while rests of the ponds were supplied with commercial diet. There were 100 nos each of catla and rohu, along with 200 nos each of mrigal and bata(av.wt.250gm) and the average wt of IMCs were 1.5kg. and were maturing for the second consecutive year. He was surprised to notice that broods in experimental pond matured up within 20 days and were ready for breeding operation. Due to less number of males oozing at that time he could start breeding program only on 30th March2014 on catla, while broods in other ponds were still immature. In 2014, he has produced and sold 29millions of IMC spawn. This success in early breeding not only build up his own confidence but also helped him to held up the faith of the customers intact(who otherwise would have gone to Ramsagar) and also provided him a lump sum return of his initial investment in the business.

Reconfirmation of the potential of CIFABROOD™: a proven carp brood diet through on farm testing of KVK-Khordha

CIFABROOD™ is one of the high-flying proven carp brood diet recently developed by Central Institute of Freshwater Aquaculture (CIFA). With the approved action plan the KVK implemented the trial during 2013-14 in two private hatcheries in Balianta and Banapur Blocks of Khordha district. Hatchery owners were convinced about the technology through discussion and available literature for implementation. Interestingly the technology was delivered by KVK with its presence in extension activities though concerns on adoption of innovation dominated. Advantages of the diet were strongly conversed which added value for the hatchery owners to adopt. The trial was conducted in two ponds (0.3ha each) stocked with Indian Major Carps (200 numbers each) during 15th February 2014. The feeding trial started on 25th February 2014 and fishes were fed @ 3% of body weight with CIFABROOD^{TM} in experimental pond while farm made feed prepared by the hatchery owner was provided in the control pond. Results indicated that within 45 days all the fishes in the trial pond were matured and fishes in the control ponds were phenotypically immature. But the farmer was compelled to postpone the breeding programme due to delayed monsoon and the first breeding was undertaken with Catla on 10th May under a temperature of 40-42^{0}C. The average fertilization rate was observed to be 88.14% with a spawn recovery of 809 lakh from 364kg of female broods (Average spawn production per kilogram of female is 2.22 lakh). Early spawning and excellent survival rate of spawn has helped the participant hatchery to mark a place in the seed market and to supply during off season (Pre-monsoon). In turn the spawn buyers had an average survival rate of 42.18% from spawn to fry and 73.5% from fry to fingerling by June 22nd 2014, which fetches a good price to the farmers. This trial by KVK has reconfirmed CIFABROOD^{TM} as a proven brood carp diet which has shown to impact at all the three crucial stages of seed production.

Feed and Feeding for Carp Seed

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Feed is the most important and critical input in fish production system constituting about 60-70% of total operational cost. Therefore, formulation of appropriate feed for commercial fish farming is of paramount importance. The dependence of farmed fish on supplementary feeding is more pronounced with the transformation of extensive to semi-intensive and intensive fish farming where the natural feed produced through pond fertilization is not sufficient to sustain the standing crop of cultured species. The most essential criteria of a quality fish feed is that it should be nutritionally balanced and cost-effective. The prepared feeds balanced in protein, lipid, carbohydrate, vitamins and minerals with optimum dietary P/E ratio resulted better survival, growth, immunity and reproductive potential of fish. The nutrient requirements of fish differ with their different life stages. Among all the life stages of fish, the larval stage is the most critical stage in fish and the growth, survival and health of fish is largely depend on the provision of high quality feed in addition to the better husbandry practices. Most of the fish requires higher protein and energy contents in their larval stages. Similarly, they prefer animal protein more over the plant protein in the younger stages as it is more digestible and palatable. Invariably all fish require live feeds in the form of both zooplankton and phytoplankton in the early phase of their life. The size, shape, colour and texture of fish feed also vary in relation to fish size. The basic knowledge on nutrients and nutrient requirements of fish are the pre-requisite for formulating the nutritionally balanced cost-effective fish feed.

Nutritional requirements

About 40 essential dietary nutrients in the form of major and minor nutrients are required by fish and prawn.

Protein and amino acids

Protein is the most expensive component in fish feed which determine the feed cost. Roughly, 80-90% of the total feed cost is spent to meet the protein requirement of fish in the diet. Therefore, it is important to determine the optimal protein requirement of fish. A significant reduction in feed cost can be achieved if diets with low protein could be fed to fish without compromising growth and health. However, inadequate protein in the diet results in reduction or cessation of growth. On the other hand, if too much protein is supplied in the diet, only part of it will be used to make new proteins and the remainder will be converted to energy. Besides these, inclusion of dietary protein levels beyond the optimum level results in high level of ammonia production, which affects the voluntary feed intake and growth of fish. But the utilization of dietary protein by an organism depends on types of diet, digestibility of dietary protein, its amino acid profile, the ratio of energy to protein in diet and the amount of protein supplied. Other factors that affect protein utilization are animal size, sex, genotype and environmental conditions. Since protein acts both as structural component as well as an energy source, its requirement for fish is 2-3 times higher than that of mammals. The protein requirement varies from 25-55% for different fish species. The gross protein requirement decreases with increase in age and size of fish. Generally 25-30% protein is optimum for practical diets for herbivorous and omnivorous fishes for pond feedings and 35-40% during seed production/nursery rearing. However, carnivorous fish requires higher 35-40% dietary protein during pond culture and 45-50% during seed production in hatchery.

The information on protein requirement is of limited value unless amino acids requirement of fish is understood. The fish does not have true protein requirement but need a well-balanced mixture of essential and non-essential amino acids. Gross protein requirement of a fish is the requirement of essential amino acids and some non-specific nitrogen to maintain metabolic activities. With hydrolysis of protein, about 20 different amino acids are released, out of which 10 are essential viz. arginine, histidine, isoleucine, leucine, lysine, methionine + cystine, phenylalanine + tyrosine, threonine, tryptophan and valine, which are not biosynthesized but required by fish. In earlier days, the studies on essential amino acid requirements of fish were made based on the amino acid profile of chicken egg protein. As high correlations were found to exist between the amino acid requirements and whole-body amino acid composition in several fishes, it was suggested that such data be used to set the basis for the estimation of amino acid requirement of fish. While comparing the data on essential amino acid composition of whole body tissue of several teleosts, *viz.,* catla, rohu, mrigal, common carp, atipa, rainbow trout, Atlantic salmon, coho salmon, channel catfish, gold fish, gold shiner and fathead minnows, it was observed very narrow differences in the amino acids values and therefore, the amino acid requirements of all the teleost fishes as percentage of protein are almost similar.

Lipids

Lipids are important nutrients in the diets of fish as sources of energy, essential fatty acids and phospholipids, provide a vehicle for absorption of other fat-soluble nutrients such as sterols and vitamins, play a role in the structure of cell and cellular membrane, serve as precursors of many hormones and also precursors for prostaglandin synthesis, influence the flavor and textural quality of prepared feed as well as fish carcass, and regulate the storage characteristics of fish products. Dietary lipids supply energy and provide essential fatty acids needed for structural maintenance of membranes and proper functioning of many physiological processes. Lipids are almost completely digestible by fish and seem to be favored over carbohydrate as an energy source. Special attention is now being given by researchers, feed manufactures and farmers to develop feeds, which maximize nutrient retention and minimize nutrient loss. Fish are known to utilize protein preferentially to lipid or carbohydrate as an energy source. Therefore, it is important from a nutritional, environmental and economical point of view to improve protein utilization for tissue synthesis rather than energy purposes. The optimization of dietary digestible protein/dietary energy ratio (DP/PE) has proven to have an important role on protein and energy utilization. The increase of DE content of fish diets, by lipid supplementation, has been shown to have a protein sparing effect, therefore reducing nitrogen to the environment. The increase in dietary lipid levels, must, however, be carefully evaluated as it may affect the carcass composition, mainly due to an increase of lipid deposition. The localization and composition of lipid deposits also strongly influence the nutritional value, organoleptic properties, transformation yields and storage time of fish carcass. Lipid being highly digestible has greater sparing action than dietary carbohydrate or protein and it playing a definite role in feed utilization. Since dietary lipid level is also a dominant factor in determining the quality of the fish, it is important that a proper amount of lipid be incorporated in fish diet. Excess lipid not only suppresses *de novo* fatty acid synthesis, but also reduces the ability of fish to digest and assimilate it, leading to reduced growth rate. Again, excess lipid in the diet may also result in the production of fatty fish ultimately having a deleterious effect on flavour, consistency and storage life of the finished product. Excessive amounts of lipid in diet also possess problem in feed manufacturing.

These are highly digestible in fish and are reported to spare protein. Excess dietary lipid suppress *de novo* fatty-acid synthesis and reduces ability of fish to digest and assimilate, resulting in reduced growth. Also, feeding excess lipids is known to produce fatty fish and have deleterious effects of flavor, consistency and storage life of finished products. Although, a wide range of variations (4-15%) in gross lipid requirement has been estimated for several species, 7-9% dietary lipids are generally considered optimum for practical diets of carps and prawns.

It is well known that human health benefit is attributed to the presence of long chain n-3 PUFA in fish lipids. Fish oil is the rich dietary source of PUFA viz. eicosapentanoic acid (EPA) and docosa hexaenoic acid (DHA). As in other vertebrates, fish cannot synthesize 18:3 n-3 (linolenic) and 18:3 n-6 (linoleic) polyunsaturated fatty acids (PUFAs) but fish have a requirement of these two essential fatty acids that are to be provided from exogenous sources. Fish fed diets deficient in two of these PUFAs (18:2 n-6 and 18:3 n-3), usually develop deficiency sign such as retarded growth, low feed efficiency, fatty livers, increased water content in whole body or muscle, high hepatosomatic index (HSI) and substantial accumulation of 20: 3n-9 in tissue polar lipids. Freshwater fish, in general, requires either dietary 18:2 n-6 (linoleic) or 18:3 n-3 (linolenic) acids or both. Marine fish have dietary requirement of eicosapentaenoic acid (EPA, 20:5 n-3) and/or docosahexaenioc acid (DHA, 22:6 n-3). Present knowledge of EFA requirements of freshwater fish, based on a relatively small number of species, suggests that the EFA requirements of freshwater fish can be met by supplying linolenic acid, 18: 3n-3, and linoleic acid, 18: 2n-6, at a concentration of around 1.0-2.0% of the diet by weight. Dietary phospholipids have beneficial effects on growth and survival of fish and prawn larvae.

Cholesterol is synthesized in the body, but some crustaceans, like prawns, require cholesterol in the diet. Feeding of diets incorporating sterol and cholesterol at 0.25% and 0.5% levels yielded beneficial effects in prawns. The Indian major carps and marine shrimp have requirement of phospholipids to the tune of 4% and 1-2%, for enhancing larval growth and survival rates. Supplementation of n-3 and n-6 PUFA is also required for broodstock diet which is done by providing vegetable oil and fish oil of marine source and this greatly influences gonadal maturation, breeding efficiency and spawn recovery of Indian major carps. Dietary incorporation of 3% shrimp (marine) head-oil, being a source of n-3 fatty acids, improved feed efficiency in *Macrobrachium rosenbergii*.

