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Training Manual on Improved Tilapia Culture and Dyke Cropping in Pond/Gher



September 2011

Cereal Systems Initiative for South Asia in Bangladesh
(CSISA-Bangladesh), WorldFish Center



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Training Manual on Improved Tilapia Culture and Dyke Cropping in Pond/Gher

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Training Manual on Improved Tilapia Culture and Dyke Cropping in Pond/Gher
A Course Manual for Tilapia Farmers



Preface

Due to inadequate technical knowledge and training in advanced methods of gradually growing tilapia culture, framers are not getting expected yield. From the very beginning of the CSISA-BD project, WoldFish Center has taken initiative to introduce advanced methods in tilapia culture. To do this, the shortage of skilled trainers and training materials, has, particularly, been realized. Presently, a number of manuals on tilapia culture from Department of Fisheries, Bangladesh Fisheries Research Institute, WorldFish Center and different GOs and NGOs are available. The training manual on 'Improved Tilapia Culture and Dyke Cropping in Pond/Gher' has been developed by the World Fish Center based on practical experiences from the field and with the help of other published manuals and taking into account various environmental and socioeconomic challenges the fish farmers may have to cope with.

The manual 'Improved Tilapia Culture and Dyke Cropping in Pond/Gher' is well-suited to the training needs of extension workers and fish farmers. Extension workers and fish farmers shall be benefited from the manual during project period. The manual can further be improved in the light of the outcomes and experience from filed. It is hoped that different GOs, NGOs and individual would be able to play active role in manpower development and boost up fish production of the country by effective use of the manual.

We are indebted to all the people and organizations associated directly or indirectly with the preparation and publication of the manual.

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Training Manual on Improved Tilapia Culture and Dyke Cropping in Pond/Gher

Introduction to the Manual and its Application

Tilapiaculture in the ponds all over the country and ghers in the south-west is getting highly popular. However, due to lack of technical knowledge and ambiguous ideas, most of the farmers are not getting expected yield. Even many are losing money in tilapia culture. With particular emphasis on this, the training manual 'Improved Tilapia Culture and Dyke Cropping in Pond/Gher' has been prepared by CSISA-BD Project. We are hopeful that the manual would play a unique supporting role in the improvement of the Tilapia culture management in ponds and ghers of the farmers.

Duration of the Training

The manual has been developed for a 2-day fundamental training course. However, depending on the actual need of the trainees, timetable can be modified within training duration of the two days. In general, the daily programme should be continued from 10 am to 14 pm. The venue of the training should be in an area where farmers live or near to the pond / gher dyke or any other convenient places.

Training Methodology

Most of the learning matters should be accomplished using participatory approach. Here, ample opportunities would be given to farmers to exchange their own experience, so they can easily participate and achieve effective learning. The following experience-based participatory approaches will be used in each of the sessions -

1. Brain-storming, 2. Group Discussion, 3. Open Discussion, 4. Event Analysis, 5. Real Objects and Practical Demonstration, 6. Speech-Discussion, and 7. Question and Answer

Number of Trainees

Maximum 25 trainees can take part in the training. Because, the way the participatory techniques have been designed, if the number of trainees are more than 25, there may be problems in effective communication between trainers and trainees. Mainly the manual has been designed for target farmers under CSISA-BD project.

Role of trainers in training

The role of trainers in participatory training is mainly creating learning environment so the trainees can learn by spontaneous participation. A trainer is a facilitator and at the same time, a learner. In the process of blending learning materials with the knowledge and experience of the trainees, trainers will learn many things and at the same time will assist to provide right knowledge by amending many ideas. This way, the trainees and trainers will augment the training process as complementary to each other and assist in achieving learning goals.

Training theme and useful instruction

The themes of the training have been determined in the light of practical need of the farmers at the field level and on the basis of evaluation and recommendation from the experts. In the different session planning, subject-oriented handouts are given in this manual. By reading the handouts, the trainers will enrich themselves, which in turn assist the trainees in participating in thematic discussion. Different subject matters are arranged chronologically. Running the session will be easy if the trainers prepare themselves by assessing the session planning thoroughly well-ahead the training commences.

Using the Training Manual

To implement a successful dynamic programme, crafting individual with necessary knowledge and skill is crucial. The precondition of this is training. Traditional training is just the wastage of time in improving the knowledge and skill of the trainees.

To maintain the quality of training, the apposite use of the training manual is essential.

All the directions on the use of the manual properly and effectively by the trainers and the trainees have been described. Following duties and responsibilities need to be undertaken to achieve the objectives of the manual -

1. Before the start of the session, the trainer should read through the session plan carefully. This will help the trainer to run the session properly.
2. Handout given with each session needs to be thoroughly studied. To maintain the sequence of subject matter and discussion, pre- prepared flip-chart should be used.
3. Needless to say that the manual is only an instruction device. Therefore, trainer should run the session with necessary adjustment considering the knowledge and experience of the trainees.
4. Training methodologies and technicality of each session are described in detail. These have been carefully planned to ensure active participation of the trainees in the training. Sticking to the methodologies will ensure the active participation of the trainees and expected outcomes of the session will be achieved.
5. The training sessions are arranged in sequence. Necessary information will be discussed within fixed time in each session. If necessary the trainer, in light of his/her own experience, can change or modify the session keeping main topic as it is. However timely starting and ending the session is good for both trainers and trainees.
6. Assessing the success of the training programme is important for both trainers and trainees. Therefore, learning of the trainees needs to be evaluated during the training.
7. The manual is a valuable resource. Please preserve it carefully. At present and in future the manual will act as a reference.

Learning Environment

A primary object of the training is to create lively environment. The issue of learning environment is even more important as a supporting tool. Lively learning environment is such an environment where every trainee will actively take part in discussion and comment on. Facilitator will take the responsibility to ensure this. The trainer will be keen to know the expectation, thinking and reaction of the trainees. The active participation of the trainees should be ensured and their experience and comment should be given priority. This way, a lively atmosphere will be created in the training. The following guidelines can be followed to ensure a good learning environment and to make it lively.

Training guidelines:

1. To be respectful to all others.
2. To maintain gentle manner and impartiality.
3. To give due priority to comments made by others, because something really good can come out from the discussion.
4. To ensure the participation of each and every one particularly the silent ones.
5. To be a good listener i.e., more listening and less uttering.
6. To be careful about talking (side-talking, whispering) each other by the participants during discussion.
7. To create environment so the trainees can talk one by one. If everyone speaks at the same time, nothing can be heard / understood.
8. To be patient and understanding.
9. To be careful about sensitive issues.
10. To keep faith / confidence on the knowledge and experience of the trainees.
11. To become fellow / coworker so the trainees do not hesitate to speak out.
12. To confess frankly if something is not known.

Improved Tilapia Culture and Dyke Cropping in Pond/Gher Training Course

Timetable

Duration: 2 days

Day	Time	Subject matter/Theme
1	10.00-10.30	Inauguration-Registration and Course Introduction
	10.30-11.00	Introduction of Tilapia and Benefit of Tilapia Culture
	11.00-12.00	Nursery Management of Tilapia (to be cont'd)
	12.00-12.15	Tea Break
	12.15-14.00	Nursery Management of Tilapia
2	10.00-10.30	Review of the Discussion of Previous Day
	10.30-12.00	Culture Management of Tilapia in ponds and gher
	12.00-12.15	Tea Break
	12.15-13.30	Vegetable Culture on Pond / gher dyke
	13.30-14.00	Economic Analyses of tilapia and Vegetable Farming and Record Keeping

Group Session Planning

Day – 01

Time – 10.00

Duration – 30 min

- Target Group : Tilapia Farmers
- Title of the Session : Inauguration - Registration and Course Introduction
- Goal : To inaugurate training course on improved tilapia culture and dyke cropping in pond/gher so trainees and trainers will be known to each other and will get a positive idea about the course
- Objectives: At the end of the session
- Trainers will be introduced with trainees
 - Trainees will have positive perception about the course
 - Trainees will register their names in the particular forms of the course
 - They will be able to speak about overall goals and objectives of the course
 - Trainees will be able to express their expectation from the course
 - They will be able to speak about course regulation, different activities and their effectiveness

Subjects to be discussed in the session	Training method	Time
Introduction		2 min
Welcome: Welcoming the participants, exchange of greetings and sitting arrangement	Speech	
Subject matter		25 min
<p>Distribution of training materials and registration</p> <ul style="list-style-type: none"> • Notebooks, pens etc. should be distributed among the participants • Registration of the name of participants in particular form Knowing each other & inauguration of the training course • Trainer will introduce himself/herself to the trainees through chatting and discussion • One of the participants will recite from the Holy Quran and/or narrate from the Gita/Bible • Welcome address from the participants • Welcome address from the trainer and inauguration of the course <p>Training expectations</p> <ul style="list-style-type: none"> • Trainer will know and determine the training expectation from the trainees <p>Course timetable</p> <ul style="list-style-type: none"> • Trainer will distribute the timetable and explain the queries (if any) about timetable <p>Course guideline</p> <ul style="list-style-type: none"> • Trainer will explain the importance of course guideline and rules of writing guideline, and attach the VIP card written by the trainees after compiling or guideline written on poster paper on the board <p>Overall goal and objectives of the course</p> <ul style="list-style-type: none"> • Trainer will read out the handout with course goal and objectives and will explain 	Speech Discussion Individual activities VIP card	
Summary		3 min
Vote of thanks by the trainer to the invited participants	Question-answer	

Linking with next session

Training materials Banner, registration form, training materials for distribution, timetable

Improved Tilapia Culture and Dyke Cropping in Pond/Gher

Training Course

Goal and Objectives of the Training

Training goal

To improve the knowledge and skill of participants on improved tilapia culture and dyke cropping in pond/gher so they can get more yields from tilapia and vegetable culture following proper methodologies

Overall objectives

At the end of the course the trainees will be able –

- to explain the history and growth of tilapia culture
- to speak on benefits of tilapia culture
- to speak on characteristics of standard nursery and grow out pond / gher
- to speak on nursery pond management and production methods
- to speak on grow out pond / gher management and production methods
- to speak on the problems in tilapia culture and to solve them
- to know the disease of tilapia and to treat the diseases
- to explain the importance of vegetable as food
- to culture vegetables on the dyke of pond / gher
- to analyze cost-benefit of tilapia culture and dyke cropping in pond/gher

Group Session Planning

Day – 01

Time – 10.30

Duration – 30 min

Target Group : Tilapia Farmers
 Title of the Session : Introduction of tilapia and benefit of tilapia culture
 Goal : The trainees will get clear ideas on origin, history and benefit of tilapia culture so realizing the importance of the said aspects they will be able to increase tilapia production in their ponds using advanced technology

Objectives: At the end of the session

- Trainees will be able to speak on the origin of tilapia
- Trainees will be able to speak on the benefits of tilapia culture

Subjects to be discussed in the session	Training method	Time
Introduction		2 min
<ol style="list-style-type: none"> 1. Welcome: Welcoming the participants and exchange of greetings 2. Review of earlier session 3. Linking with present session 4. Explaining the objectives of present session and words of encouragement 	Discussion Question answer	
Subject matter		25 min
<ol style="list-style-type: none"> 1. Origin and history of tilapia 2. Biology of tilapia 3. Benefits of tilapia culture 	Question answer Speech Flip chart	
Summary		3 min
<ol style="list-style-type: none"> 1. Review of the major points 2. Verification of the objective 3. Distribution of the handouts 	Question answer	

Linking with next session:

Training materials ➤ Flip cart, white board, marker and handout

Planning of the flip chart

(Please follow the handout for detailed description)

<p>Benefits of tilapia culture (Photo of tilapia)</p>	<ul style="list-style-type: none">• Male and female sex• Productivity of monosex (only male) is higher• Can be cultured in saline water (salinity 12– 15 ppt)• Three crops are possible in perennial pond• Can be profitably cultured in seasonal ponds and small ditches, canals close to the homesteads
<ul style="list-style-type: none">• Tilapia grow to 200 – 300 g within 3 - 4 months• High demand in local market• Prefer all kind of supplementary feed• Can be cultured in high stocking density• High disease resistance ability	

Introduction of tilapia and benefit of its culture

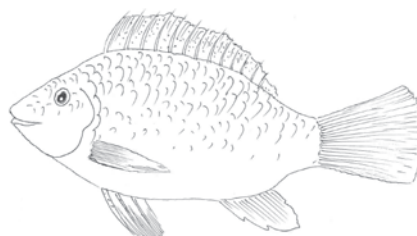
The origin and history of tilapia

The origin of tilapia is Africa. The fish has about 70 species. The tilapia was first imported to our country from Thailand in 1954. The species of that tilapia was *Oreochromis mossambicus*. Culture of this tilapia was not successful. Next *Oreochromis niloticus* was brought in to Bangladesh in 1974. This fish became well-known to the country. Again in 1994, genetically improved farmed tilapia (GIFT) was brought in to Bangladesh from the Philippines by ICLARM (present WorldFish Center). For the first time, the culture of GIFT - *Oreochromis niloticus* became successful in Bangladesh. Tilapia culture is expanding with the days. It can be noted here that this variety of tilapia has been further improved mainly by the effort of Bangladesh Fisheries Research Institute (BFRI) and WorldFish Center. It is now highly popular at farmers' level. Recently many tilapia hatcheries have been established in different regions of the country. The fry of mono sex tilapia have been produced in these hatcheries. Every year, the number of tilapia farmers is increasing in the districts of Comilla, Noakhali, Sylhet, Jessore, Gopalganj, Rajshahi, Mymensingh, Dhaka etc.