Carbohydrates

Carbohydrates not only serve as the least expensive source of dietary energy but also help in improving the pelleting quality of practical fish diets. Therefore, some form of digestible carbohydrate should be included in fish diets. Feed cost per unit of fish produced can be minimized by optimal use of low-cost energy carriers such as carbohydrate-rich ingredients, ensuring that the use of costly protein is kept as low as possible. Replacing dietary protein by carbohydrate or lipid energy may result in a higher production per unit spent of costly protein sources such as fishmeal, and the effluent nitrogen can be reduced per unit of fish produced. Carbohydrates may also serve as precursors for the various metabolic intermediates necessary for growth, i.e., dispensable amino acids and nucleic acids. Thus, in the absence of adequate dietary carbohydrates or lipids, fish have only protein available to meet their energy needs. When other energy sources are available, some protein may be utilized for growth instead of energy. This relationship between protein and carbohydrates has been referred to as the protein-sparing action of carbohydrates. It is important to provide an adequate carbohydrate level in the diet in order to reduce catabolism of protein for energy and for synthesis of glucose, which reduce protein retention and increases the nitrogen release to the environment. The ability of fish to utilize carbohydrate appears to be related to their digestive and metabolic systems adapted to the different aquatic environment and dietary carbohydrate level and complexity. The carbohydrate utilization of the fish depends up on the feeding habit, structure and function of the digestive system. The capacity of fish to utilize carbohydrate varied by species and in response to variables such as digestibility and starch complexity. Cold water and marine species generally maintain adequate performance with carbohydrate levels in order of 20.0%. Apart from trout, the tolerance of freshwater and warm-water species is generally higher, up to a maximum of 40.0%.

Several species of carp are considered herbivorous in nature and hence use of cheap sources of digestible energy becomes an important consideration. Carps are able to utilize D-glucose, fructose, sucrose, dextrin and raw potato starch. Given herbivorous feeding habits of some of the cyprinids in their natural habitat, utilization of cellulose by cyprinids is reported. It has been observed that cellulose is not utilized well as other digestible carbohydrates by common carp, but fish utilizes rice or tapioca starch well. Carbohydrates being 55-60% digestible in carps, form an important dietary constituent for herbivorous and omnivorous species. The optimum dietary requirements of carbohydrates are 25-30% for Indian major carps and medium carps, 30-40% for common carp, less than 25% for rainbow trout and 6-15% as gelatinized starch for Salmon sps. For sinking feed, the carbohydrate levels generally kept below 40% in carp diets. However, in extruded floating feed, the carbohydrate get gelatinized and therefore, its level of inclusion could be enhanced to 45-50%. The commercial diet of prawns normally contains 35-40% carbohydrates. The carbohydrate utilization capacity of young fish is always less than the adult fish.

Energy

Energy is not a nutrient, but is a property of nutrients, which is released during metabolic oxidation of proteins, lipids and carbohydrates. Energy is defined as the capacity to work, but in biological definition, it refers to muscle activity, energy for chemical reactions in body, to enable movement of molecules against a concentration gradient and for other biological as well as physiological functions in the body. Fish do have a low energy requirement because no energy expenditure is involved for maintenance of body temperature and due to its neutral buoyancy. Other explanations for low energy requirement are less muscle activity to maintain their position in aquatic ecosystem as many fishes have swim bladders, and less energy expenditure for excretion of ammonia, which is 85% of metabolic wastes that are excreted directly through gills into surrounding water. Physical activities like swimming, escaping from predators and stress, temperature, size, growth rate, species and food are some of the factors that affect energy requirements of fish. Proteins, lipid and carbohydrates contain 5.6, 9.4 and 4.1 kcal of GE/g respectively.

Successful fish culture depends up on the provision of diets containing adequate levels of energy and appropriate balance of nutrients to permit the most efficient growth and to maintain the health of the animal under given circumstances. Dietary energy level is also critical because protein in the feed is utilized as an energy source when feed deficient in energy is fed to fish; whereas, when feed excessive in energy is fed, feed consumption decreased and result in growth reduction due to lack of other necessary nutrients for normal growth. As protein constitutes the single most expensive item in fish diets, it is imperative to incorporate only the amount necessary for normal maintenance and growth. Any excess dietary protein is considered as biologically and economically wasteful. Incorporation of appropriate levels of non-protein energy sources in the diet determines the efficiency of protein utilization and hence the growth of fish. Carbohydrate and lipid are the major non-protein sources in fish diet. Compared to lipid, carbohydrate is much less expensive, available abundantly and a ready source of energy. Carbohydrate also improves the pelleting quality of the diet due their reasonably good binding properties. Therefore, it is suggested that the carbohydrate may be added in excess of the required amounts that can be efficiently utilized for energy by fish. Again, use of high level of lipid as dietary energy source may create problem in pelleting and keeping quality of feed in addition to adversely affecting the fish whole body composition.

Dietary protein: energy ratio

The condition where energy intake is inadequate, energy is drawn from protein sources. Excess protein is not only wasteful and uneconomical but also causes stress to fish and aquatic pollution as well. Diets containing excess energy leads to lipid accumulation resulting in fatty fish. Therefore, a balance between protein and energy is considered important in fish diet, so that energy spares protein for growth. The optimum protein and energy (P:E) ratio is known to be size-related and is higher in small fishes. It is reported that the P/E ratio of freshwater fish species varied from 88-113 mg/kg diet.

Vitamins and minerals

Vitamins are required in trace amounts; are essential for fish growth and to fight against diseases. And they are required for metabolism of other nutrients in tissue components. Many of the water-soluble vitamins also act as co-enzymes. Fishes derive required vitamins from natural food, which become limited in intensive fish culture due to high stocking densities. Minerals are required for osmotic balance of various metabolic processes and for structural functions in fish. Some minerals such as calcium are directly obtained by fish through gills and skin or both, while others are made available from natural food and ingested detritus. Vitamins and minerals are, therefore, provided as premix in balanced artificial feeds.

Fish require 11 water-soluble vitamins, namely thiamine, riboflavin, pyridoxine, niacin, pantothenic acid, inositol, folic acid, choline, biotin, ascorbic acid and B_{12} as also 4 fat-soluble vitamins such as A,D,E and K. Water-soluble vitamins, when taken in excess over tissue storage, are excreted after metabolizing vitamins required for the fish. Excess fat-soluble vitamins in the diet result in abnormal growth and liver diseases.
There are 20 recognized inorganic demands, which perform essential functions in the body. The minerals required by fish are calcium, chlorine, magnesium, phosphorus, sodium and potassium along with a number of trace elements such as cobalt, copper, iodine, iron, manganese, selenium, zinc, aluminium, chromium and vanadium. Calcium and phosphorus are closely related in metabolism. Phosphorus and calcium are required for bone formation. Calcium plays a major role in blood clotting, muscle function and proper nerve impulse transmission. Phosphorus is involved in energy transformation, permeability of cellular membrane, genetic coding and general control of reproduction and growth. Commercial grade vitamin and mineral premix are generally used in preparation of feeds, which should not exceed inclusion level of 2% for each in carp feeds.

Additives

The common additives and other components such as cholesterol, mold inhibitor, antioxidants, pellet binder, monocalcium phosphate, minerals, vitamins, choline chloride, vitamin C (coated), inositol, immunostimulants, pigments, etc., are used in small quantities in feed industries in India to improve the dietary quality.

Practical diets

The supplementary feed used in aquaculture generally consists of rice-bran and groundnut oilcake which are compounded in 1:1 and some farmers use mustard oilcake/til oil cake, sunflower oil cake in place of groundnut oilcake. Cake-bran mixture in conjunction with natural fish-food organisms is still a practice for semi-intensive carp farming in India. This mixture is not nutritionally balanced, and is normally used to supplement protein and energy. It is observed that stocked species receive about 50% protein, 8% lipid and 27% carbohydrate and 4 kcal/g gross energy from natural food organisms like plankton and of animal origin. Phytoplankton provides high quantities of n-3 and n-6 PUFAs. Owing to non-availability of commercial feeds and economic reasons, more than 90% farmers use farm-made feeds of cake-bran mixture or improved version of the feed mixture in carp culture. The farm-made feeds are prepared based on ingredient availability and feeding experiences. In Andhra Pradesh, farmers use defatted rice-bran and groundnut oilcake in 7:3, and a farmer in Punjab is reported to enrich his traditional cake-bran mixture with animal protein, sugar industry by-product rich in minerals and feed is further supplemented with vitamins and minerals. Inter-linking of artificial feeding with natural fish food organisms has been found beneficial as latter influences dietary efficiency and economic utilization of formers. There has been a rapid shift from traditional feeding to pellet feeding of "nutritionally complete diet".

Feed resources

Feed is as good as its ingredients. Several agro-based ingredients have been identified, analyzed for their use in fish feeds (Table 1).

The ingredients that contain less than 20% protein and 18% fibres are classified as energy supplements. The bottom dweller candidate species appear to take maximum advantage of energy supplements added in practical diets that spare protein for their growth because benthic fish food organisms are inadequately available; these do not adequately support their growth and survival.

A protein deficit is known to occur when absolute protein requirement of the fish population stocked per unit area is higher than available protein from natural fish food organisms needing protein supplementation from exogenous source. The ingredients that contain 20% or more protein are grouped as protein supplements.

Table 1. Chemical composition of some feed ingredients (in % dry matter basis)

Ingredients	Moisture (%)	CP (% DM)	EE (% DM)	Fibre (% DM)	NFE (% DM)	Ash (% DM)
Groundnut oilcake	7-10	40-43	4-8	6-7	30-33	8-10
Soybean meal	8-10	50-55	1-2	4-5	30-32	5-6
Rice-polish	8-12	12-18	12-14	7-10	40-48	5-8
Rice-bran	7-10	12-16	12-14	8-12	40-45	5-8
Deoiled rice-bran	8-10	15-18	1-2	10-15	45-50	8-12
Rapeseed cake	11-12	32-38	5-7	11-15	30-35	6-7
Salseed cake	8-10	7-8	3-4	10-13	62-68	10-12
Til oilcake	7-10	35-42	3-6	10-15	40-48	10-13
Mustard oilcake	8-10	32-38	6-9	10-16	35-40	10-12

Cotton seed-cake	7-10	32-35	6-8	12-16	35-40	8-12
Sunflower oilcake	10-12	30-32	4-8	15-18	30-35	8-10
Copra cake	8-12	20-25	6-10	12-17	35-40	5-8
Maize flour	10-12	5-6	3-4	2-3	70-80	2-3
Barley grains	10-12	8-10	2-3	4-6	70-80	2-3
Wheat flour	10-15	8-11	2-4	1-4	65-80	1-3
Fish meal	8-10	55-65	8-12	-	-	15-18
Tapioca flour	10-12	3-6	2-3	-	75-82	2-3
Shrimp waste	10-15	22-34	2-7	-	-	10-20
Squila meal	10-14	40-46	1-3	-	-	12-18
Squid meal	8-12	70-75	4-8	-	-	3-5
Clam meal	8-10	48-50	8-11	-	-	4-6
Silkworm pupae	8-10	40-45	15-25	-	-	12-15
Deoiled silkworm pupae	8-10	60-70	2-5	-	-	6-7
Blood meal	10-15	85-90	1-2	-	-	2-4
Meat meal	8-10	50-70	4-9	-	-	10-15

CP, Crude protein; EE, ether extract/crude fat; NFE, nitrogen free extract/soluble carbohydrate

Ingredient digestibility

Together with chemical analysis, the data on nutrients and energy digestibility provide a strong base for selection of dietary ingredients. The assessment of ingredient digestibility is essential for least-cost diet formulation, screening of feedstuffs in relation to raw material quality, processing and storage conditions, and for formulating diets to minimize aquatic pollution.

Fish meal, a highly sought after animal protein widely used in aqua-feeds, contains few anti-nutritional factors and is well digested. The apparent protein digestibility (APD) of fish meal, sesame oilcake, linseed oilcake and mustard oilcake for different carps including Indian major carps are 73.6-93, 78.9-89.6, 82-85.8 and 85.3-89.5%, respectively. Protein digestibility of fish meal has been reported to a maximum of 95%, and the variation in fish-meal protein digestibility may be due to differences in origin and processing of the material. There is no difference between APD values (90-91%) of soybean meal and fish meal in grass carp. The protein digestibility of 86-92% was reported for some plant ingredients in Indian major carp yearlings. Depending on the water temperature, the APD of defatted rice-bran, wheat-flour, silkworm pupae range between 60 and 88, 78 and 80 and 86 and 88%, respectively, in common carp when evaluated against water temperature of 15, 20 and 25°C.

The protein of shrimp meal, copra meal and rice bran is equally digestible as that of fish meal. The APD values are reported to range from 99.09 to 99.85% in these four ingredients. The apparent protein digestibility which is in the range of 90.9-94.6% for groundnut oilcake is higher than 74.0-76% as observed in channel catfish. The APD values of fish meal, soybean meal (defatted) and *ipil-ipil* for milkfish of different size groups held in seawater range from 2 to 71, 54 to 74 and 41 to 47%, but protein digestibility of ipil-ipil in 165 g milkfish, held in seawater, showed a negative value. The apparent lipid digestibility (ALD) has been reported as 93.08-100% for fish meal, 78.42-100% for rice bran, 91.95% for mustard oilcake and 19.52% for maize meal in carps, tilapia, catfish and seabass. The apparent energy digestibility (AED) in different size groups of Indian major carps vary widely. The data on digestibility of different ingredients for various important species of fishes and shellfish are presented in Tables 2 and 3.

Table 2. Apparent digestibility of protein and energy for various feed ingredients in Indian major carp species

Ingredients	Apparent digestibility coefficient (%)					
	Rohu		Catla		Mrigal	
	Protein	Energy	Protein	Energy	Protein	Energy
Soybean oilcake (solvent extracted)	94	90-96.18	94.1	--	92.8	81.27-89.33
Soybean meal	84	--	--	--	--	--
Sesame oilcake	89.1	--	--	--	89.6	--
Mustard oilcake	88.2	63.14-64.33	86.6	--	89.5	50.27-55.75
Linseed meal	82	--	--	--	--	--
Groundnut oilcake	83.8	78.36-82.98	--	--	88.2	76.82-81.97
Rocket salad	--	63.32-76.04	--	--	--	63.07-74.77
Silkworm pupae meal	85	66.46-68.01	--	--	--	58.34-60.27
Fish meal	74.1	69.34-72.64	76.1-90.4	--	73.6	53.97-58.03
Slaughter house waste	73.6	61.23-69.51	--	--	73.5	57.4-64.09
Rice-bran/ rice-polish	88.3-90	43.55-48.80	90	--	84.4-91	45.82-49.07
Wheat-bran	88.1-93	58.58-68.02	88.5-93	--	89.6-93	44.69-53.86
Pigeonpea dust	86.3	--	--	--	81.2	--
Yellow corn	86-96	--	86-96	--	86-96	--
Potato starch	86-96	--	83-98	--	85-98	--

Table 3. Apparent digestibility of protein and energy for various feed ingredients in exotic carps at different temperature

Ingredients	**Apparent digestibility coefficients (%)**	
	Protein	Energy
White fish meal (65.8% CP)	90 - 94	86-89
Fish meal (63.5% CP)	74-93	86-87

Meat meal (69% CP)	91-95	76-82
Silkworm pupae meal (52.6% CP)	86-88	79-82
Maize-gluten meal (64.3% CP)	82-93	73-85
Maize meal (8.2 CP)	80-82	70-73
Defatted wheat-germ meal (31.3% CP)	92-94	70-77
Defatted rice bran (18.8% CP)	60-88	48-76
Rice bran (12.0 CP)	88-94	89-92
Wheat flour (15.8% CP)	78-80	49-79
Sesame oil cake (35.5 CP)	89-92	83-84
Sunflower (32.0 CP)	88-90	80-82
Mustard oil cake (34.0 CP)	88-92	81-83
Groundnut oil cake (42.0CP)	88-90	85-87
Green gram husk (24.0 CP)	80-84	75-78
Black gram husk (27. 0CP)	80-82	80-82

Larval nutrition of fish

Up to 3rd day of hatching, the fish larvae depend on its yolk sac and therefore do not require any external feed. The larvae accept formulated diets immediately after yolk-sac absorption on the fourth day of hatching. The formulated diets containing 40-45% crude protein, 8-10% lipids, 26-30% carbohydrates, 3.5-4.0 kcal/g gross energy are generally provided to carp larvae in conjunction with natural fish food organism. While balancing protein and energy, attention is given on balancing PUFA (n-3 and n-6) and vitamin C to ensure better survival and growth. Use of micro-encapsulated egg diet has been reported for indoor larval rearing of carp larvae. This diet fortified with vitamins and minerals has primary advantage of each particle having nutritional balance as that of whole egg.

Lately, dietary supplementation of probiotics (yeast and bacteria) and phospholipids compounds (soylecithin) has gained popularity in India. The diets containing single cell proteins have been found very effective in indoor trials for larval growth and survival, and results were comparable with those of zooplankton. A basal diet for carp larvae has been developed utilizing a commercial source of live culture of *Saccharomyces cerevisae* and *Lactobacillus coagulans* supplemented at 30% level in liver-starch-cud liver oil based diet. The formulated diet is suitable for indoor hatchery rearing system, ensuring 100% survival and fast larval growth.

Realizing the need for efficient utilization of natural lipids as also for meeting high energy demands of growing fish and prawn which are incapable of *de novo* synthesizing or inadequately synthesizing phospholipids compounds, dietary incorporation of soylecithin at 4% level along with vegetable and fish oil (1:1) is optimum for carp larvae, and feeding of diet greatly influenced tissue level deposition of phospholipids in 3 species of Indian major carps. Some of the feed formulations for rearing the carp spawn is given in Table 4.

Table 4. Feed formulations for Indian major carp spawn

Feed	Ingredients	Composition (%)
1	Fresh liver	50
	Bioboost forte (Probiotics supplement)	30
	Starch	13
	Cod-liver oil	5
	Mineral premix	1
	Vitamin premix	1
2	Finely powered soybean meal	10
	Finely powdered groundnut oilcake	32
	Finely powdered fish meal	20
	Finely powdered rice-bran	30
	Vitamin and mineral premix	2
	Phospholipid (as soya lecithin)	4
	Veg. Oil : fish oil (1:1)	2
3	Groundnut oilcake	40
	Roasted soybean meal	20
	Rice-bran	10
	Fish meal	20
	Vegetable oil	4
	Fish oil	3
	Vitamin+mineral premix	2
	Bioboost forte	1

Feeding of balanced diets in presence of natural food in composite seed rearing and carp culture, improved survival rates of fry and fingerlings with their respective average values of 40% and 70%, respectively. However, in nature carp fry of 5-10 mm size subsist on unicellular algae and when they grow to 10-20 mm size, they feed on other food materials like protozoans, zooplankton, etc. Because of its high biological value, fish meal is added in larval feeds of carps at 15-20% level for preparing nutritionally balanced diets for carp fry and fingerling. Over the years, several other alternative sources of animal and plant proteins have been experimented to replace more expensive and scarce fish meal in aquaculture feeds. Agro-industrial by-products and other animal and plant wastes are blood meal and other slaughterhouse wastes, meat meal, poultry wastes, feather meal, shrimp meal, marine trash fishes and other materials of animal origin.

Cake-bran mixture was compound with blood meal in 1:3:6 and used for feeding rohu fry, that registered faster growth. Fermented fish or poultry viscera silage was also used as animal protein in carp diets in place of fish meal. Diets incorporated either with defatted soybean meal, non-defatted or defatted silkworm pupae have performed as those of fish meal based diet in carp fry. Dietary inclusion of fermented silkworm pupae silage in feed of carp is found superior to untreated silkworm pupae or fish meal.

Soybean meal is considered one of the most nutritious ingredients of all plant proteins and with supplementation of methionine and vitamins and minerals, it can totally replace fish meal in practical feeds of growing carps. Supplementation of 0.4-0.5% lysine and 10% oil become necessary especially when soybean meal replaces fish meal partially or completely. It is established that mustard oil cake can be used up to 35% in carp feeds along with other plant materials. A combination of fish meal and mustard oilcake is found better, utilized with high rate of growth performance of fish in carp polyculture. Rapeseed meal can be used in carp diet up to 24% level.

In intensive carp culture, 35% groundnut oilcake has been used along with rice bran, soybean, fish meal, vitamins and minerals at appropriate levels, that diet contains 30.27% protein, 8.95% lipid and 3.49 kcal/g energy.

Some of the feed formulations as reported by different researchers for rearing the carp fry and fingerlings are given in Table 5.

Table 7. Some feed formulations for fry and fingerlings of Indian major carps

Feed	Fry		Fingerlings and growers	
	Ingredients	Composition (%)	Ingredients	Composition (%)
1	Azolla powder Soybean meal Groundnut oilcake Sesame oilcake Rice-bran Vitamin mineral mix Attractant (seeds of Trigonella and Murraya)	60.0 19.0 13.9 4.0 2.0 1.0 0.1	Rice-bran Groundnut oilcake Roasted soybean meal Fish meal Vegetable oil Fish oil Vitamin-mineral premix	35.0 25.0 25.0 7.0 5.0 2.0 1.0
2	Groundnut oilcake Soybean meal Rice-bran Fish meal Vitamin mineral mix	26.0 23.0 33.0 16.0 2.0	Groundnut oilcake Soybean meal Rice-bran Meat-cum-bone meal Vitamin-mineral premix	28.0 20.0 30.0 20.0 2.0
3	Groundnut oilcake Soybean meal Rice-bran Meat meal Vitamin mineral mix	28.0 20.0 30.0 20.0 2.0	Soybean meal Groundnut oilcake Mustard oilcake Rice-bran Vitamin-mineral premix	7.0 30.0 35.0 26.0 2.0
4			Groundnut oilcake Soybean meal Fish meal Rice-bran Vitamin-mineral premix Vegetable oil	40.0 20.0 8.0 30.0 1.5 0.5
5			Fermented silkworm pupae Rice-bran	6.7 19.3 62.0

			Groundnut oilcake	5.0
			Groundnut oil	5.0
			Binder mix (tapioca flour, maida and rice flour in 6:3:1 ratio)	2.0
			Vitamin-mineral premix	

Azolla, an aquatic fern, is fairly rich in protein containing high amounts of lysine (6.45% of protein). The plant and its protein concentrate has also been evaluated as the source of dietary ingredient and the results have suggested that it can be used at 60% inclusion levels along with other plant materials and without incorporation of fish meal. *Azolla* culture should be encouraged which can be done in low-lying areas to produce raw materials.

Feeding practices

The size of the prey should always match with mouth gap of an animal, and hence, the particle sizes of the prepared feeds are adjusted according to the mouth gap of the growing fish and prawn. Dust or fine particles, if present, may often clog gills causing great damage to fish. It should be borne in mind that specific demand of growing ones are satisfied through feeding properly sized feeds. Crumble feeding of formulated diets to fry or early fingerlings is always considered better than broadcast feeding. The feed particles and pellet sizes for various stages is given in Tables 8 and 9.