Biology of Tilapia

The Latin name of the fish is *Oreochromis niloticus*. The body of tilapia is covered with ash coloured scales. The number of spine in dorsal fin is 17. The genital of male is small and conical with forked front. They live in small ponds, ditches, canals, beel, jheel, reservoirs etc. and other shallow water bodies. They can tolerate wide ranges of salinity and temperature.

The main enemy of nilotica is protozoan parasite. The nilotica can be infected by *Trichodina* and *Chilodonella* of parasitic ciliate group in the nursery ponds. The disease resistance ability of nilotica is very high. They can eat all kinds of food materials. However, the major foods for tilapia are aquatic algae and insects. As supplementary foods, fine rice bran and mustard oil cake powder are used. However, recently commercially produced floating and sinking feed pellet are extensively used.



চিত্র: তেলাপিয়া মাছ

Figure: Nilotica

Tilapia becomes sexually mature within 3 - 4 months. The male tilapia build nest in the deeper part of ponds and water bodies during breeding season. This time male tilapia invites female to spawn in the nest. Once female tilapia releases the eggs, male fertilize them. The larvae hatch inside the mouth of female tilapia. The fish multiply rapidly. They spawn 3-4 times a year. Tilapia can be marketed after 3 - 4 months of stocking. They can grow up to 5 - 6 inches and about 200 - 300 g within 3 - 4 months. Presently, the demand of tilapia is increasing.

Due to rapid multiplication in ponds, the high density of tilapia creates an uncontrollable situation. As a result, farmers neither get tilapia of expected size and weight and nor get any profit from the culture. To overcome the situation, the concept of mono sex tilapia (100 % modified male) culture comes in place. It can be noted that, the growth rate of mono sex (100 % modified male) tilapia is 20 - 30 % more than the growth of the female of the same age. The productivity of mono sex tilapia is 50 - 70 % higher than the production of mixed sex tilapia. Recently, due to the drought, necessary time and water in pond is not always available for carp culture. However, even within that short time, the fish farmers can culture tilapia of improved variety profitably in those ponds.

Advantages of tilapia culture

- Fast growing
- High demand in local market
- Prefer all kind of supplementary feeds
- Can be profitably cultured in seasonal ponds and small ditches, canals close to the homesteads
- Can be cultured at high stocking density
- High disease resistance ability
- Can be cultured in saline water (salinity 12 - 15 ppt)
- Three crops are possible in perennial pond

Group Session Planning

Day – 01

Time – 11.00

Duration – 2 hours 45 min

- Target Group : Tilapia Farmers
 Title of the Session : Management of tilapia nursery
 Goal : The trainees will get clear ideas on the importance of tilapia nursery, the features of standard nursery pond and nursery management activities so realizing the importance of the said aspects they will be able to increase fry production in their ponds using advanced technology
- Objectives: At the end of the session
- Trainees will be able to speak on the importance of tilapia nursery
 - Trainees will be able to speak about the features of standard nursery pond
 - Trainees will be able to carry out the nursery management activities properly

Subjects to be discussed in the session	Training method	Time
Introduction		5 min
1. Welcome: Welcoming the participants and exchange of greetings 2. Review of the previous session 3. Linking with present session 4. Explaining the objectives of present session and words of encouragement	Question answer Discussion	
Subject matter		150 min
1. Importance of tilapia nursery 2. Features of a standard nursery pond 3. Steps of nursery pond / gher preparation a. Renovation of dyke and bottom b. Removal of aquatic weed c. Control of predatory and unwanted fishes d. Lime application – importance, type of limes, doses and quantity, application methods and cautions e. Fertilization application: importance, type of limes, doses and quantity, application methods and cautions f. Testing natural food items g. Testing the suitability of water 4. Stocking management a. Identification of good and bad fry b. Fry transport, determination of stocking density, acclimatization and releasing 5. Post stocking management a. Feed management b. Pulling harra c. Fry harvest	Question answer Speech Flip chart	
Summary		10 min
1. Review of the major points 2. Verification of the objective 3. Distribution of the handouts	Question answer	

Linking with next session

Training materials ➤ Flip cart, white board, marker and handout

Planning of the flip chart

(Please follow the handout for detailed description)

<p>Management of tilapia nursery</p>	<p>Fertilizer application Type of fertilizer: Doses of fertilizer: Fertilizer application method: In dry pond: In water filled pond: Time of fertilizer application: Cautions in fertilizer application:</p>
<p>Importance of Tilapia Nursery Features of a standard nursery pond</p> <ul style="list-style-type: none"> • The pond should be relatively rectangular and flood free (above the flood level) . • Sandy loam soil at the bottom is better • Pond should be 10 – 20 dec in area • Bottom mud of nursery pond should be less than 6 inches • Should be in an area with enough sun light. 	<p>Testing the suitability of water: Why to test the water suitability? How to test? When to test?</p>
<p>Nursery pond / gher preparation steps Pre stocking:</p> <ol style="list-style-type: none"> a. Renovation of dyke and bottom b. Removal of aquatic weed c. Control of predatory and unwanted fishes d. Lime application e. Fertilization application methods f. Testing the suitability of water g. Identification of good and bad fry h. Determination of stocking density i. Fry transport, determination of stocking density, acclimatization and releasing 	<p>Identification of good and bad fry Matters of observation (body colours, behaviour, abdomen) Fry transport Methods Cautions Stock management: Determination of stocking density 2000 – 3000 per dec Fry acclimatization and releasing When to release fry? How to release fry?</p>
<p>Pond bottom and dyke repair: Why to do? How to do? When to do? Control of aquatic weed: Why to do? How to do? When to do? Control of predatory and weed fishes: Why to do? How to do? When to do?</p>	<p>Post stocking management Feed management (what feed, when to apply, how much to apply) Harra pulling Fry harvest</p>
<p>Lime application: Why to apply lime? What type of lime should be applied? How much? How to apply? When to apply? Cautions</p>	<p>Fry</p>

Nursery management of tilapia

Importance of tilapia nursery

Tilapia breed naturally. However, improved tilapia fry are produced in hatcheries. Hatcheries sell very small fry or spawn (0.1 – 0.2 g) of tilapia. If spawn of this size are stocked in pond, due to high mortality, expected yield is not obtained. Therefore, spawn collected from hatcheries should be reared in nursery pond for at least a month. When the spawn reach to the size of 2 – 3 inches (5 – 7 g), they should be released in the grow out pond / gher which ensures better production. That's why, the nursery management of tilapia is very important.

Characteristics of a standard nursery pond

- The pond should be relatively rectangular and flood free.
- Sandy loam soil at the bottom is better
- Pond should be 10 – 20 dec in area
- Bottom mud of nursery pond should be less than 6 inches. However, bottom of old ponds should be sun dried after necessary removal of bottom mud.
- Should be in an area with enough sun light

The canal of gher can be used as nursery ground for spawn

The steps of nursery pond / gher preparation

In nursing activities, the importance of pond / gher preparation is crucial. The expected yield can not be achieved if pond / gher is not well prepared though other management activities are satisfactory.

Dyke repair and removal of decomposed mud

During nursery pond preparation, sometimes dyke repair and removal of decomposed mud are necessary. Because damaged dyke and presence of decomposed mud may create a range of difficulties. Such as –

If dyke is not repaired –

- Predatory fish may enter from outside
- Spawn may float away during monsoon or heavy rain
- Toxic gas may form at the pond bottom
- Polluted water from outside may enter in to the ponds

If black mud is not removed

- Pond water become toxic
- Oxygen scarcity is observed in the pond water that increases the spawn mortality
- Toxic gas may form at the pond bottom
- Fish are easily infected by different diseases that may create an epidemic

Removal of aquatic weed

Different plants present in water are known as aquatic weed. The aquatic weeds directly or indirectly are harmful to the fish culture. Generally, aquatic weeds like water hyacinth (*Eichornia crassipes*), water lettuce (*Pistia*), duck weed (*Lemna*), water lily (*Nymphaea*), paniphal (*Trapa*), shusni shak (*Marsilea*), kalmi lata (*Ipomoea aquatica*), helencha (*Enhydra*), keshordam (*Jussieaceae*), jhanji (*Utricularia*), kata sheola (*Ceratophyllum*), bishkatali (*Polygonum*), arail (*Leersia*), Najas, kapure sheola, bhotka sheola etc. are present in pond / gher. If the aquatic weeds are present in the ponds, they should be removed manually.

The harmful effects of aquatic weeds

All kind of aquatic weeds have a number of direct or indirect negative impacts in spawn culture. The negative impacts of aquatic weeds in spawn culture are as follows -

- Aquatic weeds absorb nutrient content from soil and water. As a result, primary production decreases.
- As aquatic weed block the entrance of sun light in to the water, photosynthesis is hampered.
- Aquatic weeds create barriers in the movement of spawns and the spawn become easy prey of different predatory animals.
- Aquatic weeds act as the refuge of predatory fish and animals.
- Harra can not be easily pulled in the pond when necessary.
- Aquatic weeds make the netting difficult.
- Because of excess aquatic weed, spawn may die during night due to lack of oxygen.

Aquatic weed control methods

Using manual labour – All the aquatic weeds can be pulled up manually after cutting with chopper / scissors. Sometimes using a rope, the root of aquatic weed can be pulled up.

Biological method – There are many fishes that can control aquatic weed by foraging on them, e.g., grass carp.

Control of predatory fishes

Predatory fish can be removed from the ponds using the following three methods. Such as -

1. Drying out of ponds: This method is very effective in removing unwanted insects and predatory fishes. Shallow pump can be used in this purpose. After drying out the ponds, bottom should be kept exposed in direct sun light for a few days to such an extent that when someone walks on the pond bottom, there will be foot print but feet will not be soaked. Both time and money can be saved if this is done during February – March.

2. Rotenone application: If drying out is somehow not possible, predatory fishes can be removed by using an organic piscicide - rotenone. However other chemicals except rotenone should not be applied. Application of chemicals to control predatory fishes may harm the environment and human health to a great extent. Presently even using rotenone has been discouraged.

The doses of Rotenone

The doses of rotenone depend on its power (activeness), dissolved oxygen content in water and temperature. The recommended dose of rotenone of different powers per foot decimal water are described in the following table -

Name of the chemical	Power (Active ingredient)	Doses of application
Rotenone	9.10 %	20 - 25 g
Rotenone	7.00 %	25 - 30 g

Techniques of rotenone application: The required quantity of rotenone should be mixed with water little by little in a bucket to make the thick paste. Then the whole amount should be divided in to three portions. The first portion should be made to small balls and should be evenly distributed to the deeper parts of entire pond. The rest two portions should be mixed with water and should be distributed to the entire pond. After 20 – 25 minutes, the dead / floating fish should be caught using a net. Rotenone can be made more active if pond water is overturned after its application. Fish harvested by rotenone are not unsafe for human health.

Presently, many companies suggest applying rotenone during very early morning. Because, dissolved oxygen is generally very low during that time and rotenone acts rapidly.

Cautions in rotenone application

- Rotenone pack / container should only be opened just before the application
- Rotenone should be kept out of the reach of the children.
- During mixing rotenone with water and application in pond, entire face should be covered with a piece of cloth (gamchha)
- Rotenone must be applied in the direction of air flow

To estimate the exact amount of chemicals needed, the depth of pond water should be measured accurately. Here, the average depth of pond should be measured considering both shallower and deeper parts of the pond. Depth should be measured at least in 5 – 10 places.

3. Repeated netting

If drying out or poisoning is not possible, predatory fishes can be removed by gentle netting repeatedly. Most of the predatory fishes can be removed by netting in small and shallow water bodies.

In case of nursery, drying out of pond is better to remove predatory fishes. However, to remove predatory fish of pond / canal for nursery, drying out of pond is better. Entire nursery pond should be fenced with 2 feet high filter net so that snakes, frogs and other unwanted animals can not enter in to the pond

Lime application

The significance of lime application

Liming in nursery is an important activity. The significances of liming are as follows –

- Maintain water pH higher than 7.5
- Keep the parasites and germs out of the water during pond preparation
- Assist in natural food production through increasing the abundance of nutrient materials by enhancing the rate of decomposition of organic matters
- Free the phosphorus bound in sediment for plankton growth
- Remove the turbidity of water
- Increase the activeness of fertilizer

Types of limes

There are different types of lime available in the market, such as - lime stone or agricultural lime, burnt lime or quick lime (known as lime stone in market), slaked lime, dolomite and gypsum.