Table 8. The particle and pellet size of feed for different life stages of carp culture

Stage of fish (carps)	Particle and pellet size
Spawn	< 50-80 mm particle
Fry	0.5 mm dia. Of crumbled dry feed pellet
Fingerlings (3-4 g)	Crumbles of 1.5-2 mm dia.
Growers	2.5-3 mm dia dry pellet

Table 9. Feeding schedule followed in different stages of carp culture

Spawn to fry (culture period 15 days)	Fry to fingerlings (culture period 90 days)	Grow-out culture (culture period 10-12 months)
4 times of initial body weight during first week and 8 times of initial body weight during second week in 2 rations	6-8% of biomass during first month, 5-6% of biomass during second month and 3-4% of biomass during third month in 2 rations	3-5% of biomass in the first month and 1-3% of the biomass in the subsequent months provided twice a day

Finely powdered feed is broadcast in ponds for spawn and fry rearing. In many advanced laboratories or hatcheries, automatic feeders are used for fish larvae, which provide feed at the desired intervals. Frequent feeding at 30 min to 1 hr interval in hatchery is known to yield good results in terms of growth and survival. For feeding fingerlings, feed dough or dry pellets are provided in check-trays, feeding baskets or in perforated gunny-bags, which are tied up in bamboo-poles, and these are kept suspended in pond-water at several points. Perforated plastic fertilizer bags are also used for providing feed, which are kept hanging in water column with the help of bamboo poles. Each of these bags can hold about 20 kg feed. When fish nibbles near holes, certain amount of feed mixture comes out through the holes, thus acts as a demand feeder. Such feeding practices are common in carp farms of Andhra Pradesh. In Punjab farmers use a number of feed baskets tied up in a row in a floating material which is kept floating across water-bodies. Floating pellets are suitable for feeding in cages. These types of feeding methods are useful to have a check on feed loss. Efforts are necessary to maintain good feed conversion ratio (FCR), not exceeding 1:2, under optimum pond and feeding management.

Use of mechanical feeders

Different types of mechanical feeders have been developed to reduce labour cost involved in feed management. Each feeder essentially consists of a hopper, a regulator, a dispenser and a controller. The feeders are classified as non-demand feeders and demand feeders. Auger, disc, drop and pneumatic feeders are non-demand feeders, which have different dispensing mechanisms to release required quantities of feed at regulated intervals in a farm. Demand feeder delivers feed in ponds upon receiving signals from fish and demand feeding is always desirable as it allow fish to feed *ad libitum* (Table 10).

Table 10. Advantages and disadvantages of common feeding practice in aquaculture

Type of practice	Advantages	Disadvantages
Hand feeding to satiation	Best assurance of maximum feeding effectiveness; may decrease size variation; higher food consumption; higher growth rates	Labour intensive; may result in higher FCR; carcass fat levels may increase
Use of feeding charts (in conjunction with automatic feeders)	Less labour intensive	Large pond sizes preclude accurate estimates of fish biomass; low predictability of feed consumed at different temperatures; capital-intensive
Demand feeders	Labour saving; permit fish to feed *ad libitum*	Size variation higher; all individuals may not be able to feed to satiation; hierarchy is manifested

Farm made feed preparation for producing the table size fish in pond

A common balanced diet is delivered to the six species of carps stocked in composite carp culture. Generally for semi-intensive carps and prawn polyculture, a feed containing 24-25 % protein and 6-8 % lipid meet the nutritional requirement of the crop. To prepare a feed containing above percentage of protein and lipid, one can chose any one of the formula given below (Table 12) according to the locally available feed ingredients.

Table 12. Some formulations for producing the farm made fish feed with locally available ingredient

Ingredients	Ratio
Groundnut oil cake (OC): Rice bran (RB)	50:50
Mustard OC: RB: Linseed OC (LOC)	40 :40 :10
Sun Flower OC: RB: Silkworm Pupae	65:30:5
MOC : LOC: RB:Silkworm Pupae	45:15:35:5
Sesame OC: RB	6 0:40

Generally feed is applied in the form of powder or dough. But feed pellet are found to show better performance than the dough. Now-a-days small grinders and pelletisers are available to prepare the feed pellets which are handy and could be transported from one place to other. In a village cluster, some fish farmers can collectively procure a grinder and a pelletizer for the preparation of pelleted feed. Some guidelines are given below for the preparation of farm made fish feeds:

How to make feed pellets

- Ingredients in required quantities are milled and mixed together.
- Grinding and mixing can be done by a portable mini grinder cum pulveriser.
- Add 2-3% of wheat flour (Maida)/ cassava as binder.
- Steam the mixture with some water, to reduce the anti-nutrient factors present, if any.
- Cool the mixture, may add 1% commercial vitamin and mineral premix.
- Add required amount of water and make the dough.
- Dough is the ready-mix to prepare feed pellets.
- Process the dough in a portable mini pellet machine.
- Use desired dice to get feed pellets.
- Sun dry the pellets and use in aquaculture pond.
- Pellets can be crumbled by the above grinder to small pieces for nursery and juvenile rearing.

Storage and preservation of farm made feed

- Farm made feed pellets should be used as fresh as possible.
- It can be stored for 3-4 months in dry and well ventilated store room.
- Polythene or gunny bag can be used to store the feed pellets.
- Moisture contamination is to be avoided as far as practicable to keep the feed in dry condition.

- Sun drying of the fed pellets is required at least once in every fortnightly to avoid the fungal growth.
- Fungal infested feed are not advised to use in fish pond.

Application of farm made feeds

- One can broadcast the finely crumbled or powdered feed in the nursery pond.
- Course crumbles are applied in basket as feed dispenser device.
- Feed pellets are given to the grow out fish or brood by hanging tray or basket at different depth of the water in the pond.
- Feed pellets are to be supplied in spited doses as per the consumption by cultured fish.

Health Management of Carps in Hatchery and Nursery Ponds

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Indian Aquaculture has gained momentum since July 10, 1957 after fishes are induced to bred. The land mark achievements of induced breeding opened the aquaculture sector gradually from open waters to closed system. Subsequent development of Chinese carp hatchery and FRP hatchery also give a rapid stride on seed industry in the country. Further, traditional freshwater aquaculture in India has a long history and comprised mainly of Indian Major Carp cultivation. Since 1980's, commercial carp culture expanded slowly and steadily to different parts of the country particularly Andhra Pradesh, Punjab, Haryana, West Bengal, Orissa and Karnataka. The primary goal of commercial aquaculture is to boost production from a unit area. The Indian major carps mature in confined freshwater but fail to breed spontaneously in confinement. With the aid of pituitary extracts and synthetic hormones, the Indian Major carps can now be induced bred successfully. Circular eco-hatchery is by far the most common hatchery systems adopted all over the country.

The most important criteria for successful fish culture practice are the availability of healthy fish seeds. Availability of required quantity of seeds of the desired species at the appropriate time is also a guiding factor that leads to success of aquaculture operation. The nursery rearing involves nurturing of the 72-96 hour old hatchery-produced spawn, which has just begun to eat. Nursery rearing continues for a period of 15-20- days, during which they grow to fry of about 25-30 mm. It has been observed that in drainable/undrainable earthen ponds, the spawns attain this desired size within a 3-week period but with a survivability of only 40-45%, even after following scientific management practices with utmost care. High losses are incurred during the early development of cyprinids. Rearing of spawns in cemented rectangular cisterns can increase the survivability rate to about 65%, but the resource-poor aqua-farmers in villages cannot afford to construct a cemented nursery chamber. They own earthen ponds of assorted sizes.

Even when the fry-staged IMC are reared for a period of 90 days to obtain the fingerlings (80-100 mm size), a maximum of 70% survivability is obtained in well-prepared earthen rearing ponds. Mortality of fish seeds occurs due to stress, infection or diseases. The etiology and the particular cause of such fish seed mortality must be properly diagnosed, so that the survivability rate increases in earthen ponds and farmers get a satisfactory production with higher profit margin. The need for adopting suitable health management measures to reduce the loss is being increasingly felt by fish seed producers.

General cause of diseases

In nature, there exist a delicate balance between the host, pathogen and the environment. Disease outbreak occurs when this delicate balance is upset. Diseases caused by bacteria and parasites are quite common in nursery and rearing ponds; non-infectious diseases due to pollution, algal toxins, feed contamination and water quality also occasionally lead to crop loss.

A pathogen cause a clinical disease only when it can establish in or on the host, proliferate, overcome the non-specific and specific defenCe barriers of the host, produce the pathogenic factors, cause cellular and tissue damage, produce significant pathological changes, impair the function of the target tissue and cause mortality. Stress can accelerate this process. Stress is caused by environmental or other factors, which disturbs the normal function of the animal to such an extent, that the chances of survival are significantly reduced. Common husbandry practices like handling, netting, transportation and other factors like suspended solids, low oxygen, high organic matter, overcrowding, high ammonia can cause stress to IMC and other fishes in their early life stages.

The egg stage appears to be less tolerant and is particularly susceptible to small changes in environmental conditions. It has been reported that intense algal photosynthesis release large amount of oxygen into water. If this gas-supersaturated water is used for the hatchery operations, it may cause gas emboli to develop within the fertilized eggs, resulting in decreased hatching yields. It has harmful impact on fry-staged fishes also. In terms of infectious disease risk, newly developed fry are disadvantaged as compared to older stages by not having a fully mature immune system. They will not have developed any acquired immunity to specific infectious diseases. High mortalities among fry are likely since even low infection levels may be lethal to small fish. Fry of Indian major carps are particularly susceptible to gas bubble disease. The freshly consumed phytoplankton is capable of photosynthesizing within the gut of fry and can produce oxygen gas. Affected fry exhibit gas distended abdomen and unusual swimming posture with their ventral surface uppermost.

Disease prevention and Control

Diseases caused by various etiologic agents followed by morality of cultured stock have become limiting factors in the production of aquaculture sector. The farm and hatchery personnel in their distress to save the stock have often resorted to the use of various remedial measures, including the antimicrobials for disease control. The frequency of use of antimicrobial agents is higher in the hatcheries and semi-intensive farms compared to the traditional systems of aquaculture. A wide range of broad spectrum antibiotics, the tetracyclines, macrolides like erythromycin, amino-glycoside antibiotics such as streptomycin, kanamychin, gentamycin, nitrofurans, like nitrofurazone, furazolidone, and even the third generation quinolones such as ciprofloxacin, norfloxacin and nalidixic acid are being used in aquaculture. However, a strong scientific database in required for the use of antibiotics either as prophylactics or therapeutics for various life stages of cultured stock, and their pharmacological aspects in the prevailing agro-climatic regions. Besides antibiotics, chemicals, immunostimulants and vaccines are also used for disease prevention. For each steps of prevention starting from the nurseries to grow out it is necessary to have an standard operating protocols for disease management which will act a barrier for disease outbreak.

Bacterial and viral infections

Bacteria like *Aeromonas hydrophila, Edwardsiella tarda* and *Pseudomonas sp*. can cause infection in fry-staged fishes and fingerlings. Majority of the bacterial fish pathogens in tropical waters are ubiquitous and can cause disease as primary pathogens or as secondary opportunist under stressful condition of the host. Major clinical signs of *Pseudomonas sp.* infection include body reddening, skin lesions, protruding belly and eyes, loss of natural colour and progressive disintegration of fin and tail tissue. Same for *Aeromonas hydrophila* infection are skin lesion with blood, sluggishness, anorexia, eroded fins and ulcers on the roof of mouth.

For the external surface ulcerative type of bacterial diseases caused by *Aeromonas hydrophila* and *Pseudomonas sp*., a dip bath treatment of the infected fishes in Copper sulphate solution at 500 ppm or potassium permanganate at 5 ppm concentration for 60 seconds has been found to very effective. Strict sanitation of hatchery equipments, elimination of carrier fish from the water supply, use of Calcium oxide at regular intervals in ponds may prevent the diseases to a considerable extent. The best preventive measures for bacterial diseases like fin rot and tail rot are the maintenance of favourable environment and good sanitation. Application of Oxytetracycline hydrochloride along with supplementary feed at the rate 75 mg per kg fish for three weeks may help to get rid of *Aeromonas* and *Pseudomonas* infections. Generally brood fish when transported to the hatchery operation for breeding utmost handling care to be taken and preferably dip treatments of potassium permanganate are to be given as a prophylactic. It has been observed that after breeding is over many brooders die after 1-2 days during spent condition. It is advised to give an antibiotics treatment preferable through injection to prevent mortality. Simultaneously feed management and water quality parameters are to kept at optimum levels.

Few bacteria, *e.g.,* Mycobacteria and viral fish pathogens get transmitted from parents to progeny via eggs or possibly sperm that the offspring are infected before hatching. This vertical transmission is suspected in case of viral infection caused by some Rhabdoviruses, which affect cyprinids.

Fungal infections

The fungi *Saprolegnia* sp. has been reported to cause infection in spawn and fry of Indian Major Carps. Often it infects as external fungi on fish eggs. The fungus first establishes on dead and unfertilized eggs and gradually spread to healthy developing eggs destroying the entire batch of incubated eggs. The fungus manifests itself as white to grey cotton wool-like growth smothering the eggs. Egg washing and removal of necrotic substances such as unfertilized and damaged eggs helps to minimize fungal infection to hatcheries. The fertilized eggs before releasing into the incubation-cum-hatching chamber are given a dip treatment in methylene blue or sulphanilic acid at 2-5 ppm concentration for one hour.

Saprolegnia sp. infected fry-staged IMC can be given a bath treatment in formalin at concentrations 1:500 or 1:1000 for 15 minutes. In order to cause disinfection of fertilized eggs, it can be treated with pure iodine at a concentration of 50-100 ppm for 10-15 mins. Acriflavin and commercially available iodophors may also be used as egg disinfectants.

Parasitic infections

The ciliated protozoan ectoparasite *Ichthyophthirius multifilis* often infect the fry and fingerlings of Indian Major Carps. This parasite (0.03-0.4 mm) is visible as white grit-like spots on skin, gills and fins. Affected fishes show erratic swimming movements, mucus secretion occurs and they gasp for air.

Monogenetic trematodes like *Dactylogyrus* sp.(gill fluke) and *Gyrodactylus* sp. (skin fluke) with their well-developed attachment haptor and feeding apparatus can cause extensive pathology and mortality in early developmental stages of fishes. Fishes become restless, gasp for air; they appear anaemic with opened operculum. Proliferation and hyperplasia of respiratory epithelial cells and skin epithelial cells occur in cases of gill fluke and skin fluke infection respectively. *Myxobolus* sp. is a Myxosporidian protozoan endoparasite reported to infect immature IMCs. Affected fishes exhibit loss of balance, typical whirling movements; malformation of jaw and vertebral column takes place.

Prolonged bath of the *Ichthyophthirius multifilis*-infected fishes in Malachite Green oxalate at a concentration of 0.15-0.20 ppm for 4-6 hours will be useful. Such a treatment must be repeated four times at intervals of 1-2 days. In order to control the existence of monogenetic trematodes, a permanent bath treatment of affected fishes in Dipterex at 0.5 ppm concentration at water temperature between 27-31° C can be very effective. A bath treatment in 5-10 ppm Potassium permanganate solution for 1-2 hours helps to get rid of these infestations. The non-toxic antibiotic Furazolidone has been found to be effective against *Myxobolus* infections. Application of the same with supplementary feed at concentrations 152-194 mg per kg fish is recommended. Formalin @ 5-15 ppm is also recommended for control of such parasitic infections in early stages.

Conclusion

For the larvae of fishes, which are much tinier than the adult, the period between first feeding and metamorphosis is a crucial one in which many larvae die. This is a serious constraint for the fish farmers. We understand that different stress factors such as inadequate physico-chemical and microbial quality of culture water, poor nutritional status and high stocking density can cause infection by opportunistic pathogens. Acute level of pollutants and suspended solids can directly bring about abnormalities and mortalities in seed fishes. Supplementary feeds stored under improper and humid conditions can lead to deterioration of its quality. It may prove harmful for the spawn, fry and fingerlings. Algal blooms in small fishponds may contribute to crop loss. Application of Ammonium sulphate at 10 ppm concentration over pond surface can be useful in this regard. Considering some of the environmental requirements, dissolved oxygen concentration may be less than 5ppm for a period not to exceed 8 hours within a 24-hour period, but at no time shall the concentration be lower than 2 ppm. Pond waters with pH values ranging from about 6.5 to 8.5 at daybreak are most suitable for fish production. Water supporting good seed fish population must contain less than 5 ppm of free carbon dioxide. Total ammonia concentrations must only be in trace amounts. A 30-45 cm Secchi Disc reading in pond water indicates that it is in good condition and phytoplankton production is neither excessive nor scarce. Presence of such congenial conditions in nursery and rearing ponds must be monitored frequently so that the delicate early stages of IMC and other fishes may grow in a non-stressful environment.

Fibre Reinforced Plastic Fabrication & Maintenance

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Introduction

Glass Fibre Reinforced Plastic (GRP) has emerged as one of the important class of construction material for making load bearing structures and products. Several products are being made out of these materials and the applications are spread in almost all fields of engineering. A thorough understanding of the materials and their property are essential for their effective utilization. Over the years several new materials have been developed by man for his technological needs and comforts. As the technology became more and more sophisticated, correspondingly the materials used also have to be made more efficient. The conventional materials may not always be capable of meeting the demands. New materials are being created for meeting these performance requirements. The glass-reinforced plastic (GRP) otherwise known as FRP is one class of such materials developed for the modern technological applications.

The first step in a FRP designing process is the selection of a set of design parameters, which are listed below:

- Overall shape, sizes and dimensions of the product
- Selection of raw materials likes fibre, resin, filler, etc.
- Selection of the structural concepts like beams, un-stiffened panels, stiffened panels, sandwiches, panels, etc.
- Selection of the material microstructure
- Selection of interconnection of various structural elements and support arrangements.
- Selection of the processing/ fabrication / erection method
- Selection of finish, color, texture, fittings and accessories, etc.

General Tools required	FRP Raw Materials required
• Brushes • Hacksaw • Hammer • Chisel • Screw Driver • Sand Paper • Drilling Machine • Sander Machine	• Unsaturated Polyester Resin • Glass wool • Curing Agent (Catalyst & Accelerator) • Mould Releasing Agent (PVA & Wax Pool) • Pigment (As per Color choice) • Polish

FRP Hand Lay-up Process/ Fabrication Method

Painting

Trimming

Curing and releasing the mould

Lay-up process (Resin & Glasswool)

Gel coats

Mould release agent

Wax coats

Plywood mould

Fig: Lay-up process of Fibre Reinforced Plastics

Step-1: Design of Mould

Mould is the prime requirement for making any FRP product. A suitable mould must be made before any molding process is undertaken. This is one of the most important steps, since it affects the quality of the molding. When wide ranges of possible molding processes are available, many different types of moulds are required. This can be made from wide varieties of materials including wood, plaster of Paris, concrete, sheet metal, epoxide, polyester resins, non-ferrous metals and steel or a combination of these factors, which affect choice of mould materials, include the number and size of the moldings to be produced, the type and finish required and the molding process. While designing the mould, several parameters like material selection, mould thickness, mould trim line size, mould taper, etc. are to be considered.

Mould for hatchery unit

Step –2: Construction of Mould

Open mould processes of FRP fabrication make use of only the male or female half of the mould. Since pressure is not applied in hand lay-up or spray-up methods, the moulds need not be as strong as the moulds used in compression molding. Also, when heating is not required metallic moulds are not essential. Wooden mould requires finishing work on moulds after every cycle of molding. FRP moulds are ideal for intricate shapes. When heating or pressing is required the metallic mould has to be coated with wax and releasing agent. For trimming some allowances may be allowed, which is slightly larger than the product dimensions.

Step – 3: Seal the Mould

The mould must be sealed to keep the resin from sticking on to it. Sealers also tend to make the mould surface smoother. Mould sealed with polyester resin is thoroughly dried. The plastic resin produces the best sealer finish. It buffed to give a higher polish on the molded laminate.

Step – 4: Wax the Mould

After the mould is properly sealed, hard paste wax is applied on it twice. A good automobile wax, one that contains Carnauba, is desirable. Polishing should be done on the mould as to an auto body, using a clean soft cloth.

Step – 5: Apply Mould Release

Mould release (PVA) is to be applied over the paste wax to make the separation of mould and product quite easy. The separation should be at the wax line, but if the mould release is not present, the heat of cure may destroy the wax. Water-soluble film forming of paste type mould release may be used as mould releasing agent and applied with brushes/sponge. It will dry after 3-4 hours of application and form a thin plastic film, which can be removed with water.

Step – 6: Apply Gel Coat of Resin

Mix the gel resin first with the colour pigments (10%) and then 1-2% accelerator (Cobalt naphthanate) is added to this mixture. Then add 2% catalyst (MEKP) to it and mix again. Brush the resin mix in a thick coat on the mould surface. Allow it to cure. The first coat should be as thick as possible without severe drainage. It makes a nice surface with polish. These gel coats are allowed to cure before any other materials are added to the laminate. Sand the cured gel coat or rough lightly with steel wool before the next coat is applied to prevent the delamination.

Step – 7: Application of Resin

The resin is mixed with the normal amount of accelerator and catalyst, and applied over the cured get coat. This resin coat will hold the glass material in place, and also help to keep out air bubbles.

Step – 8: Apply First Layer of Glass Material

Cut chopped stand mat (300 g/m^2) to the shape of the product (allow enough on all sides to grasp the material and pull out the wrinkles) and lay it over the mould, which has just been covered with resin. Lay it down from one side to prevent air from being trapped in it.

Step– 9: Additional Glass Material Layers

Additional layers of material (300 g/m^2 or 450 g/m^2) either chopped stand mat or woven moving placed over the mould in the same manner as the first ones. This layer may be of different kind of material than the first. Greater strength is achieved with each additional layer. Be sure to remove all air pockets between the layers. Layers will stick well if each layer is added in the right manner.

Step – 10: Final Resin Coat

A final coat of resin with colour is added after the laminate is cured properly. This coat is needed to get a better finish on the outer side of the product.

Step –11: Curing the Laminate

The fiberglass reinforced plastic laminate is allowed to be cured until it is hard. If the laminate is removed from the mould before the plastic is cured, the layers of glass fabric may separate from each other. The usual time of curing is from 16-24 hours and it could be adjusted with catalyst concentration to reduce the curing period. In some cases it is desirable to remove the laminate from the mould before it is completely cured, as slight flexibility of the laminate at this stage will allow easier removal/ separation from the mould.

Step –12: Removal of the Product from the Mould

Remove the laminate from the mould with as much care as possible. It is easy to damage the laminate and the mould at this point. An inexpensive putty knife with the end ground well may be used for this purpose. Several thin pieces of wood may be pushed between the mould and the laminate. Water will soften the film forming mould release for easier removal. A soft mallet may be used for this purpose.

Step –13: Trim and Finish the Edges

The edges of the laminate are very rough when it is removed from the mould. The extra fabric and plastic resin dripping is removed with hand wood working or metal cutting hand tools. The trimmed edges is planned with a hand plane, filed with wood or metal files, and sanded with wet or dry sand paper. After sanding, the edges may be coated with resin. This is not always necessary, but, it improves the appearance of thicker laminates. It will seal the edges and improve the color. If the edges are not sealed, they are to be buffed.

Step –14: Strength of the Materials/ Laminates

When fiberglass materials are combined with plastic resins and the resins are cured, the greatest strength is produced. It is possible only when the correct balance is kept between the two materials. In general, the larger the volume of glass in the product the greater the strength achieved to the product.