The dose of lime

During pond preparation, per decimal 1 kg quick lime or 0.5 kg dolomite can be applied.

Lime application techniques

During pond preparation, the required quantity of lime in powder form should be evenly distributed in the entire pond including the slope of dried water bodies. In ponds filled with water, required quantity of lime should be evenly distributed to the entire pond after mixing with water in an earthen pot (chari) or in a tin drum.

Timing of lime application:

- Lime should be applied 1 - 2 days after irrigation in dry pond or pond with wet bottom.
- In case of the water-filled pond, 5 – 6 days before the fertilizer application

Cautions in lime application:

1. During mixing lime with water and application in pond, entire face should be covered with a piece of cloth (gamchha).
2. In no condition, lime should be mixed with water in a plastic bucket.
3. Lime should be added after putting water in the bucket. Before pouring water in the bucket containing lime, its top should be covered with jute made bag (chot/bosta).
4. Lime should be applied in the direction of air flow.
5. If the eyes/ body parts get in touch with lime, should be instantly washed with clean water and seek doctor's advice.

Fertilizer application

The objectives of fertilizer application

Natural foods for fish are the different feed particles present in the water. The feed particles are of two types – phytoplankton and zooplankton. Among the two types of feeds – the most important natural feed for fry are zooplanktons. On the other hand, zooplanktons multiply through feeding on phytoplanktons and bacteria. To sum up, the main objective of fertilizer application is to produce sufficient natural feed for fry in the nursery ponds.

Type of fertilizer: Generally, two types of fertilizers – organic and inorganic are applied in the nursery ponds. Because, organic fertilizers are directly consumed by zooplankton and bacteria. In addition, organic fertilizers free the inorganic nutrients in water to enhance phytoplankton production. Cow dung or compost can be used in the pond as organic fertilizer. However, cow dung should not directly be used as organic fertilizer. Because decomposition of cow dung may reduce the dissolved oxygen level in water. In this case, decomposed cow dung may be used.

Technique of compost preparation

Site selection

- Avoid direct sun light – under the tree or under a shade on the dyke
- Humid place
- Moisture should be present
- A place where rain water do not stand

Ingredients and doses

Ingredients	Mixing rate
Green perishable soft plants, water hyacinth, water lettuce, green soft branches, banana leaves, egg shell, green sweepings (left over) etc.	48 %
Cow dung	48 %
Lime	2 %
Urea	2%

Method of preparation

Green plants should be chopped in to pieces. Each of the ingredients should be kept in 3 - 4 heaps separately. A pit should be made for making the compost. The length, width and depth of the pit will be 6 feet, 4 feet and 3 feet, respectively. The ingredients should be arranged one after another as green plants, cow dung, lime and urea layer after layer. After arranging the ingredients the pit should be covered with soil.

Testing the moisture

The compost pit should be checked after 2-3 days of preparation from the dampness (moisture). If the compost pit is found to be with less or no moisture, water or cow urine should be spread on the pit. For regular production of compost, four compost pits should be built. After 7 days the compost ingredients should be transferred from first pit to the second one and first pit should be filled with new ingredients. This way after ever 7 day, the compost ingredients should be transferred from one pit to the next one and the process should be continued in a cyclic order. After 28 days the compost will be ready to apply in the pond / canal.

Doses of fertilizer

The sample of recommended fertilizer doses during pond / canal preparation is as follows –

Name of the fertilizer	Recommended dose (per dec)
Cow dung /	6- 8 kg / dec
Compost	8 - 10 kg / dec
Urea	100 - 150 g / dec
T S P	50 - 75 g / dec

**The dose of fertilizer can vary than the dose recommended here based on the nutrient present in the bottom soil of the water bodies. It should be noted that excess application of organic fertilizers result in the lack of dissolved oxygen in pond water. As a result, the mortality of fry may increase substantially.*

Techniques of fertilizer application

In dry ponds / canals

After uniformly spreading necessary amount of organic fertilizers in the pond bottoms, the fertilizers need to be mixed well with bottom soil by ploughing. If necessary small amount of mustard oil cake (0.5 kg / dec) may be mixed with the said dose of organic fertilizers. After filling the pond with water, TSP should be soaked in water for 12- 24 hours and finally should be distributed evenly in the pond / canal after adding urea in the mixture.

Water filled pond / canal

TSP and cow dung should be soaked in adequate water for 12 – 24 hrs in a bucket or drum. Just before applying, urea should be mixed with the mixture and should be evenly applied in the entire ponds in a sunny day. The dose of fertilizer depends on the productivity of pond / canal and the experience of fish farmers.

The timing of fertilizer application: Preparatory fertilizers should be applied 5 - 6 days after liming and 5 – 7 days before fry stoking. Applying fertilizer in a sunny morning before the afternoon is better.

Some useful tips about fertilizer application

- Fertilizers are less effective in acidic soil. In the water with high and low pH, phosphorus precipitates quickly at the bottom.
- Fertilizers are less effective in turbid water.
- The fertilizer activity reduces if there are aquatic plants in the pond water. Because Aquatic plant absorb comparatively more nutrients than that of the phytoplankton.
- If pond / canal do not hold water more than three weeks, the effectiveness of fertilizer decreases.
- In a deep water pond, phosphorus can not act well. Here phosphorus becomes unproductive in bottom sediments as precipitation
- In case of the application of mixed fertilizers, adequate water should be mixed with
- Fertilizers are generally less active if applied in a cloudy or rainy day.
- Storing urea in open air reduces its activity.

Observation of natural food

Under the normal fertility of soil and water (due to the application of fertilizer in the pond), the feeds (small insects, phytoplankton and zooplankton) produced in a water body are known as natural feed of fish. The feeds are so small that they are not visible in naked eye. Their presence is realized by observing the colour of pond water. Generally the water rich in natural feeds looks light green, brownish green or light brown. The natural feeds are of two types –

- Plant origin – very minute algae (phytoplankton)
- Animal origin – minute aquatic worms and insects (zooplankton)

Observation of natural food

Before the fry stocking, after 3 - 5 days of fertilizer application, natural feed of pond should be tested. The water colour will be light green, brownish green or reddish.

Techniques of natural feed observation

At first water colour should be observed by own eye. The presence of natural food in the water can be checked by the following techniques –

1. Secchi disk test
2. Glass test
3. Hand test
4. Plankton net

Facing the sun, secchi disk should be plunged in the pond water and observed the white colour – either it is seen or not. The disk should be fixed in such a depth where white colour can be seen in a little pulling up of the thread and can not be seen in a little more plunging. The colour of plunged portion of the thread should also be taken in to consideration. Red portion of the thread above the water indicates the presence of excessive natural feed in the water and in this condition, application of fertilizer and supplementary feed need to be stopped for the time being. White portion of the thread above the water indicates shortage of natural feed in the water and accordingly fertilizer dose should be increased. Green portion of the thread above the water indicates the presence of optimum natural feed in the water and spawn / fry can be released in the pond.

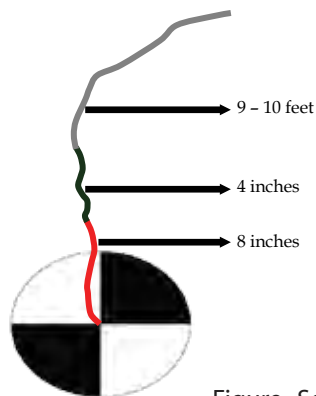


Figure. Secchi disk

Time of secchi disk testing: Secchi disk should be used after sun rises.

Caution: Secchi disk can not be used in a cloudy day or in turbid water.

2. Glass test: After 5-7 days of fertilizer application, the pond water should be taken in a clean drinking glass after filtering / sieving by a gamchha (large napkin). If minute plant particle and tiny animal-cule (5 – 10 / glass) can be seen inside the glass in the sun light, then this will indicate the presence of natural food in the pond water. This will not work if water is tested in a coloured, printed / stained or opaque glass.

3. Hand method: Hand should be plunged in the pond water and palm should be observed. If palm is not seen after plunging the hand prior to elbow, this will indicate the presence of excess natural feed in the water. Invisibility of palm after plunging the hand up to elbow will indicate the presence of optimum feed and visibility of palm will indicate lower presence of natural feed in pond water. The test is not applicable in turbid water.

Time of secchi disk testing: Secchi disk should be used after sun rises.

Caution: Secchi disk can not be used in a cloudy day or in turbid water.

Plankton net: Plankton net is iron made circular ring attached with a funnel shaped net of very fine meshed cloth (mesh size 20 - 200 micron) tied with a small glass bottle at the end. The handle of plankton net is made of iron or wood. Using the handle, the plankton net needs to be pulled at the 0.5 foot depth from the surface within 2 feet distance five times at the same direction to collect the plankton in glass bottle tied with the net. The amount of natural food should be tested by observing the density of plankton in the glass bottle.

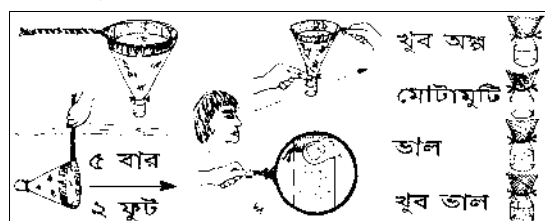


Figure: Testing of the effectiveness of the fertilizer using plankton net is important

Testing water suitability

Testing water suitability is essential before stocking of the fry. For testing water suitability, a hapa should be set in the fish pond such a way that the base of hapa does not touch the pond bottom. Then 15 – 20 fry should be released in the hapa for observation for 24 - 48 hours. Survival of all of the released fry or 10 – 20 % mortality within this time indicates that pond water is not toxic or polluted. If pond water has any problem, stocking should be delayed and fry should only be released after necessary treatment of the water. In this case several times successive harra pulling or waiting for a few days may solve the problem.

Stocking Management

Identification of good and bad fry

Only fry stocking in right quantity can not ensure good production. To get high yield, good quality fry should be stocked along with maintaining proper stocking density. The quality of fry is largely influenced by the source of fry and their handling. Whatever the reasons responsible for the bad quality of fry, fish farmers may lose huge money if those fry are stocked. If good quality fry are not stocked –

- Mass mortality may occur after stocking
- Growth rate may be low
- As the fish can not grow to marketable size in time, fetch low market price

That's why the quality of fry should be ensured before stocking. The characteristics of good and bad fry are described in the following table –

Matters of observation	Good fry	Bad fry
Body colour	Blackish green	Grayish pale
Behavior (when current is created in a round container)	Can swim against the current	Gather at the center of the container
Food	Stomach is full of feed	Stomach is empty.

Fry transport

Presently in our country the hatchery produced fry are transported in polythene bag using modern way. Transporting fry in modern way is much safer. Considering the time and distance of transport, the hatchery owners supply fry in polythene bag maintaining optimum density.

Stocking density

It is better to stock 2000 – 3000 fry per decimal water area. However, stocking density may vary based on culture system and the experience of farmers.

Timing of fry release

In a cool weather, fry can be released in nursery pond / canal any time of the day. However, fry release in the afternoon or evening is better. Fry should not be released in the bright sun of noontime, in a cloudy day or in a humid weather (particularly in a day of low pressure).

Conditioning of fry and release

The released fry may suffer from mass mortality due to the difference in temperature and oxygen, instantly after stocking. This rate of mortality can largely be reduced if the fry are properly conditioned in the new environment before releasing them in the nursery canal / pond. The acclimatization is nothing but bringing the water temperature of transport container and nursery canal / pond at the equilibrium. The step-wise activities of conditioning of fry in new environment are as follows –

The transport bag should be kept as floating for 15 – 20 minutes in pond water. After opening the bag with fry, water should be exchanged gradually between the pond / canal and the bag and the temperature of the two should be brought in to equilibrium. The difference between temperature of bag and pond / canal should be examined now and then using hand. Temperature should be carefully monitored so the difference of two waters is no more than 1 – 2 o C. When the temperature become similar, the bag with fry should be slowly plunged in the pond / canal water and with the help of mild current towards the container, the healthy and strong fry will come out from the container against the current. It should be noted that, fry should be released closed to the embankment, not in the middle of pond / canal.

Post stocking management

Feed management

The feed of fry are mainly of two types. Such as – natural feed and supplementary feed. In nursery pond / canal, only fertilization can ensure natural feed for the fry. However, natural feed can not always fulfill the nutritional demand of fry. Therefore, application of supplementary feed in fry pond / canal is very important.