Process of repairing a damaged FRP surface

Step – 1: Make the damaged portion a rough surface by using Sand paper or proper tools such as Hand File, Hack Saw, Sander Machine, etc. or cut out the peripheral portion of the damaged surface.

Step – 2: Cut out required area of glass wool.

Step – 3: Measure the quantity of Polyester Resin and Curing Agent required for that particular damaged area.

Step – 4: Find and select any specific material to act as a mould for the particular damaged portion of the FRP structure surface.

Step – 5: Follow the FRP Hand Lay-up Fabrication Process as given in the chapter.

Impact of Portable FRP Carp Hatchery in India: Lessons Learnt and Future Strategy

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Introduction

Development of the induced breeding technique of carps by Choudhury and Alikunhi during 1956 while working in the wet lab at Pond culture division of Central inland fisheries research institute, Cuttack is considered to be the greatest scientific innovation that laid foundation of the aquaculture growth in India popularly known as blue revolution. Since then several studies has been made to improve and refine the technology of induced breeding for carps in India. Among them development of the fibber reinforced plastic hatchery or FRP hatchery or portable carp hatchery is a significant one which has been very popular among the farmers. The technology is considered as flagship technology by Indian council of agriculture research and widely recognized by government and private agencies. This heightened awareness and recognition has helped rapid dissemination of technology among wide range of stakeholders viz., university, colleges, research institutes, NGOs, fisheries departments, farmers, entrepreneurs and corporate bodies. However, the performance and impact of these technologies across the country has not been uniform and a wide range of utilization level was reported.

Conceptual framework

The assessing impact of the FRP hatchery technology is a challenging task as the gadget is only structure to support induced breeding technology. The induced breeding technology was made popular across the country with the circular hatchery which is primarily made from the bricks, mortar and concrete. The hatchery is an integral part of the induced breeding technology. Moreover, successful adoption of the technology is also dependent on the forward and backward linking technology like broodstock management and seed rearing respectively. Hence, the performance of the gadget is dependent on the adoption of the other related technology. Therefore, the evaluation of the technology need to consider integration of related technologies that has determining effect on the social and economic impact of the adopted zone.

The real impact of the portable hatchery can at best is assessed through taking system approach in which the system of the seed production system develops with hatchery playing central role. The hatchery has the capacity to produce as large as 300 million spawn in a year which can produce stocking material up to 200 to 300 ha of water bodies. In between the hatchery and culture there are large number of small and marginal farmers who raise the stocking material from spawn to fry and fry to fingerlings as short-term crop. Therefore, the seed production system develops around hatchery in which large number of seed growers, broodstock grower and culturist also collaborates as joint stakeholder. Hence, the impact assessment required to take a holistic and system approach in which at least four technologies i.e broodstock management, hatchery management, seed rearing and fish culture were adopted by diverse group of entrepreneurs/farmers with the central role played by the hatchery. Hence, present paper evaluate the impact of the hatchery as a central mechanism to develop seed production system with benefits accruing to large number of stakeholders through application of diverse technical interventions.

Capacity and opportunities in the portable carp hatchery

FRP hatchery technology is a system of the production of the spawn from brood fish through simulating the natural flow system using fiber reinforced plastic as material. This is a miniature and flexible form of the conventional circular hatchery system which can be easily transported, installed and dismantled. It consists of the breeding pool, hatching pool, collection chamber, shed, pump, overhead tank and pond. The various ways the different components of the hatchery can be combined to develop diverse types of the system. Even though each system constitutes a core element of the hatchery but the diverse combination of the components makes them quite unique and different from each other's. In other words, a hatchery operator having one breeding pool, one or more hatchery pool, one or more brood stock pond, one or more nursery pond, one or more rearing pond or culture ponds. He can choose to operate at the various level of capacity utilisation based on the physical resources and technical capabilities.

Table 1. Theoretical level of productivity of portable hatchery

Indicators	1 BP+1 HP	I BP+2HP	1 BP+ 3 HP
No of cycle per month	**10**	20	30
Cycle per season (2 month)	15	30	45
No of brood fish required for the season (kg)	300	600	1200
Actual brood-stock maintenance (kg)	375	750	1500
Brood-stock pond required (ha)	0.5	0.75	1.0
Spawn production (lakh)	150	300	600
Nursing pond space (ha)	2.0	4.0	6.0
Production of fry (30%) (lakh)	45	90	180
No of ponds (av. size 0.01 ha) for nursery raising using twice	100	200	300
Rearing pond space (ha)	3.0	6.0	9.0
No of ponds with (av. size 0.1 ha) for earing	30	60	90
Total no of fingerlings for stocking (60%) (lakhs)	27	54	108
Pond space for culture (with stocking density @ 5000/ha) ha	500	1000	2000

*Allowance for non-maturity, catchability, mortality etc @25%)

The seed is produced in batches with each cycle taking 1- 4 days depending on the number of the hatching pool available. Hence, the total production of the seed is dependent on the number of cycle with the assumption that in each cycle full 20 kg of broodstock is used for hatching.

Table 2. Linkages of seed production to the land (pond area) required

	Number of cycles of hatching						
	1	5	10	15	25	30	40
Kg of brood fish required (kg)	20	100	200	300	500	600	800
Brood fish in pond (kg)	35	150	300	500	800	1000	1200
Spawn produced (lakh)	10	50	100	150	250	300	400
Fry produced (lakh)	3	15	30	45	75	90	120
Fingerlings (lakh)	1.2	6	12	18	30	36	48
Culture area (ha)	18	80	160	250	450	500	650
Land requirement							
brood stock pond (ha)	0.03	0.2	0.3	0.5	0.75	1	1.3
Nursing space (ha)	0.3	1.7	3.3	5	8	10	12.2
Rearing space (ha)	1	4.0	7	12	20	24	28
Farm facilities (+ Others 25%)	0.3	1.0	2	3	8	5	8
Total land required	1.8	6	12	20	38	40	50

*Assumption: Stocking: 3-5 million for spawn, 0.3 to 0.5 million for fry and 5 to 10 thousand of stocking

<u>Development of profitable the seed production system</u>

FRP Carp Hatchery

↓

Spawn: 20 million (in 20 operations in a season)

↓

Fry: 6 million (with 30% survival)
10 ha seasonal ponds required

↓

Fingerlings: 3 million (with 50% survival)
50 ha rearing ponds required

↓

Grow-out Culture
500 – 600 ha of culture ponds can be stocked

Fig 1: seed production system through portable hatchery

It is estimated that establishment of the one hatchery can produce sufficient stocking material for the about 500-600 ha of water areas in the region. The seed can be reached out to the farmers under best condition within 50 to 100 km. Hence, it was observed that one hatchery in a cluster of 2-3 blocks is ideal to make the region self sufficient. It was also recommended to establish such decentralized system of the seed production all across the country so that the seed will be available at the door step of the farmers.

Based on the number of hatching pool, the hatchery system is either one, two or three million capacity of spawn production per operations of hatchery (four days). In the hatchery the spawn (final product from hatchery) is harvested on 4th day during operation. Fertilized eggs are kept in hatching pool for incubation and it takes 14-18 h for hatching, and then after 72 h for transformation to spawn. Thus, four days are required for spawn production from one million capacity unit. It can produce two and three million spawn in four days with the two and three breeding pools, respectively.

The economics of hatchery operations is dependent on many factors like capacity of hatchery, level of use of the gadget, price of inputs and outputs, availability of brood stock, regions of operations, season of operations, etc. It is estimated that on an average a minimum of 20 cycles can be made in each year and based on these operations the hatchery is found to be highly profitable. A set up with three hatching pool and one breeding pool can recover the whole capital investment in one season. Therefore, the hatchery was found to be a very profitable enterprise for the small and medium scale entrepreneurs in rural areas.

Table 3. Economics of FRP hatchery operation

(Price in 1000 Rupees)

Items	I BP with 1 HP	1 BP with 2 HP	1 BP with 3 HP
Fixed Capital	130.0	163.0	233.0
Depreciation cost 10 %	13.0	16.3	23.0
Variable Cost per Cycle	2.5	4.0	5.5
Total Costs(20 cycles)	76.0	112.6	146.8
Gross Return (for 20 cycle)	132.0	264.0	396.0
Profit (Gross income - Total costs)	56.0	151.4	249.2
Profit over investment	43.0	135.1	226.0

(BP- Breeding pool; HP- Hatching pool)

Realisation of the potential

As described in the previous sections, the portable hatchery is a gadget with maximum level of capacity as given above but actual realisation of the potential depend on the capacity of the operators to maintain inputs, gadget, market the output. Several visits and studies were made over the actual utilisation of the hatchery. The reasons for utilisation (lack of utilisation depend on the various factors like administrative, management, economic factors.

Table 4. The summary of the factors affecting utilisation of the hatchery

Constraints	Factors	Outcome	Examples
Administrative	Lack of installation in state farms	Not utilised	Meghalaya state department
	Hatchery not allotted to the farmers	Not utilised	Assam
	Fund not available for transport	Not utilised	NEH areas
	Not able to provide manpower	Not utilised	State governments
	Lack of operational fund	Not utilised	Most of the government farms
Technical	Lack of suitable site for installation	Failure to operate	Chattarpur, Ranchi
	Non-availability of knowledge	Failure to operate	Mizoram, Arunachal Pradesh
	Lack of technical manpower	Failure to operate	
	Water condition not suitable	Lack of spawn survival	Bali, Sundarban
	Lack of rain and dry condition	Not able to spawn	Rainfed areas
Management	Limited resources available	No fund to operate	SVA, Nuapada
	No brood-stock pond available	Dependent on outside broodstock	Komna, Nuapada
	No sufficient number of brood pond		Diptipur
	Non availability of rearing pond		Rainfed areas, HEH areas
Economic	Lack of economics of scale	Discontinued	SVA, Nuapada
	No proper marketing network	Not able to sell spawn	NEH areas
	Lack of sustainability in supply	Spawn buyers not available	Most of the new hatcheries

Forward and backward linkages

The portable hatchery operates as a small part of the chain of whole process of the seed production. In the backward chain brood stock maintenance and production and forward chain nursing and rearing is critical to produce the quality and quantity of seed. Therefore, the efficiency of the seed production involving hatchery is related with these two linkages. The same is applicable to every category of the hatchery operated for the spawn production. The production of the quality seed is dependent primarily on the quality of the broodstock. The specific recommended practices of selecting and feeding the broodstock is available and adopted by hatchery operators. Similarly, the production of fry from spawn and fingerlings from fry involved specialized training, package of practices and skill. The land space available for the seed production from the spawn is critical to the success of the hatchery operations. These three sets of activities in seed production i.e brood stock maintenance spawn production and seed rearing are undertaken either by one operator or multiple operators. The diverse set of the systems are available in the country. The large seed producers generally maintain integrated farm to produce fingerlings from the broodstock. But many small operators are linked through specialised activities in broodstock raising, hatchery, seed nursing and rearing among individual operations. The second category of the system of seed production is widely prevalent, particularly among the small operators and FRP hatchery operators. In addition, there are multiple types of forward and backward integration or linkages. The contract farming of the seed rearing between the hatchery operators and seed growers are also prevalent. In such case, the inputs are provided by nursery operators including spawn and seed growers provide land, water and labour. The profit is equally shared by partners. In some cases, the seed growers provide broodstock to hatchery operators for spawning and the spawn produced are equally shared. The institutional framework in the linkages determines the efficiency of the seed production system. Therefore, the FRP hatchery operations can be seen in the context of these linkages that are essential elements and preconditions to the efficient use of the technology for seed production.

Sustainability of the technology

The sustainability of the technology is dependent on the activation of the self-sustaining forces in dissemination and operation of the technology. In other words, the technology needs to be economically viable, socially acceptable and environmentally friendly to be considered as sustainable. The commercialization of the technology by CIFA is a big step forward in the sustainable dissemination of the technology. Now, the production of the gadget is handled by the private sector on payment basis with desired profit. Hence, the technology is available on payment and the element of sustainability is inherent in it. At the production level the benefit cost ratio is in the favour of producer as the producers are expected to return back the investment in three years period and the technology is expected to operate at the profitability of 30 to 40% of the investment. As compared to the conventional hatchery, the water requirement is lower and small sized pools require minimum quantity of water. But, the sustainability of the operations is dependent upon the institutional linkages with the forwards and backward functions as indicated above. The general impressions at present indicate towards sustainability of the technology at the operator level. The actual sustainability can be assessed after few years when the operations pass through many years of the test.

Issues and constraints

Even though the hatchery is made available wide across the region, locations and institutions, the utilization of the technology is not uniform. Few cases there are full utilization and used in the commercial scale for spawn production. Where as many of them are still not being installed or underused well below the potential. As of now, the information on the utilization of the technology is not available but the indications on the issues and constraints affecting operation of the technology is available. Below is the few issues affecting the operationalization of the technology as the users level.

***Underutilization of technology*:** Even though most of the hatchery sets are being dispatched to many locations across the country. All of them are not in operations either due to lack of installation or availability of the facilities and infrastructure required for the operation of the hatchery. The water shortage, lack of technical expertise and lack of operating manpower etc are the reasons for lack of installation of the hatchery

***Non-availability of broodstock*:** Broodstock availability is a major constraint in operation of the portable hatchery. The present system of the dissemination is not taking into consideration the broodstock development. The broodstock is not easily available from the market. In many cases, the hatchery operators are depending upon the culture ponds for broodstock. Culture ponds are not a reliable source of the broodstock as it is not produced for the purposes nor is the best source of quality broodstock.

Lack of rearing facilities: Most of the hatchery operators have small rearing facilities but for the full operation of the hatchery a large area of seed rearing is required. For each operation about 3 ha of rearing space is required for a full operation about 50-60 ha of the rearing space is required. Most of them are not well connected to the seed producers. Therefore, enough demand for the spawn is not created.

Lack of technical knowledge on rearing: Specific skill, attention and entrepreneurship are required for the seed raising. The training and experience are essentially required to raise seed as without it there would be mortality and loss. But, technological package disseminated to the hatchery operators does not include extending seed production technology. Therefore the lack of the technical knowledge on seed production is a major constraint in operation of hatchery.

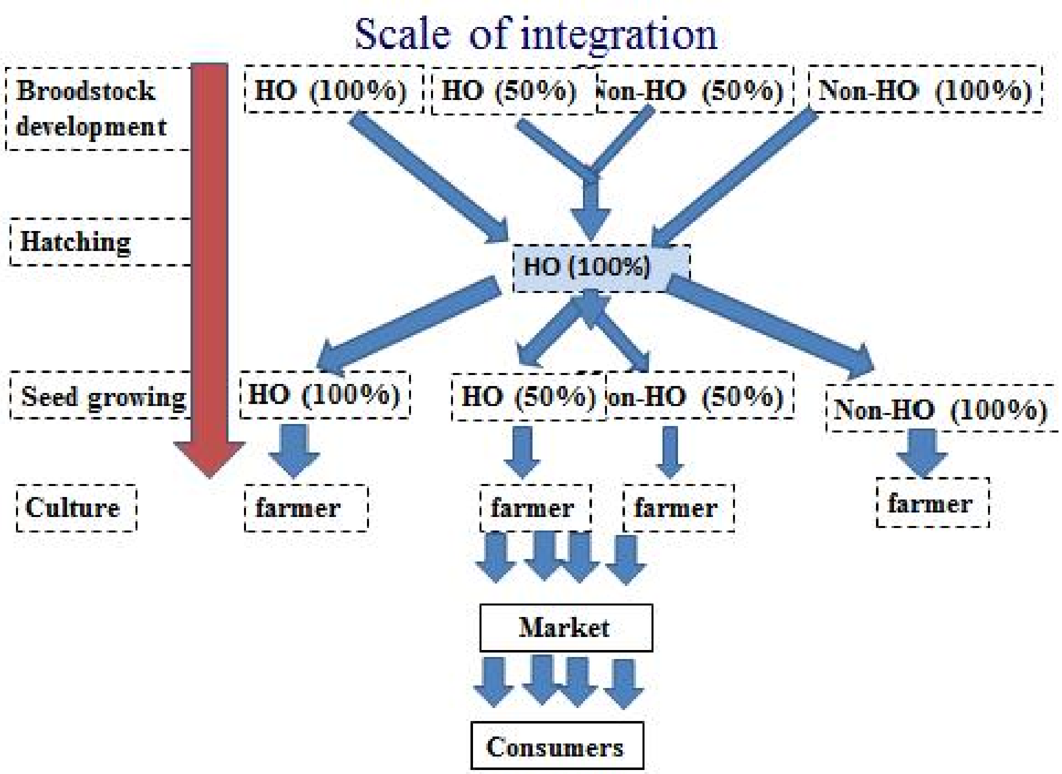
***Inadequate rearing network*:** It has been observed that the large portion of the beneficiary of the technology are the small scale operator, institutions like universities, KVK, NGO lacking adequate rearing space to grow seed. Even though the capacity to produce spawn from the hatchery is quite large, the space required to grow them is generally outside their control. Many small scale fish seed growers, women farmers, SHGs are involved in rearing. But, the network is often weak and unreliable as there is lack of coordination among them. Due to lack of such network, the hatcheries are not operating at its potential.

Competition from organized market: Many of the FRP hatchery operators are new entrant into the business and therefore lack adequate strategy and skill to operate in market. On the other hand, the organised markets, particularly the network of traders of West Bengal are highly developed in eastern India. They are able to deliver fry at door step. In order to compete to these agents, the hatchery operators along with the seed growing networks needs to equip with skill and strategy to compete with the market.

Lack of entrepreneurial skill: The operation of the hatchery require arrangement of inputs, development of rearing network, marketing skill as well as other management capabilities. But the beneficiaries of the FRP often lack this enterprising ability. This is particularly constraining when the institutions are involved in hatchery operations and the spawn production are under the potential.

The colleges, NGOs and other institutions using the technology are not oriented towards the production of spawn and seed. The hatchery is being used for demonstration or instructional purposes like teaching and training. The gadget is only used once and twice and therefore not contributing to the seed production in the region.

Management models for portable hatcheries



Based on the level of integration with the broodstock management and seed rearing the economics of the management of the hatcheries is determined. In general, management of the standalone hatcheries leads to uncertainties in the availability of the broodstock and rearing space in time and hence, the hatchery operator engaged in both forwards and back ward linkages. Based on these three management models for the portable hatcheries management and its economics are calculated.

Model 1 (no integration with broodstock and rearing, 1 BP & 1 HP)

Conditions:

- Fish farmers purchased brood fish from market and produced spawn sold to outside
- Farmers having small agricultural land used for paddy/ horticultural/diary/poultry etc
- Man-power engaged in Aquaculture activities are part-time in nature, they are also involved in other activities
- Aquaculture activities are seasonal in nature
- Farm located in remote village
- Technology System [One breeding & one hatching pool]
- No. of operation = 15 cycle/year
- Breeding pool = 20 kg fish/ operation
- Hatching pool =10 lakhs egg/ operation

Pond facilities required: The brood fish is the basic inputs in the hatchery. Brood fish can either be directly purchased or produced in the firm. It is technically recommended to produce the broodstock at the farm to get at cheaper price as well as produce quality seed. But many cases the smaller operators depend on mature fish produced outside. The total quantity of brood fish required for 15 cycles is 300 kg but actual quantity of brood fish required taking into account the maturity condition, catchability and buffer stock will be around 450 to 500 kg. The total cost of purchase of brood stock is about 65,00 rupees. But, the fish can be sold back after breeding but with reduction in the quality and weight of the fish. The net loss to the value due to breeding is about 20%.

Manpower requirements: four categories of the manpower are involved in the hatchery operations i.e. skilled manpower with mechanical expertise for operation of electrical, plumbing and mechanical; skilled labour involved in netting the fish and operation of hatchery, technical person skillful in injection and hatchery operations and the managers. In the small scale hatchery very often the owners, managers and technical person are the same and they mostly depend upon the skilled labour for the operations. The total labour requirements are around 90 days. In Order to operation the hatchery 1 hp water pump run needs to be run for about 1000 hrs with the cost of electricity of about 1500 rupees. With the whole year of lighting together costs about 3000 rupees on electricity. A telephone Land line for rural area costs about Rs.1500/- per year.

Chemicals: the PG or ovaprim being used as inducing agent. Ova prim for male @0.2 ml/kg and Female 0.5 ml/kg makes the requirement of 105 ml prices at Rs 400/10 ml. In addition, one liter of the potassium permanganate is needed with price of Rs 200. Net cost of the chemical is about Rs 4500/-

Equipment and farm facilities: The farm facilities like electricity, telephone, shed etc are required. For the successful hatchery operations many smaller as well as bigger implements and equipment are required. The detail of the requirements along with the cost and annual value is being presented in the table.

Consolidated cost of lower scale operation of FRP hatchery

	Amount in Rs	Comment
Brood fish	14000	20 % of value of broodfish
Chemicals	4500	Ovaprim and KMno4
Equipment	2200	Annual value
Facilities	11500	Annual value
Labour	13600	Seasonal labour
Total	45300	

Tools and Equipment required and cost

Sl. No.	Items	Qty (Nos)	Rate (Rs.	Total (Rs.)	Life in years	Annual value in Rs
1	Plastic bucket	02	70	140	3	50
2	Plastic mug	02	15	30	3	10
3	Breeding hapa	02	450	900	3	300
4	Outer hapa	02	250	500	3	150
5	Inner hapa	02	175	350	3	120
6	Spring weighing balance (5 kg)	01	100	500	5	100
7	Hand net	02	150	300	3	100
8	Small table	01	400	400	5	80
9	Serings & Niddle-01 set/operation	15	5	75	1	75
10	Hand brush with long handle	02	35	70	2	35
11	Plastic hand brush	02	15	30	2	15
12	Brood fish carrier	01	1500	1500	5	300
13	Hammock	01	600	600	3	200
14	Covering nets	(LS)	200	200	3	60
15	Pipe wrench	02	375	750	3	250
16	Tester	01	45	45	1	45
17	Adjustable wrench (12")	01	225	225	3	75
18	Screw driver	02	65	130	2	65
19	Pliers	01	150	150	3	50
20	Spanner	01 set	350	350	3	120
			Total	6785		2200

Farm facilities required and cost

Sl.No.	Items	Qty (Nos)	Rate (Rs.	Total (Rs.)	Life in year	Annual value in Rs
1	Pump	1	6000	6000	5	1200
2	Electricity connection	1	30000	30000	20	1500
3	CFL lamp	4	150	600	2	300
4	Cost of electricity for pumping	1	1000	1000	1	1500
5	Cost of other electricity	1	3000	3000	1	1500
6	Telephone	1	1500	1500	1	1500
7	Shed and tank	1	30000	30000	15	2000
8	Pipes and fittings	1	8000	8000	4	2000
	Total					11500

Labour required

Sl.No.	Items	Qty (Nos)	Rate (Rs.	Total (Rs.)	Life in year	Annual value in Rs
1	Technical manpower (mechanical)	5	200	1000	1	1000
2	Technical hatchery	60	200	6000	1	6000
3	Skilled labour	90	140	12600	1	6600
	Total					13600

Output

	Items	**Quantity/lakh**	**Price/lakh**	**Gross sale price**
1	Spawn 15 operations	150	500	75000
2	Input cost			45000
3	Profit			30000

Model 2 (1 BP and 2 HP with 50 % own broodstock and 50 % spawn rearing)

In the model two a typical farm operates with one breeding pool and two hatching pool. Capacity of each system Breeding pool is 20kg/operation and one hatching pool:10 lakhs eggs/operation. It is assumed that such model farm operates for 25 cycles per year. The achievement of the 25 cycles of operations of hatchery can be considered as the efficient among the freshwater carp hatcheries of India. Even though two to four months of the breeding period available in the country the farmers in practice only go for breeding in selected days looking at the weather conditions, brood stock, rearing space and labour availability. Average farmers with resources can go for about 25 cycles easily. Therefore, it is reasonable to consider such intensity as a stylized category of the hatchery operators and the working of these groups can be analyzed.