Supplementary feed

The additional feeds that are applied from external sources along with the natural feeds present in water to ensure rapid growth of fry are known as supplementary feed. To ensure normal growth of tilapia fry like all other animals, presence of necessary amount of all nutrient materials like protein, carbohydrate, vitamin and minerals in fish feed is essential. The normal growth of fry hampers if any of the nutrient material at required amount is not present in feed. In high density fish culture using modern technology, only natural food can not fulfill the demand of fish for all the nutrients. To fulfill these demands of fry, different types of feeds from external sources should be applied in the pond / canal regularly. The feeds generally applied for fry by the farmers of our country can be divided in to two types based on their sources. Such as –

1. Plant origin: Fine rice bran, wheat bran, broken rice, flour, molasses (sticky), mustard oil cake, sesame oil cake etc.

2. Animal origin: Fishmeal, meat meal, powder of prawn / shrimp head, crab powder, blood of livestock animals etc.

Importance of supplementary feeds

- To increase the rate of physical growth of fish
- To control the cannibalism of fry
- To culture at high stocking density
- Fry mortality decreases at a large extent
- Disease resistance of fry increases
- More production from small water area

As the rearing period of fry in the nursery is 25 – 30 days and lime and fertilizer are applied once during pond preparation, from the experience, it has been observed that lime and fertilizer application for second time is not necessary during post stocking period. Therefore, to maintain normal growth of fry, application of supplementary feed is very important. In this case, purchase of feed of relevant manufacturer / company from feed retailers along with collection of leaflet / user manual supplied by them and application of feed following their guideline will result in fast growth of fry along with high survival.

Generally two types of supplementary feeds are used in tilapia nursery – a. Homemade feed, and b. Commercial feed.

Aspects need to be considered in preparing homemade feed

Usually homemade feeds are used in small scale tilapia nursery. In this case, farmers may apply homemade feed to pond considering the following points.

Aspects need to be considered in selecting ingredients for homemade feed

The fish farmers in our country mainly use oil cake and rice bran as supplementary feed for fish. The main objective of the application of supplementary feed is the production of more fry. Therefore, supplementary feeds need to be profitable for fish farmers and environmentally sound. Some of the important aspects in selecting supplementary for profitable juvenile production are described here

- Easy availability of ingredients
- Financial ability of fish farmers
- Cost of ingredients
- Nutrient demand of fry
- Preference of fry
- High food conversion ratio

Calculating nutrient composition of the ingredients of supplementary feeds

The research on commonly used fish feed ingredients of our country shows that the ingredients contain high amount of necessary nutrients. The nutrient analyses of some ingredients observed in researches are given below –

Name of the ingredients	Nutrient content (%)		
	Protein	Carbohydrate	Lipid
Rice bran	11.88	44.42	10.45
Wheat bran	14.57	66.36	4.43
Mustard oil cake	30.33	34.38	13.44
Sesame oil cake	27.20	34.97	13.18
Fishmeal – grade A	56.61	3.74	11.22
Blood meal	63.15	15.59	0.56
Flour	17.78	75.60	3.90

In calculating nutrient content of fry feed only protein is estimated. The nutrient content of feed prepared from more than one ingredient can easily be determined using general unitary method. The technique of calculating protein content in food is shown below –

Suppose, 1 kg feed is prepared using fishmeal, mustard oil cake, wheat bran and flour as binder. Then the protein content of the feed prepared from the ingredients will be –

Ingredients	Protein content (%)	Dose used (%)	Required quantity (g)	Protein available in feed (%)
Fishmeal	56.61	35	350	19.81
Blood meal	63.15	10	100	6.31
Mustard oil cake	30.33	15	150	4.55
Wheat bran	14.17	30	300	4.25
Flour	17.78	10	100	1.77
Minerals	-	-	1 spoon	-
Total		100	1000	36.69

Preparation of supplementary feed: Fry feed can easily be prepared using different ingredients. Fish farmers can also prepare feed by themselves. If possible feed can be prepared using mixing machine. The preparation techniques of mixed feed for fry is described briefly here –

- Required quantity of oil cake should be soaked in double quantity of water at least 20 – 24 hours ago and oily water from the surface of the mixture should be thrown away.
- Rice bran, chaff and fishmeal should be sieved properly
- Broken rice should be boiled, if used
- All the ingredients should be mixed thoroughly in a container
- Ingredients should be mixed well
- Flour should be boiled in necessary water to make it sticky
- The ingredients should be mixed with sticky flour to form paste and finally small thin grain / pellet should be prepared by hand or using a machine

The level of nutrient content in feed required for fry made at home can not be maintained properly. However, the trusted manufacturer with goodwill produce feed for fry based on their food habit and nutritional requirement. Therefore, using commercial feed from those companies is better.

Recommended dose of homemade feed in nursery:

The age of fry (day)	Recommended dose (%)
1 – 7	30
8 – 14	25
15 – 21	20
22 – 30	15

Supplementary feed application: The daily ration necessary for nursery should be divided in to 3 - 4 portions and should be applied in 3 - 4 times.

Cautions in feed applications

- Feed should be applied daily at the same time and same location.
- If water turns to deep green, feeding should be reduced or stopped for the time being.

If natural feed (particularly phytoplankton) creates problem in the pond water, then two silver carps of 5" size per decimal can be released

Within 30 - 35 days of the starting of nursery, stocked fry will reach to 2" size. The fry of this size can be stocked in grow out pond.

Hapa nursery: In tilapia culture, hapa nursery is a modern technique. When setting up of nursery in pond / canal is not possible during monsoon, fry mortality can significantly be reduced in hapa nursery. In addition, in the ponds located in coastal saline area, hapa nursery can be set to carry on culture activity in saline water. Hapa is a mosquito net like stuff, i.e., an upside down mosquito net is a hapa. Hapa is usually made from synthetic blue nylon net. It may be of different sizes. The stocking density of fry in hapa is 250 – 300 fry. Feeding dose and application are same as before. Hapa should be set such a way that the top of hapa remain 6 inches above the water level and base remain 1 foot far above the bottom mud. Hapa should be cleaned after every 4-5 days so algae do not clog the net mesh and prevent water flow. It is better to use commercial floating feed in hapa.

Group Session Planning

Day – 02

Time – 10.00

Duration – 30 min

Target Group : Tilapia Farmers
 Title of the Session : Review of the discussion of previous day
 Goal : Reviewing the activities of previous day and getting reflection of everyone, so the trainees can recall already discussed matters and this way make the sessions more effective

Objectives : **At the end of the session**

- The trainees will reach in agreement through reviewing the learning of previous day and correcting the mistakes and inaccuracy, if any

Subjects to be discussed in the session	Training method	Time
Introduction		2 min
1. Welcome: Welcoming the participants and exchange of greetings 2. Review of the previous session 3. Linking with present session 4. Explaining the objectives of present session and worlds of encouragement	Question answer Discussion	
Subject matter		25 min
1. Reviewing the activities of previous day by a trainee 2. Reflection on the discussed matter of previous day by all the trainees (Question answer)	Question answer Speech	
Summary		3 min
1. Review of the major points 2. Verification of the Objective	Question answer	

Linking with next session

Training materials ➤ Flip cart, white board, marker and handout

Group Session Planning

Day – 02

Time – 10.30

Duration – 90 min

- Target Group : Tilapia Farmers
- Title of the Session : Tilapia culture management in pond / gher
- Goal : The trainees will get clear ideas on the importance of tilapia culture, management activities in pond / gher so they will be able to increase tilapia production in their ponds realizing the importance of discussed matters and following the advanced technologies
- Objectives : **At the end of the session**
- Trainees will be able to select suitable water bodies for tilapia culture
 - Trainees will be able to carry out pond / gher preparation and management activities in tilapia culture properly

Subjects to be discussed in the session	Training method	Time
Introduction		4 min
1. Welcome: Welcoming the participants and exchange of greetings 2. Review of previous session 3. Linking with present session 4. Explaining the objectives of present session and words of encouragement	Question answer Discussion	
Subject matter		80 min
1. Important points for selection and preparation of tilapia pond / gher 2. Characteristics of a standard water body 3. Pre stocking management of tilapia culture a. Repair of bottom and dyke: importance, methods and cautions b. Control of aquatic weed: importance, methods and cautions c. Removal of predatory fishes : importance, methods and cautions d. Lime application : importance, types, dose and quantity, application methods and cautions e. Fertilizer application : importance, types, dose and quantity, application methods and cautions 4. Stocking management a. Timing of fry stocking b. Determination of stocking density : importance, density and cautions c. Fry transport and release: importance, density and cautions 5. Post stocking management a. Feed management: importance, methods and cautions b. Fertilizer application c. Checking of fish health 6. Fish harvesting and marketing 7. General problems in tilapia culture and control measures	Question answer Speech Flip chart	
Summary		6 min
1. Review of the major points 2. Verification of the Objective 3. Handout distribution	Question answer	

Linking with next session

Training materials ➤ Flip chart, white board, marker and handout

Planning of the flip chart

(Please follow the handout for detailed description)

<p style="text-align: center;">Management of tilapia nursery</p>	<p style="text-align: center;">Pre stocking management</p> <p>Most of the activities of pre stocking management of fish culture are same as tilapia nursery management stated in session 3. Therefore, all activities of this types are not presented in this session</p>						
<p>Important points for selection of pond / gher for tilapia culture</p> <ul style="list-style-type: none"> • Soil type and quality • Water supply and drainage system • Is the land above the flood level • How is marketing facilities of the produced fish • Availability of tilapia fry in the area • Availability of tilapia feed in the area • Financial ability of tilapia farmers 	<p style="text-align: center;">Stocking management</p> <p>Timing of fry release</p> <ul style="list-style-type: none"> • Fry should be released after 5 – 6 days of fertilizer application in grow out pond / gher • Fry should be released in the morning or any time of the day, if water is cool • Small fry should not be released in a rainy day. Because oxygen content is low and carbon dioxide content is high in rain water and as a result fry may die. <p>Stocking density</p> <p>1. Tilapia mono culture</p> <ul style="list-style-type: none"> • If 150-200 fry are released per dec pond area, the average weight of fish will be 200 – 300 g within 3 - 4 months • If 200 fry are released per dec pond area, the average weight of fish will be 250 – 300 g within 3 - 4 months • If 300 fry are released per dec pond area, the average weight of fish will be 200 – 250 g within 3 - 4 months <p>2. Tilapia poly culture</p> <p>Stocking of 4 " – 6" (inch) carp juveniles such as silver carp 05 – 06, catla 02 – 03 and rohu 02 – 04 along with 100 tilapia fry per dec results in better yield.</p> <p>3. Spawn / fry transport and stocking</p>						
<p>2.Characteristics of a standard pond / gher</p> <ul style="list-style-type: none"> • Area • Shape and size • Dyke • Embankment slope • Soil 	<p style="text-align: center;">Post stocking management</p> <p>Feed for tilapia and feeding management:</p> <table border="1" style="margin-left: auto; margin-right: auto; border-collapse: collapse; text-align: center;"> <thead> <tr> <th style="padding: 5px;">Average weight of fish</th> <th style="padding: 5px;">Feed (body weight %)</th> </tr> </thead> <tbody> <tr> <td style="padding: 5px;">10 – 15 g</td> <td style="padding: 5px;">20</td> </tr> <tr> <td style="padding: 5px;">15 – 30 g</td> <td style="padding: 5px;">15</td> </tr> </tbody> </table>	Average weight of fish	Feed (body weight %)	10 – 15 g	20	15 – 30 g	15
Average weight of fish	Feed (body weight %)						
10 – 15 g	20						
15 – 30 g	15						

Culture method of Tilapia

Important points for selection of pond / gher for tilapia culture

- Soil type and quality
- Water supply and drainage system
- Is the land above the flood level
- How is the communication
- How is the rental or purchasing cost
- How is marketing facilities of the produced fish
- Availability of tilapia fry in the area
- Availability of tilapia feed in the area
- Financial ability of farm owner

Characteristics of a standard pond / gher

Area: The area of tilapia pond / gher may be a few decimals to several acres. However from the management point of view, the area should be 1 – 2 bighas.

Shape and size: Starting from fish harvest all other management activities are easier in a rectangular pond. However pond / gher can be of other shapes as well. However, based on the shape of the land available for the pond, there isn't any problem if pond is of the similar shape. The shape of the water body does not have much impact on the production.

Dyke: The pond / gher dyke should be elevated at such level so that the rain water or the water from other outside sources can not enter in to the pond / gher. Wide dyke is essential. Because, pond / gher dyke become damaged regularly due to many reasons. A pond of 2 bigha should have at least 4 / 5 feet wide dyke. However, whatever the width of a dyke, it should be repaired at few years interval.