Broodstock: the broodstock requirements are about 500 kg but net requirements of about 800 kg taking into consideration catchability, maturity and breeding failure. In the process of breeding the net loss of quality is about 20%. Therefore, the cost of broodstock as input to the hatchery is about Rs 22400.

Labour: the total cost of the labour is Rs 29,000/-. In this case, the skilled labour is required for almost two and half months. Each day about 3 labours will be engaged for two shifts but the actual utilization of the labour in hatchery is only 25% as the rest labour can be used in other activities like culture, seed rearing, agriculture or other farm activities. The expenditure on chemicals is Rs 85000/-

Electricity: water requirement increases with increase in the operations. For each operations approximately 7500 liters of water is required so the pumping cost for 25 cycles comes to about Rs 2000.additional electricity of Rs 1000. The total electricity cost is 3000 rupees per year.
Output: spawn production is about 250 lakh with the net selling price of 12500 per annum.

Cost of management

	Quantity	Rate	Price
Brood fish	600	140	22400
Labour	150	140	21000
Technical labour			8000
Chemicals			8500
Equipment			2310
Fixed cost			13175
			75385

Tools and Equipment

Sl. No.	Items	Qty (Nos)	Rate (Rs.	Total (Rs.)	Life in year	Annual value in Rs
1	Plastic bucket	04	75	300	3	100
2	Plastic mug	04	15	60	3	20
3	Breeding hapa	02	450	900	3	300
4	Outer hapa	02	250	500	3	150
5	Inner hapa	02	175	350	3	120
6	Spring weighing balance (5 kg)	01	100	500	5	100
7	Hand net	02	150	300	3	100
8	Small table	01	400	400	5	80
9	Serings & Niddle-01 set/operation	25	5	125	1	125
10	Hand brush with long handle	02	35	70	2	35
11	Plastic hand brush	02	15	30	2	15
12	Brood fish carrier	01	1500	1500	5	300

13	Hammock	01	600	600	3	200
14	Covering nets	(LS)	200	200	3	60
15	Pipe wrench	02	375	750	3	250
16	Tester	01	45	45	1	45
17	Adjustable wrench (12")	01	225	225	3	75
18	Screw driver	02	65	130	2	65
19	Pliers	01	150	150	3	50
20	Spanner	01 set	350	350	3	120
	Total			7485		2310

Other costs

Sl.No.	Items	Qty (Nos)	Rate (Rs.	Total (Rs.)	Life in year	Annual value in Rs
1	Pump	1	6000	6000	5	1200
2	Electricity connection	1	30000	30000	20	1500
3	CFL lamp	3	150	450	2	225
4	Cost of electricity for pumping	1	2000	2000	1	1000
5	Cost of other electricity	1	3000	3000	1	3000
6	Telephone	1	1500	1500	1	1500
7	Shed and tank	1	40000	40000	15	2500
8	Pipes and fittings	1	9000	8000	4	2250
						13175

Labour

Sl.No.	**Items**	Qty (Nos)	Rate (Rs.	Total (Rs.)	Life in year	Annual value in Rs
1	Technical manpower (mechanical)	5	200	1000	1	1000
2	Technical hatchery	60	200	6000	1	6000
3	Skilled labour	150	140	21000	1	21000
						29000

Output

		Quantity/lakh	**Price/lakh**	**Gross sale price**
1	Spawn 25 operations	250	500	125000
2	Cost			75500
3	Profit			49500

Output in brood-stock

		Quantity in kg	Price kg	Gross price
1	Broodstock	300	140	42000
2	Cost			20000
3	Profit			22000

Output in seed rearing

		Quantity/lakh	Price/lakh	Gross sale price
1	Seed rearing	120	1200	144000
2	Cost			70000
3	Profit			74000

Model 3 (Technology System 01 breeding & 03 hatching pool Model-3, 100 % brood stock and seed rearing)

This model is developed with the assumption of maximum practical number of cycle. Eventhough theoretically more than 60 operations can be taken up in a year. In practice 45 to 50 cycles are the highest numbers of the operations that has been observed in the field In the research stations, 25 to 30 cylces are the maximum scale of operations achieved. At the farmers of level, the weather conditions, water availability, broodstock availability, labout availability and growing space are the some of the major constraints which often creat hindrance in raising the scale of the operations. Therefore, a 40 number of the operations in a years is the maximum achievable scale in the portable hatchery. In the model three it is assumed that the farrmers have all the facilities, infrastructure and inputs required to operate at the maximum level. The maximum level of operations assumed to be 40 per year.

Brood stock: the quantity of the brood-stock required is Quantity of brood fish required /yr =20 kg×40 operation= 800 kg . actual stock required to be maintained is about 1200 kg keeping at the risk factor in the breeding operations as discussed earlier. The price of the broodstock is about Rs.1,68,000. The netloss of the quality of the fish is about 20%, therefore, net consumption of the value of the broodstock as an input is about Rs34000

Labour. At the higher scale of the operations the labour requirement is very high as work needs to be carried out throughout the day. The total labour requirements is 960 mandays (04× 3 shift/day×40 operation/yr × 2 persons/shift = 960 days) with the assumption that half of the work is being done in hatchery while oth half of their time is being used in other non-hatchery farm operations like ponds, agriculture or other activities. The net cost of the skilled labour is Rs67000/-

Chemicals: use of the ovaprim per male @0.2 ml/kg and Female 0.5 ml/kg needs a total of 300 ml costing Rs 12000 and cost of $KMoN_4$ is Rs.500/- (L.S.).

Electricity: the total pump run of two numbers of pump is 3762.3 hrs and cost of electricity is about Rs 8000 (1.472 KWh× 3762.3× Rs.1.40/-per unit = Rs.7753.34/-) . In addition cost of lights and fans for the year is Rs 2000.

Telephone cost per year is about Rs 3000 per year as the intensive farmes needs to keep greater contacts with the input providers, technicians as well as customers.

Cost of management

	Quantity	Rate	Price
Brood fish	1200 kg	140 @20%	34000
Labour	960/3	140	44800
Technical labour			7000
Chemicals			12500
Equipment			2740
Fixed cost			22125
			123165

Tools and Equipment

Sl. No.	Items	Qty (Nos)	Rate (Rs.	Total (Rs.)	Life	Annual value
1	Plastic bucket	04	75	300	3	100
2	Plastic mug	04	15	60	3	20
3	Breeding hapa	03	450	1350	3	450
4	Outer hapa	03	250	750	3	250
5	Inner hapa	03	175	525	3	175
6	Spring weighing balance (5 kg)	01	100	500	5	100
7	Hand net	02	150	300	3	100
8	Small table	01	400	400	5	80
9	Serings & Niddle-01 set/operation	40	5	200	1	200
10	Hand brush with long handle	04	35	140	2	70
11	Plastic hand brush	04	15	60	2	30
12	Brood fish carrier	01	1500	1500	5	300
13	Hammock	01	600	600	3	200
14	Covering nets	(LS)	200	200	3	60
15	Pipe wrench	02	375	750	3	250
16	Tester	01	45	45	1	45
17	Adjustable wrench (12")	01	225	225	3	75
18	Screw driver	02	65	130	2	65
19	Pliers	01	150	150	3	50
20	Spanner	01 set	350	350	3	120
	Total			6785		2740

Cost of machinery and equipment

Sl.No.	Items	Qty (Nos)	Rate (Rs.	Total (Rs.)	Life in year	Annual value in Rs
1	Pump	2	6000	12000	5	2400
2	Electricity connection	1	30000	30000	20	1500
3	CFL lamp	3	150	450	2	225
4	Cost of electricity for pumping	1	8000	8000	1	8000
5	Cost of other electricity	1	2000	2000	1	2000
6	Telephone	1	3000	3000	1	3000
7	Shed and tank	1	50000	50000	15	3500
8	Pipes and fittings	1	10000	10000	4	2500
						22125

Labour

Sl.No.	Items	Qty (Nos)	Rate (Rs.	Total (Rs.)	Life in year	Annual value in Rs
1	Technical manpower (mechanical)	5	200	1000	1	1000
2	Technical hatchery	60	200	6000	1	6000
3	Skilled labour	480	140	44800	1	44800

Output from hatchery

		Quantity/lakh	Price/lakh	Gross sale price
1	Spawn 40 operations	400	500	200000
2	Cost			123000
3	Profit			77000

Output in brood-stock

		Quantity in kg	Price kg	Gross price
1	Broodstock	1200	140	168000
2	Cost			80000
3	Profit			88000

Output in seed rearing

		Quantity/lakh	Price/lakh	Gross sale price
1	Seed rearing	400	1200	488000
2	Cost			240000
3	Profit			248000

Impact to Society

The portable hatchery ensures both direct and indirect benefits. The direct benefits are accrued through increased production of seeds leading to increased fish production in the region. The hatchery operators are benefited through increased income from hatchery, whereas, seed rearing group generates income by rearing fry and fingerlings from spawn which is the output of hatchery. The indirect benefits are in terms of better quality seed, local seed production, assured quality, training of manpower etc.

Table3. Benefits of portable hatchery

Types Benefits	Benefits	Stakeholders	Outcome parameters	Quantifiable parameters
Direct benefits	Availability of seed	Fish farmers	• Increase in production • Increase in income • Availability of fish to consumers	• Fish production • Income
	Production of spawn	Hatchery operator	• Income increase • Production of spawn	• Income • Spawn production
	Availability of spawn	Seed grower	• Income increase • Production of fry and fingerlings	• Income • Fry/fingerlings production
Indirect benefits	Local seed production	Fish farmers/ traders	• Reduction in mortality • Availability of healthy seed • Reduction of risk in long transportation of seed	• Reduction in fish seed from outside
	Quality seed production	Fish farmers	• Traceability of seed • Access to information on seed quality • Reduction in stress of seed in production and transport • Assured size, quality, quantity and	• Increased preference
	Skill development	Hatchery operators	• Skilful in handling hatchery	• Number of persons trained
	Conservation of fish	Environment	• Breeding of new species	• Number of species bred

Conclusion

The challenge of meeting ever growing demand for the carp seed across the country is looming large. The present system of centralized and wide distant transportation is not sustainable for the seed production and distribution. Therefore, the decentralized seed production system with hatcheries established at all across the country is critical for the further development of the freshwater aquaculture sector. Packaging of the portable carp hatchery along with the decentralized seed production system could be effective in meeting the ever increasing demand for seed across the country. Through this system large quantity of carp seeds are produced and several small and medium farmers are benefited across the country. Technological inputs along with the investment by the end users have created successful models all across the country. The portable FRP carp hatchery holds great promise in contributing significantly to the growth of the freshwater aquaculture sector in the country.