Dyke slope: The slope of pond dyke should be minimum of 2 : 1. Slope should be built such a way that one can go close to the pond water by walking. As tilapia build nest after digging soil, steep dyke becomes easily damaged. Therefore for tilapia pond, dyke with appropriate slope is essential.

Soil: Generally water bodies of loamy soil are the best for fish culture. Thick layer of mud is built-up in pond of sandy soil within 2-3 years of fish culture. As a result, the water holding capacity of pond increases and ponds become suitable for fish culture.

Depth: Pond / gher should be such deep so it can hold 4 - 5 feet of water. In those cases, where water is supplied to pond from deep tube well, pond depth / height including dyke should be 7- 8 feet. On the other hand, if there is no provision of water supply from outside, pond should be such deep so it can hold at least 3 feet water in lean season. In these situations, decision should be taken after necessary survey on the ponds / gher located in the region.

Water supply and drainage system

In improved fish culture, regular water supply and draining out are necessary. Therefore, inlet and outlet pipes / drain are required. Generally, a pipe of 6 inches diameter is sufficient for a pond of 1 acre.

Pre stocking management

Most of the activities of pre stocking management of fish culture are same as tilapia nursery management stated in session 3. Therefore, all activities of this types are not presented in this session.

Stocking management

Fry should be released after 5 – 6 days of fertilizer application in grow out pond / gher. Fry should be released in the morning. If water is cool, fry can be released in any time of the day. Small fry should not be released in a rainy day. Because oxygen content is low and carbon dioxide content is high in rain water and as a result fry may die. Heavy rain during the day of fry release or in the next day may cause mortality of all released fry. The risk is not that severe for large fry.

Stocking density

1. Tilapia mono culture

High stocking density of fry results low growth. Therefore, fry should not be released at high stocking density in tilapia culture. If 150 fry are stocked per dec pond area, the average weight of fish will be 300 – 350 g within 3 - 4 months. If 200 fry are stocked per dec pond area, the average weight of fish will be 250 – 300 g within 3 - 4 months

If 300 fry of 6- 8 g size are stocked per dec pond area, the average weight of fish will be 200 – 250 g within 3 - 4 months. For that reason, farmers should decide the stocking density of tilapia culture considering their ability and experience. Here, stocking of 3-4 silver carp juvenile of 5 – 6 (inch) per decimal in addition to tilapia controls natural feed of pond and provides extra income.

In general ghers do not have water more than 5 feet, therefore, high density tilapia mono culture will be risky. Good profit can be obtained in high density tilapia culture in suitable pond.

2. Tilapia poly culture

Stocking of carp juveniles such as silver carp 05 – 06, catla 02 – 03 and rohu 02 – 04 along with 100 tilapia fry per dec result in better yield. Here the average size of carp juvenile is 4 – 6 (inch). Generally in poly culture, regular application of homemade supplementary feed by low investment can give satisfactory production and extra income.

It should be remembered that, in case of either mono culture or poly culture, standard and maximum application of improved quality feed particularly floating pellet can give more production and profit.

Crop rotation:

Usually the farmers culture one tilapia crop and in some cases two crops in pond and one crop in gher annually. However, by improved management and well-thought planning, getting more production is possible following the methods described below –

Tilapia culture in pond

Tilapia fingerlings of 10 – 15 g can be stocked in the ponds where at least 3 feet water is available year round and tilapia can be produced in 3 cycles.

Tilapia
Mar - Jun

Tilapia
Jul - Sept

Tilapia
Oct - Feb

Tilapia culture in gher

Tilapia fingerlings of 10 – 15 g can be stocked in the gher where at least 3 feet water is available after Boro harvest and tilapia can be produced in 2 cycles and boro rice in one cycle.

Tilapia
Apr / May -
Jul / Aug

Tilapia
Aug -
Nov / Dec

Boro rice
Nov / Dec -
Apr / May

Post stocking management

Feed for tilapia and feeding management:

Like in nursery, homemade feed should be applied following the doses described below. The feed with food conversion ratio (FCR) less than 2 should be applied.

Fish should be fed with following ratios daily -

Average weight of fish	Feed (body weight %)
10 – 15 g	20
15 – 30 g	15
30 – 50 g	10
50 – 100 g	5
100 – 200 g	4
More than 200 g	3

Commercial feed

Tilapia feed manufactured by different companies are available in the market. The better quality feeds should be used. Generally, commercial feeds are of two types – floating and sinking. For higher yield and saving the wastage, floating feed is better. In this case, feed should be applied following the leaflet / user manual of the particular manufacturer which can be collected from the feed retailers.

If commercial feed is used, it should be remembered that 1 kg fish should be produced using maximum 1.25 – 1.50 kg feed (FCR – 1.25 – 1.50)

Timing of feeding

Usually fish should be fed 2- 3 times a day. Feeding at 10 – 11 am in the morning and 4 – 5 pm at the afternoon is better. However, farmers can change the feeding time according to his convenience. If feeds are applied more than necessary, water quality deteriorates rapidly along with wastage of valuable feed. For that reason, estimating the necessary amount of feed is important. On the other hand, if feed is applied less than the requirement, fish growth becomes slower. Feed should be applied over the wide area of the pond. As a result, many fish of the pond can feed at a time without much competition for feed. The right size of the pellet should be selected based on the size of the mouth of fish so fish can easily grasp the pellet. It should be remembered that application of excess feed than necessary or application of larger feed pellet than what fish can grasp is nothing but wasting money for no reason.

Checking the amount of applied feed for fish

To know if the supplied feed for fish is sufficient, the abdomen of some fish can be checked after 1 hour of feed application. Full abdomens of fish look somewhat swollen. If fish do not become full from the supplied feed, they do not easily leave the feed application place rather they continue their movement near the place. As the level of the hunger of fish, so is their excitement for a feeding frenzy. This can be easily understood from the experience.

Required feed should not be distributed at once. Rather the feed should be distributed slowly to realize the feeding demand. To observe rapidness or demand of feeding during feed application the amount of feed should be determined. Usually, that much feed should be applied so fish can complete within 15 – 20 minutes. It has been observed that if fish are not fed one day in a week, next day their affinity of feeding increases. Doing this does not hamper the fish production rather reduces the cost of supplementary feed by some extent.

Checking fish growth

Growth rate of fish should be checked at least twice a month from collected sample. How many grams weight increased in how many days should be observed and how much feed were applied for resulting growth should be assessed. The reasons behind fish not growing as expected need to be analyzed and control measures should be taken. If fishes in the pond are more or less of equal size, not many fish need to be weighed during sampling. If sizes of fish vary by far, much more (a few hundred) need to be sampled.

Sampling of tilapia and estimating feed quantity: Sampling and adjusting feed quantity based on that sampling are very important in tilapia culture. After fry stocking, every week or at 15 day intervals, 50 – 100 fish should be weighed individually after catching from 3 different places of a water body. Then total weight of fish in the pond should be calculated from the mean weight of sampled fish (no need to consider the weight of silver carp, catla/big head if present in the pond). It can be noted that, fish in the ponds are always not of equal size. Therefore, during sampling, small, medium and large – all sizes of fish need to be weighed. The total weight of sampled fish divided by the number of sampled fish give the mean weight of sampled fish. For example if the total weight of 25 fish is 1 kg, then mean weigh is 40 g (1000 g / 25 = 40 g). To calculate the total weigh of all the fish in the pond, 80 – 90 % survival of stocked fish should be considered.

Observation of fish growth during sampling (in case of fish culture using commercial floating pellet)

Culture period (day)	Preliminary mean weight (g)	Mean weight during sampling (g)
1 st 15 days (nursery)	0.6	4
2 nd 15 days (nursery - 30 days)	4	9.5
3 rd 15 days (45 days)	9.5	26
4 th 15 days (60 days)	26	52.5
5 th 15 days (75 days)	52.5	76
6 th 10 days (85 days)	76	99.5
7 th 10 days (95 days)	99.5	135
8 th 10 days (105 days)	135	170
9 th 10 days (115 days)	170	210

Source: Exhibition on mono sex tilapia, Avoy nagar, Jessore – CSISA, WorldFish 2011)

Fertilizer management

Tilapia culture is mostly supplementary feed dependant. Part of the applied feed remains unutilized by the fish. The unutilized feed and fish excreta act as fertilizer in the pond. Therefore, usually in most cases, no extra fertilizer is needed in tilapia culture. If necessary, fertilizer dose used in nursery can be followed here.

Fish harvesting and marketing

Under the proper culture management, improved quality fry and complete balanced diet, the average weight of tilapia reach to 200 – 250 g within 3 – 4 months. Other fish if stocked along with tilapia, reach to 600 – 1000 g on average. At this stage fish should be marketed according to the market demand after complete or partial harvest. However, selling live fish in local market gives higher profit.

Some of the problems in tilapia culture and their control measures

Shortage of oxygen

In the ponds of improved fish culture, shortage of oxygen often occurs. When oxygen content drops in the water, fish start floating and grasping on the surface. If the situation lasts for days, fish become seek, lose appetite, their growth rate decreases and may face mass mortality. This significantly reduces the farm production.

Control measures

If dissolved oxygen is short in the pond, water should be exchanged with new water from deep tube well or from other sources. This is the best measure. If water exchange is not possible, net or harra should be pulled in the pond or pond water should be stirred. Water from deep tube well is virtually oxygen-free and adding water from any new source to pond creates kind of a new environment for fish. Considering these aspects, pond water should be exchanged over a few days instead of changing at once. During water exchange or immediately after the event, lime should be applied in the pond at mild dose (250 g / dec).

Disease of Tilapia and their prevention and control

What is disease?

A disease is an abnormal physical condition caused by the action and reaction of the stress from deteriorated aquatic environment, active germs and pathogen present in water and internal immune power of fish.

Common symptoms of diseases

Fish show different symptoms based on the types of diseases. However, one or more of the following symptoms indicate that fish in the water body are infected by any of the diseases.

- Fish reduce or stops feeding completely
- Lesions or hemorrhages on the body
- Tail and fins start to rot
- Gills become damaged
- Cotton like fungi observed on fish body
- White spots form on the body
- Black and white spots or cyst present on the gill
- Reduced growth rate
- Fish lose balance etc.

Tilapia is known as a high disease resistant fish species. The fish is highly adaptable in adverse aquatic environment compared to many other fish species. Yet when the physiochemical parameters of water reach beyond the optimum range, the disease resistance ability of fish drops far below the expected level. As a result, fish get easily infected by germs and pathogen present in water. The risk of infection further aggravates due to polluted water caused by higher stocking density and the decomposition of unused feed in closed water body, excretory materials of fish and other waste matters. The risk of fish disease can be reduced following the precautions described below –

- Stocking of disease free healthy fry
- Disinfecting all the tools used in fish culture and fish farm
- Avoid stocking of excess fish
- Application of balanced diet as necessary
- Ensuring the proper care of fish and farm

Parasitic diseases

The following parasitic diseases are observed in tilapia

1. Trichodinid infection

Under high density fry rearing in nursery, the gill and skin of fish are massively infected by the parasite of *Trichodina* spp. Due to the infection in gills, fish, to some extent, lose the ability to intake oxygen, discharge carbon dioxide and excrete ammonia and to maintain the chemical equilibrium of the body. As a result, fish become vulnerable by the disease infection.

Symptoms of disease: Fish become increasingly restless. Fish swim abnormally. They rub the body with different things. Their breathing increases. Fish lose weight. Fins become disintegrated / tattered.

Treatment: Formalin 25 ppm or sodium chloride 200 ppm only one dose in pond water can control the disease. Infected fish should be bathed in water with 250 ppm formalin for an hour.

2. Chilodonella infection (*Chilodonella* sp.)

Chilodonella is one kind of unicellular parasite. The parasite takes refuge on the skin, fin and gill of fish. The tilapia fry become weak at the low temperature of winter and all of a sudden at the beginning of spring they get infected from the parasite.

Symptoms of disease:

- The parasites create disturbance for fish through attaching on fish body
- Fish unnecessarily start jumping above the water
- In most cases, fish become weak and motionless
- The infection of small fish is more severe
- Fish body becomes covered with bluish grey mucous
- Branchial tissues become swollen and damaged and fish suffer from breathing problem

Treatment: Application of 25 ppm formalin in infected pond. Besides, excessive fish should not be stocked in pond / gher. Pond should be disinfected by lime application before the fry stocking.

3. Fish lice (*Argulus* spp.)

Arulus is a copepod external parasite and can be easily seen by naked eye. They are known as fish lice. The parasites attach themselves on skin, fins and gills of fish with the help of sucker and feed. If necessary, the parasites swim freely in the water and take shelter on new host fish.

Symptoms:

The parasites on fish skin can be seen by naked eye. In case of small fishes, imbalance of body has been observed. Fish are seen rubbing body with various solid things. A circular lesion is observed in infected area that mostly turns to deep red colour. The surroundings of infected area become swollen and deep lesion forms. Scales become loose and even drop off.

Control

Dipterex 0.25 ppm once in a week over successive 3 weeks can be applied in infected ponds. Or Sumithion 2 – 3 ml / dec / foot can be applied.

Treatment of fish:

The lice should be pulled up from the body of infected fish with the help of forceps. Then fish should be immersed in 10 ppm potash or 5 ppm sodium chloride solution for 10 – 30 minutes. However, the duration of this treatment should be in accordance with the ability of fish tolerance.

Bacterial disease

Columnaris infection: The causative agent for this disease is a bacterium named *Flexibacter columnaris*. Because of the carelessness during fish harvest, transport, netting and other activities, fish scales drop off, skin becomes torn and small spots or lesions form on fish body. This creates the easy opportunity for bacteria to enter in to the fish body. The infection starts from the caudal fin of fish and gradually expands all over the body.

Symptoms:

- At the preliminary stage, white spots are observed on head, skin, gills and fins of fish
- The white spots are observed later to be covered by red circle
- The internal organs are usually not infected

Treatment:

As the disease initially attacks the external organs of fish, external treatment is largely successful. 25 ppm formalin 3- 4 times at one day interval can be applied in infected pond.

Application of antibiotic: Oxytetracycline: 50 – 75 g / kg fish / day should be mixed with fish feed and fed over 5 – 10 days. The dose may vary based on the intensity of disease and the age of fish.

Streptococcus infection (Streptococcus spp.)

Streptococcus is a gram positive round bacteria. In case of high density tilapia culture, fish suffer from mass mortality due to Streptococcus infection all over the world.

Symptoms:

Physical weakness and fatigue in movement
Loss of appetite
Pale reddish anus
Reddish, eye, gills and muscles
Swelling of liver, kidney and spleen of fish
Fish swim with stiff body in a circle
Eyes become swollen and puffy with opaque cornea

Antibiotic application:

Erythromycin: 50 mg / kg fish / day over 4 -7 days should be fed after mixing with feed

Motile Aeromonad Septicemia

Motile Aeromonad type gram negative bacteria are the cause of the disease. The notable bacteria are *Aeromonas hydrophila*, *A. sobria* and *A. caviae*. The motile Aeromonad bacteria are present in all kind of water bodies except ultra saline ones. However, it is still uncertain that these bacteria are the primary cause of the disease. If the opportunity available for infection, the pathogens cause massive damage to fish.

Symptoms:

- The symptoms of the disease have strong similarities with the symptoms of Streptococcus infected fishes.
- Fatigue in fish movement and physical weakness
- Loss of appetite
- Dropping off of scales
- Pale reddish anus and base of fins
- Reddish eye
- Wide and deep lesions form on fish body
- Accumulation of fluid in stomach
- Swelling of kidney, spleen and liver of fish

Treatment:

Oxytetracycline / Chloramphenicol: 50 mg / kg fish / day over 4 -7 days should be fed after mixing with feed.

Fungal disease

In tilapia farms specially in hatcheries, fungi are known as pathogen of secondary level. When skin, fins, gills of fish or outer layers of fish eggs become disintegrated / torn due to any reason, fungi infect the torn portion. Eggs and larvae die from fungal infection.

Symptoms:

Layer like white cotton is observed on fish body or on the eggs. However, the colour of layer may change due to the mixing with other substances. In most cases, the branches of fungi extend to the outer skin of fish. As a result, fish can not maintain balance of salt and eventually die.

Treatment:

Dip for infected fish in 30,000 – 50,000 ppm brine for 3 – 4 minutes. However, the duration of this treatment should be in accordance with the tolerance ability of fish. If necessary the treatment should be repeated.

Group Session Planning

Day – 02

Time – 12.15

Duration – 75 min

Target Group : Carp/Carp-Shing Farmers
 Title of the Session : Vegetable culture on pond dyke
 Goal : The trainees will get clear ideas on the importance of vegetable culture on pond dyke, aspects should be considered in vegetable selection, the basic features of vegetables / crop farming on pond dyke etc. so they will be able to fulfill the nutritional demand of their families with an extra earning through valuable vegetable culture on pond dyke

Objectives : **At the end of the session**

- Trainees will be able to speak about the importance of vegetable culture on pond dyke
- Trainees will be able to speak on the aspects need to be considered in vegetable / crop selection
- They will be able to explain the basic features of vegetables / crop farming and crop management

Subjects to be discussed in the session	Training method	Time
Introduction		5 min
1. Welcome: Welcoming the participants and exchange of greetings 2. Reviewing of the previous sessions 3. Linking with present session 4. Explaining the objectives of present session and words of encouragement	Discussion Question answer	
Subject matter		60 min
1. Importance of vegetable culture on pond dyke, advantages and important aspects 2. Important aspects of crop selection for culture on pond / gher dyke 3. Fundamental aspects of vegetables / crop farming on pond dyke 4. Vegetable culture management on pond / gher dyke	Question answer Speech Flip chart	
Summary		10 min
1. Review of the major points 2. Verification of the Objective <ul style="list-style-type: none"> • What are the importance of vegetable culture on pond / gher dyke? • What are the important aspects of crop selection for pond / gher dyke culture? 3. Distribution of the handouts	Question answer	

Linking with next session:

Training materials > Flip cart, white board, marker and handout

Planning of the flip chart

(Please follow the handout for detailed description)

<p>Vegetable culture on pond dyke</p>	<ul style="list-style-type: none"> • Source of seed / sapling • Timing of vegetable / crop seed sowing or seedling replantation • Special care for seed production • Sate of plant growth • Maintaining necessary distance • Top dressing of fertilizer • In tericultural operation • Soil condition • Use of herbal pesticide instead of chemical pesticide • High yielding, disease resistant , short cycled varieties and optimum use of slope and dyke
<p>Importance / significance of vegetable culture on pond dyke</p> <ol style="list-style-type: none"> 1. Multiple u se of small land holding 2. More profit 3. Fulfilling nutrient demand <p>In addition importance of vegetable culture in homestead pond are as follows –</p> <ul style="list-style-type: none"> • Enhance household income and ensure family nutrition • Utilization of pond dyke, slope and other areas • Grass can be produced and used as fish feed • The pond bottom mud releases the nutrients that help in production of vegetables / fruits • Proper use of family labour <p>Advantages of vegetable culture on dyke</p> <ul style="list-style-type: none"> • More than one crop are grown in an area at a time using low investment • One crop assists other crop • The maximum utilization of land on pond dyke is ensured by multi layer vegetable culture • Vegetable culture on dyke helps in 	<p>Fundamental aspects of vegetables / crop faming on pond dyke</p> <ul style="list-style-type: none"> • Elevated pond dyke • Medium elevated pond dyke • Low pond dyke • Medium l ow pond dyke • Wide pond dyke • Narrow pond dyke etc.

Importance of vegetable culture on pond dyke

From the nutritional point of view, an adult human being should consume 200 – 250 g vegetable daily. However on the basis of the total vegetable produced in Bangladesh, per capita per day share is only 80 – 100 g. Millions are suffering from nutrition deficiency due to low vegetable consumption. Many people are the victim of night blindness, anemia, mouth sores, bleeding gums, beriberi, goiter etc. due to lack of different nutrients. It is notable per capita per day vegetable consumption in South Korea and Japan, respectively, is 549 g and 348 g. Therefore, vegetable consumption should be



increased to a large extent in Bangladesh. Vegetables are full of vitamins and minerals. All most all leafy vegetables contain carotene that is converted to vitamin A after ingestion. Again coloured vegetables like carrot and sweet pumpkin also contain carotene. There are various minerals like calcium, iron, phosphorus, zinc etc. in many vegetables. In addition, lablab bean, yard long bean, pea, pointed gourd, bitter gourd, drumstick, teasel gourd are the best source of protein useful for good health. About 500,000 children in Bangladesh every year suffer from night blindness due to vitamin A deficiency. Again due to the same reason, daily 100 and annually more than 30,000 children become completely blind. Deep green leafy vegetables and coloured vegetables are full of carotene. Therefore, these vegetable are the best medicine to prevent and cure complete blindness and night blindness. To protect the children from the diseases, they should be fed daily with plenty of leafy greens and coloured vegetables since the age of 5 months.

It has been known that vegetables have cancer fighting abilities. Regular vegetable consumption can protect people from skin disease, scurvy, mouth sores, rickets, anemia and many such diseases. Vegetable are such beneficial for human body that physicians now-a-days recommend vegetables for convulsing people suffered from heart disease, skin disease and many other disease. Fibers in vegetables are very goof for curing constipation. There are no side reactions of vegetables. According to nutritionists, the vegetarians live longer. Therefore household malnutrition can easily be com-bated through year round supply of vegetables by intensive culture on the pond dyke.

Vegetable culture on the dyke of ponds / ghers is a kind of integrated culture management. And the integrated culture is producing multiple crops simultaneously in same land to earn extra revenue by ensuring maximum use of land and maintaining environmental equilibrium. Such as rice cum fish and prawn culture, fish cum duck and chicken culture, Rice cum fish and vegetable culture and fish cum livestock culture etc. Though the integrated farming is a relatively new concept in our country, it has been practiced from ancient time in other countries of the world. It is necessary to popularize integrated culture management for the rapid development of rural economy of our country.

Vegetable culture in the dyke of ponds / ghers

Vegetable culture in the dyke of ponds / ghers is culturing diversified vegetables and crops on the dykes of fish culture ponds / ghers following improved management considering the type of dyke, market demand and production season.

Importance of vegetable culture on pond dyke with fish

Vegetable culture with fish is a modern culture management. This ensures maximum utilization of small land area. Through gradual vegetable culture on the dyke of pond / gher -

- Year round vegetable supply for the family and combating nutritional deficiency
- Extra earning from vegetable sale
- Caring of fishes and at the same time attending and taking care of the vegetable, no extra labour for vegetable on the dyke
- Change of food habit through vegetable consumption
- Protection from unhealthy environment
- Multiple use of resources ensured
- Food supply increases in the markets
- Different crops can be grown in short time and with low investment

The taste of fresh vegetables is wonderful. Needless to say the nutritional quality of fresh vegetables is superb as well. Please ensure the extra earning and HH nutrition with pesticide free vegetable by vegetable culture on the dykes of your own ponds / ghers.

Important aspects of crop selection for vegetable culture on the dykes of pond / gher

Crop varieties should be selected considering the type of dykes, availability of sun light, soil type, market price, financial ability of farmers, availability of seeds / saplings, consumer demand and the crops / vegetables that do not damage the dyke. Besides, crops under same family should not be cultured as multiple crops as they get infected by same type of diseases and attacked by same type of pests and compete for same kind of nutrients. The following aspects should be considered in selecting crops -

- Type of dykes
- Availability of sun light
- Soil type / quality
- Market price
- Financial ability of farmers
- Vegetable / crops under same Family

The following matters should also be taken in to account -

- Source of seed / sapling
- Timing of vegetable / crop seed sowing or seedling replantation
- Special care for seed production
- State of plant growth
- Maintaining necessary distance
- Top dressing of fertilizer
- Intercultural operation (very important)
- Soil condition
- Use of herbal pesticide instead of chemical pesticide
- High yielding, disease resistant, short cycled varieties, and optimum use of slope and dyke

Preparation of dyke of pond / gher

Vegetables / crops should be selected depending on the type of the dyke. Culturing all kind of vegetables / crops in a particular dyke is not possible. Dyke should be prepared such a way that it suits that particular vegetable / crop. Based on the land type, pond dykes can be of many types, such as -

- Elevated pond dyke
- Medium elevated pond dyke
- Low pond dyke
- Medium low pond dyke
- Wide pond dyke

Narrow pond dyke etc.

Dykes of ponds / gher need necessary modification for vegetables / crops cultivation. This could be done by following ways -

- For cultivating vine vegetables in low dyke, land should be elevated mainlining regular distance with earth or fertile soil from pond bottom. The size of pit will depend on the crops.
- For cultivating any crops in low and narrow dyke of ponds /ghers, dyke should be made little wider and elevated using necessary earth
- If the structure of the dyke of pond /gher is suitable for crop culture, the entire dyke should be dug with a spade and weeds should be removed and the earth should be made clod-free, soft and loose.
- For multi-layer vegetable culture, the entire dyke should be dug with a spade and weeds should be removed and the earth should be made clod-free, soft and loose
- If a dyke is used for human movement, for culturing crop in that dyke, the side of the land connected with dyke of pond / gher should be made elevated (heap) using the earth for other lands.
- Without any modification of the structure of the dyke of pond / gher, the dyke can be made suitable for crop culture by making pits at particular distances

- For crop culture lands are prepared this way. During the preparation of dyke of pond / gher, required quantity of organic and inorganic fertilizer should be applied to make the land fit suitable for crop farming. Depending on the width of the dyke of pond / gher, crop can be cultured using one row or two row methods.

Pit formation on dyke

Bean or cucurbit vine vegetables such as bitter gourd, wax gourd, bottle gourd etc. can be cultured in the pits on the dyke of pond / gher. In that case good yield can be obtained by setting a machan (trellising) or sticking the base of bamboo sticks.

Size of pit / whole

Bottle gourd, sweet gourd: 1 cubit 1 cubit 1 cubit

Ridge gourd, snake gourd, cucumber, teasel gourd, bitter gourd: 15 inches 15 inches 15 inches

Lablab bean: 1.5 feet 1.5 feet 1.5 feet

Distance from one pit to other:

Bottle gourd, sweet gourd: 4.5 cubits

Ridge gourd, snake gourd, cucumber, teasel gourd, bitter gourd: 3.5 cubits

Lablab bean: 5 feet

Fertilizer application in dyke pits:

Fertilizer	Amount of fertilizer / pit				
	7 – 10 days before seedling plantation	7 – 10 days after seedling plantation	30 - 35 days after seedling plantation	50 - 55 days after seedling plantation	70 - 75 days after seedling plantation
Organic	10 kg	-	-	-	-
T S P	100 g	-	-	-	-
Urea	-	25 g	25 g	25 g	25 g
MoP	40 g	20 g	-	-	-
Gypsum	15 g	-	-	-	-
Zinc	10 g	-	-	-	-
Borax	10 g	-	-	-	-

Vegetable production model in dyke and slope of pond

Suitable place	Rabi crop	Kharif crop
Pond dyke and slope	Tomato, lab lab bean and knol khol	Bitter gourd, cucumber, bottle gourd, wax gourd, lady's finger / okra

**Other than the listed crops, farmer may select any other crop depending upon the dyke and overall situation of the season*

Management of vegetable culture on the dyke of pond / gher

To ensure proper growth and to obtain expected yield from vegetable cultivation, the activities carried out starting from seed sowing or seedling plantation to crop harvest are collectively known as crop management.

Crop management activities are as follows

- | | |
|-------------------------------|--------------------------------|
| 1. Mulching | 9. Earthing up |
| 2. Shading | 10. Staking |
| 3. Irrigation | 11. Trellising |
| 4. Weeding | 12. Pruning and fruit thinning |
| 5. Soil loosening | 13. Pollination |
| 6. Thinning of seedling | 14. Insect management |
| 7. Top dressing of fertilizer | 15. Disease management |
| 8. Gap filling | |

Brief description of some of the management activities:

Mulching: Covering plant base or bed with decomposed water hyacinth, straw, dry grass, leaves and twigs etc. is known as mulching. The right height of mulch is 2.5 – 5.0 cm from the ground. The mulching increases the water holding capacity of soil, reduces weed infestation, enhances air and water movement in soil, prevents soil erosion. The mulch materials become organic fertilizer after decomposition, that increases the rate of germination, and eases nutrient uptake by plants. Often, mulch materials are infested by ants and termites, turning up of the materials could solve the problem.

Shading: After transplantation, seedlings may die of strong sunshine or heavy rain, or seedling establishment in soil may take longer time. Therefore just after the transplantation, shading of seedling should be done using part of banana stem or other materials for the protection from strong sun shine or heavy rain.

Irrigation: Irrigation is an important management in vegetable culture. Therefore to meet up the water demand, irrigation should be started immediately after seed sowing or seedling transplantation. For vegetable culture, at least some moisture should be available in soil. Therefore, a small bucket or a watering can rose is enough to water the plants. Irrigation must be followed by top dressing of fertilizer. Most cases 5 – 7 times irrigations are needed.

Weeding: Weeds are arch enemy of vegetables. Land should always be kept weed-free. Expected production can not be obtained if weeds are not controlled in time. Land should be kept weed-free at least up to 30 - 40 days after germination. Weeding should be done in the morning, so that the uprooted weeds die in the sun shine.

Soil loosening: Soil loosening includes the operations carried to keep the soil soft and loose when the vegetables are being grown on the dyke. This practice is particularly useful when top soil becomes thickened on drying followed by rain or irrigation. Soil can be loosened using trowel, rake, spade, rototriller etc.

Thinning of seedling: In vegetable culture using sowing method, it is not always possible to sow seed maintaining optimum distance. In that case, plants become dense after germination. For keeping optimum plant to plant distance, relatively weak and extra seedlings should be uprooted within 8 – 10 days of germination.

Top dressing of fertilizer: Top dressing of fertilizer in vegetable culture should be carried out as recommended. However, irrigation must be followed by top dressing of fertilizer.

Staking: Staking is essential for vegetative growth of vine vegetables and some other particular crops. The vegetative growth is hampered if staking is not provided. The plants bend down or flop result in low production. Bamboo stick, bamboo branch, jute stick, dhaincha etc. can be used as staking materials.

Trellising: Vine crops can not grow freely on the land. These types of crops grow rapidly if supports over the land are provided. Therefore, for culturing vine vegetables, trellising should be provided using bamboo stick, bamboo branch, jute stick, dhaincha etc. to allow the expansion of their branches.



Pruning: The excessive vegetative growth of fruit crops reduces expected yield. Therefore to control plant growth and boost up fruiting, excess branches / buds should be pruned during vegetative growth. Besides, the practice also entails targeted removal of diseased, damaged or dead branches.

The pruning of top of the ribbed gourd and smooth gourd plants enhances their early branch expansion and fruiting at the lower nodes. The size of tomato becomes larger due to the pruning of the branches. If pruned, the old okra and egg plant give fruits earlier than do the newly transplanted seedling.

Pollination: It has been observed in most of the vegetables under Cucurbitaceae family that fruits rot and fall off within a few days of opening of the female flowers. The lack of pollination due to the absence of insects or bees creates this situation. Therefore, the crops should be pollinated artificially. In the morning or afternoon, a newly opened male flower should be picked up and all the petals should be removed keeping the stamen intact. Then if the top of the carpel of female flower is touched 2- 3 times gently in soft hand with that stamen, pollination occurs. This way it is possible to pollinate 8 – 10 female flowers using a single stamen.



Insect and disease management: Diseases and insects are vicious enemy of crops. If crops are not protected from disease and pests, their growth ceases and yield reduction occurs. In that case instead of using chemical pesticide at the beginning, physical control (proper land preparation, maintaining clean culture), mechanical control (Pruning of diseased parts) and biological control (conservation of beneficial insects) should be followed.

Culture methods of various vegetables on the dyke of ponds / gher

Name of the vegetables	Variety	Time of sowing / plantation	Sowing / plantation distance (foot / inch)	No. of seeds / dec (40 m ²)	Cropping duration (day)	yield kg / dec
1. Tomato	Improved & high yielding varieties	September - October	R R : 2 feet S S : 15 inches	1.5 g / 90 - 100 seedlings	After plantation : 70 - 90 After sowing : 100 - 120	70 - 100
2. Lablab bean	BARI Shim - 1 BARI Shim - 2 Baromasi White IPSA - 1 Violet IPSA - 2	Middle of June	R R : 6.5 feet P P : 6.5 feet	40 - 50 g	Early variety : 130 - 150 Late variety : 150 - 200	85
3. Knol khol	Improved & high yielding varieties	Aug - Sept - Oct - Nov	R R : 1 foot S S : 9 inches	3.2 g	40 - 60	100 - 120
4. Bottle gourd	BARI -1 (Winter) BARI - 2 (Winter & summer)	August - October and March - April	P P : 10 feet Pit size: 21 × 21 × 18 inches	20 - 25 g	140 - 185	140
5. Bitter gourd	BARI Corolla - 1	February - May	R R : 3.2 feet S S : 3.2 feet Pit size: 17.5 × 17.5 inches	25 g 4- 5 seeds / pit	After sowing : 100 - 120	20 - 25
6. Cucumber	Improved & high yielding varieties	Mid February - mid April and July - August	R R : 5 feet P P : 5 feet Pit size: 17.5 × 17.5 inches	20 g (direct sowing)	75 - 125	100 - 120
7. Sweet gourd	Improved & high yielding varieties	Year round However July - October is better	P P : 10 feet Pit size: 16 × 16 inches	5 g	100 - 120	150 - 170
8. Wax gourd	BARI Wax gourd - 1	February - May	R R : 8 feet P P : 8 feet	15 - 20 g	120 - 130	80 - 100
9. Okra	BARI - 1	Year round However February - May is better	R R : 2 feet S S : 1 foot 6 inches	25 - 30 g	80 - 100	80 - 120

Major diseases of vegetables, introduction to pest and integrated pest management

Name of the vegetables	Name of the insects	Symptoms	Control measures
1. Lablab bean, bottle gourd, cabbage, wax gourd, cucumber	Aphid	Sucks sap from the flowers and fruits. Flowers and fruits fall off	Application of organic pesticides like nim (margosa) oil and tobacco gives good result. Paste is made by mixing 20 ml nim (margosa) oil with 60 g soap powder and the paste will be dissolved in 10 L water. Finally the filtered solution is sprayed on the plant using spray machine. Powder of tobacco leaves is soaked overnight and the filtered solution is sprayed to control Aphid. In addition 10 ml malathion 57 EC or Edmaier -200ml mixed with 10 L water can be properly sprayed
2. Lablab bean, tomato	Pod borer	Nymph / caterpillar enter into the fruits by boring hole and eat the internal part of fruit and fruits become rotten	If symptoms appear at the early stage, the pest can be controlled by uprooting the infected plants and burying under soil. Even though if the infection becomes severe, 10 ml Lebacid 50 EC or Sevin 85 SP mixed with 10 L water should be sprayed
3. Bottle gourd, sweet gourd, wax gourd and other cucurbit vegetables	Fruit fly	Fruits become rotten at the young stage and fall off	Use of poison bait: 100 g ripe sweet pumpkin is chopped, smashed and mixed with 0.25 g Mispin or Sevin 85 powder in 100 ml water in an earthen pot. It should be placed with three bamboo sticks such a way that the pot with poison bait remains about 1.5 feet above the ground. Bait should be replaced with a new one after 3 -4 days. Use of sex pheromone: The pest can be controlled by placing poison baits or sex pheromone traps in the crop field at 13 yards distance.
4. Bottle gourd, wax gourd, bitter gourd, ribbed gourd and teasel gourd	Red pumpkin beetle	Adult and caterpillar bore holes in roots or shoots under soil. So the trees become wilted and finally died down from drying	At seedling stage, up to 20 - 25 days, seedlings should be covered with a mosquito net. If the infection is severe 2 - 5 g carbofuran mixed with water per seedling should be sprayed at the base of the plant
5. Okra, tomato and brinjal	White fly	Spread viral disease	10 ml Malathion 57 EC or Edmaier - 200ml in 10 L water should be sprayed at the bottom side of the leaves

Major diseases of vegetables grown on pond dyke and their control measures

Name of the vegetables	Name of the disease	Symptoms	Integrated disease management
Lablab bean, tomato, papaya	Virus	Papaya leaves turn to green and yellow coloured mosaic. In lablab bean and tomato, leaves become thicker and curly.	White fly is the vector of the disease. Therefore to prevent the entry of the fly into the crop land, organic and chemical pesticides need to be applied at the young stage of plants at every 7 – 10 days intervals. Infected plants should be quickly uprooted from the pond dyke and burnt. To chemically control white fly, 1 ml dimecron / L water should be sprayed at 15 days interval. In addition nim (margosa) oil can also be applied.
Okra, sweet gourd and ribbed gourd	Root and foot rot	At young stage, foot of seedling rotten, wilt and fall down	If the infection is observed, irrigation should be reduced. Here 10 g Diathen M – 45 or Rovral – 50 WP or Antracol 70 WP mixed in 10 L water should be thoroughly sprayed at every 7 – 10 days interval at the base of the plants successively 2 -3 times.
Chilli and lablab bean	Anthrachnose	Stem/twig and fruits become ruptured and infected fruits fall off	Infected plants or dead plants should be removed and the dyke should be kept clean. 20 g Diathen M – 45 or Ridomil gold of any fungicide of Mancozeb group mixed in 10 L water should be thoroughly sprayed at every 7 – 10 days interval into the infected plants successively 2 -3 times.
Lablab bean, pea and Indian spinach	Pata dag rog (Leaf spot disease)	Sporadic watery round spot observed on leaves, the spots eventually unite and form large spot	20 g Diathen M – 45 or Ridomil gold of any fungicide of Mancozeb group mixed in 10 L water should be thoroughly sprayed at every 7 – 10 days interval successively 2 -3 times.

Vegetable seed production, processing and preservation

The prerequisite of good crop production is maintenance and preservation of seed of improved quality. It does not matter how good the crop variety, expected yield can not be obtained if fresh seeds with vigour are not used. Therefore the necessity of improved seed to increase crop production is crucial. Different techniques of vegetable seed production are described below –

- 1. Selection of vegetables and different varieties:** The good quality vegetables and their varieties should be selected such a way that seeds can be produced in local environment.
- 2. Foundation seed collection:** Seed should be produced after collecting foundation seed from reliable sources. The seed quality can only be maintained if seeds are produced with foundation seeds instead of other kinds of seeds.
- 3. Land selection:** The following points should be taken in to consideration in selecting land for vegetable production -
 - Land with good access of sunlight and air
 - Fertile loamy soil enriched with organic matter
 - Land with good irrigation and drainage facilities
- 4. Selection of cropping season:** In case of seed production, cropping season needs to be selected such a way that suitable weather is available in that time.
- 5. Land preparation:** The dyke should be ploughed thoroughly several times and made completely weed free. Then after breaking the clods, soil should be made soft and loose. Finally recommended basal doses of fertilizer should be mixed with soil.
- 6. Fertilizer application:** At the different stages of cropping, a variety of nutrients are required to ensure proper seed structure, nourishment and increment of yield. In seed production, phosphorus and potassium fertilizers are very effective.
- 7. Cultivation method:** Seed crops must be cultivated maintaining right distance and in line.
- 8. Weeding:** Weeds compete with crops for light, air and nutrient and provide refuge for diseases and other pests. The weeds in the crop field destroy the genetic purity of seeds through cross pollination.
- 9. Irrigation and drainage management:** Irrigation management is very important for seed crops. Due to the lack of sufficient moisture in the soil, the normal growth and nourishment of seeds is hampered. The pollen dries out, seeds become prematurely ripened due to dryness and yields decrease. On the other hand if there is stagnant water on the field, plant respiration is hindered due to lack of aeration, plants die, seed grains turn chita (unfilled grain) and become infected by fungal and viral diseases. Therefore, timely water drainage system is necessary to avoid the situation.
- 10. Infection of disease and other pests:** Infectious disease of seed crops are caused by a number of pests. Therefore, different prevention and control measures should be followed to protect seed crops from diseases and other pests.
- 11. Roguing:** In seed-crop field, removing of non-target vegetables, other varieties and weak, thin and diseased plants of target crop is known as roguing. The rogues destroy the purity of seeds. Therefore timely removal of rogues particularly before the pollination is necessary.

12. **Isolation distance:** To maintain genetic / hereditary purity through preventing cross-pollination, seeds crops are cultivated keeping a particular distance. This is known as isolation. Due to isolation, pollinations do not occur among different varieties, varieties do not mix during crop collection and disease and other pests from other crops under same group do not spread to seed crops. Therefore, isolation in seed crops is very essential to maintain health and purity of seeds.

Isolation in seed crops can be maintained using distance and time gap. To carry out isolation by distance in seed crops, the nature of crop should be considered - either the crop is self-pollinated or cross-pollinated. In case of crops that are mainly pollinated by cross-pollination, isolation distance should be longer.

13. Pruning: In cultivating seed crops, the plants become strong, firm and healthy if some unwanted branches, twigs and buds are cut down. The quality seeds are obtained from these plants. The quality of seeds of cucumber, wax gourd, bottle gourd etc. become superior, if 3- 4 main branches are kept and remaining branches are pruned.

14. Fruit thinning: In general, fruits of base and top of the plant are unhealthy and smaller. Therefore if these fruits are picked, the fruits in the middle get the opportunity to grow to right size, shape and colour. Therefore, good quality seeds are obtained from these well-nourished fruits.

15. Harvest and collection of seed crops: To ensure the quality of seed and high yield, seed crops should be harvested and collected only after the crops mature properly. Both the yield and quality of seeds are affected by the collection of immature or ultra-mature crops. In case of most of the vegetables, all crops or all seeds or fruits of a crop do not mature at the same time. The pattern and sign of maturity are different for different crops. Therefore, seed crops should only be collected after maturity at the right level.

Seed processing and preservation

Seed processing means cleaning the seed samples of extraneous materials like straw, dust, inert materials and other seeds, drying them to optimum moisture levels, preserving for improved quality and making the seeds usable.

At first, straw, hay, dust, gravels, clods and other non-target seeds should be removed with the mild blow or winnowing by a platter and manually. Next, seeds should be sieved with different meshed sieves and winnowing with platter to obtain only the right seeds. Then seeds should be sun dried to reduce the moisture to a particular level. Due to the high moisture content, seed quality fast deteriorates and can not be preserved for long time. Seeds are also infected by a variety of pests and diseases. Therefore, moisture content of seeds should be reduced to 6 – 8 %.

Vegetable seeds can be directly dried in the sun putting on chatai (bamboo mat), jut mat, other mats or polythene on the ground or on the concrete floor. Seeds must not be dried in the strong sun. During drying, seeds should be stirred to ensure equal drying. After proper drying, seeds should be cooled down. To check the proper drying, a few seeds should be chewed / pressed with teeth. Croaking sound indicates the proper drying of seeds.

The quality of dried seed remains excellent if stored in any type of tin container or drum. Besides, seeds packed in thick polythene bag can be stored in coloured glass containers with tightly closed top. Powder of nim (margosa), bishkatali (water pepper) can be used in small quantity with stored seeds to protect from disease and any other pests. The stored seeds need to be sun dried from time to time to maintain the good quality up to the next season.

Group Session Planning

Day – 02

Time – 13.30

Duration – 30 min

Target Group : Tilapia Farmers
 Title of the Session : Economic analyses of tilapia culture and dyke cropping and record keeping
 Goal : The trainees will be given overall idea on cost-benefit analyses of tilapia culture, record keeping so by filling the record book properly they will be able to analyze cost-benefit of fish culture in pond / gher accurately and keep the records

Objectives : **At the end of the session**
 Trainees will be able to calculate cost and benefit in tilapia culture and dyke cropping

- Trainees will be able to fill the record books

Subjects to be discussed in the session	Training method	Time
Introduction		2 min
1. Welcome: Welcoming the participants and exchange of greetings 2. Verification of the objectives of the previous sessions 3. Linking with present session 4. Explaining the objectives of present session and words of encouragement	Discussion Question answer	
Subject matter		25 min
1. The economic analyses of tilapia culture 2. The economic analyses of dyke cropping 4. Filling the record books and exercises	Question answer Speech Flip chart	
Summary		3 min
1. Review of the major points 2. Verification of the Objective 3. Distribution of the handouts	Question answer	

Linking with next session:

Training materials ➤ Flip cart, white board, marker and handout

Cost and benefit of tilapia culture and dyke cropping

Tilapia culture is a profitable business. In comparison to other agriculture activities, tilapia culture can give high revenue in relatively short time and low investment. Moreover, there are fewer risks in tilapia culture. However, the cost and benefit depend on a number of factors –

- Experience of farmers
- Culture type
- Management technique
- Input availability
- Input cost
- Culture duration
- Harvest method and timing
- Marketing facilities, weather and natural condition

To run the tilapia culture activities, money is needed mainly for lime, poison, fertilizer, feed, fish seed, labour wages, pond renovation etc. On the other hand, seed / sapling, fertilizer, irrigation, pesticide, labour wages etc in dyke cropping need investment. The input price varies based on locality, time and situation. Consequently, cost-benefit varies depending on the situation. A generalized analyses of cost and benefit of tilapia culture and dyke cropping per decimal water bodies is described below –

Cost benefit analyses of fish culture (per decimal)

Sl. No.	Items	Quantity	Total cost (taka)
1	Pond renovation	Lump some	100.00
2	Lime	1 kg	15.00
3	Organic fertilizer	10 kg	20.00
4	Urea	1 kg	20.00
5	T S P	0.5 kg	12.00
6	Fingerling (6 – 8 g)	200 (Nos.)	300.00 – 400.00
7	Feed (commercial)	30 – 35 kg (per kg 40 Taka)	1200.00 – 1400.00
8	Miscellaneous	Lump some	100.00
Total			1767.00 – 2067.00
Total cost			1767.00 – 2067.00

Income:

Fish species	Production	Unit cost (Taka)	Income (Tk)
Tilapia	25 – 30	90 / kg	2250 - 2700
Carps	4 - 5	80 / kg	320 - 400
Total income			2570 - 3100
Profit (per decimal)			Comments
Income (Tk)	2570 - 3100		Cost benefit analyses may vary to some extent because of the variation in the local price of input and market price of tilapia
Cost (Tk)	176 – 2067813 - 1133		
Profit = Income – Cost (tk)	τ		

In poly culture, the production of carps has been considered in calculation. In profit calculation, interest on investment and farmers' own labour have not been considered.

Economic analyses of vegetable culture on pond dyke

Calculation of cost benefit of vegetable culture

We have known earlier that crops should be selected based on the type of dyke. Again cost benefit varies based on the crops. Production costs of some crops are relatively very low like red amaranth and water spinach. On the other hand, production costs of some vegetables are relatively high like tomato and bitter gourd. Same way the income from different crops varies as well. Cost benefit analyses of some vegetables suitable for culture on pond dyke are given below –

1. Economic analyses of pit and vine vegetables (sweet gourd, wax gourd, ribbed gourd, bitter gourd, cucumber, bottle gourd and lablab bean) culture (per decimal)

Sl No.	Cost items	Quantity	Cost (Taka)	Comments
1.	Plastic rope (jangla / macha) and bamboo	1 kg and 1	300	Trellising
2.	Land preparation , transplantaion of seed / sapling and care	0.5 labour	100	Family labour along with 0.5 labour
3.	Seed / sapling	25 g	100	
4.	Fertilizer		40	
5.	Irrigation	3 times	60	
6.	Pesticide and other management		100	Poison bait / sex pheromone and other pest control
	Total cost		700	Family labour has not been considered
Income sector				
1.	Yield	60 – 100 kg	1200 - 2000	@ 20 Taka / kg
Total profit			500 - 1300	

2. Economic analyses of leafy vegetables (Spinach, water spinach / morning glory, coriander, stem amaranth, Indian spinach, lettuce) (per decimal)

Sl No.	Cost items	Quantity	Cost (Taka)	Comments
1.	Land preparation, Sowing of seed / sapling transplantaion	0.5 labour	100	Family labour along with 0.5 labour
2.	Seed / sapling	4 – 150 g	50	@ Tk 1000 /kg
3.	Fertilizer		50	The price of organic fertilizer has not been considered
4.	Pesticide and other management		50	
	Total cost		250	
Income sector				
1.	Yield	40 – 120 kg	600 - 1800	@ 15 Taka / kg
Total profit			350 - 1550	

3. Economic analyses of okra / chilli (per decimal)

Sl No.	Cost items	Quantity	Cost (Taka)	Comments
1.	Seed / sapling	12 - 30 g	100	
2.	Land preparation, Sowing of seed / sapling transplantaion	0.5 labour	100	Family labour if used will not be considered in analyses
3.	Fertilizer		80	Cow dung / compost Own (cost has not been considered)
4.	Irrigation	3 times	60	
5.	Pesticide and other management		60	
	Total cost		400	Family labour has not been considered
Income sector				
1.	Yield	40 – 50 kg	1200 - 1500	@ 30 Taka / kg
Total profit			800 - 1100	

Maintaining records

To verify the success and failure of running any business, record keeping is very important. Necessary record keeping in fish culture not only helps in economic analyses, it also provides future direction for the improvement of culture management. Therefore, from the very beginning to the end of the entire culture period, records on the following aspects should be maintained –

- Physical parameters of the pond
- Water depth
- Description of the activities during pond preparation and the expenses
- Fish seed collection, transport, stocking and the expenses
- Number of fry stocked
- Information on fertilizer application, kinds, weight and expenses
- Information on feed application, kinds, weight and expenses
- Sampling information
- Harvest quantity of fish, prawn, income etc.



There is no set rule for record keeping. Recording necessary information exactly is more important than the way of recording. Fish farmers can record necessary information by any method according to his/her own advantages. SCISA-BD project use a notebook for record keeping. Besides, by keeping records on the listed aspects, fish farmers can easily maintain breakdown of cost benefit in fish culture.

Some necessary measurement units used in fish culture

12 inches	=	1 foot
435.6 square feet	=	1 decimal
10.76 square feet	=	1 square meter
40.48 square meter	=	1 decimal
1 meter	=	3.281 feet
100 decimals	=	1 acre
247 decimals	=	1 hectare
10,000 square meter	=	1 hectare
1 inch	=	2.54 centimeters
35.31 cubic feet	=	1 cubic meter
1 cubic feet	=	28.317 liters
1 cubic meter	=	1,000 liters
1 kilogram	=	1,000 grams = 2.205 pounds = 1.07 ser
1 metric ton	=	26.7924 maund
1 gram	=	1,000 milligrams
1 liter	=	1,000 milliliters
1 ppm	=	1 milligram / Liter = 1 gram / cubic meter
Cubic feet		
35.31 × ppm	=	gram /milliliter

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