GROW OUT AND PRODUCTION

Module VI of 8

Grow out and production

Module VI

FOREWORD

The growing demand for fish in Malawi and the Southern African Development Community (SADC) region requires additional efforts by the governments to increase fish production from aquaculture. All Malawi's development policies (Malawi Vision 2063, Malawi Growth and Development Strategy III 2017-2022, National Fisheries and Aquaculture Policy 2016, National Aquaculture Strategic Plan 2021) emphasise the need to promote aquaculture development in order to enhance production from aquaculture to supplement the dwindling capture fisheries production and cannot satisfy the ever increasing demand for fish. The development policies also emphasise the need to pursue sustainable practices and climate smart technologies.

Up until now, there were many reference materials which extensionists from both government and non-governmental organisations have been using to train farmers in aquaculture principles and practice. These manuals, however, were not coherent, often providing conflicting recommendations and were not vetted by the Department of Fisheries under the Ministry of Forestry and Natural Resources as proper training materials for aquaculture. Hence, it is timely that this new aquaculture manual has been developed for use in the aquaculture practice. This manual will become a nationally recognised tool for training in aquaculture practice.
The target users of this aquaculture manual are extensionists from government and non-governmental organisations, fish farmers and trainers of these groups. The manual contains technical information as well as training plans to help the trainers to conduct training in an orderly manner.

The Ministry of Forestry and Natural Resources remains committed to foster the development of aquaculture in the country for nutritional and food security, income generation and job creation.

Yanira Ntupanyama, PhD.
Secretary for Forestry and Natural Resources

PREFACE

This Technical Manual for Trainers on Good Pond Aquaculture Practices has been developed to address the gap that existed when the country did not have a universal, nationally recognised manual as basis for training our extension agents, fish farmers and for use by non-government organisations engaged in the aquaculture sub-sector. This manual will be a reference material for guiding aquaculture practices in Malawi. Accordingly, the manual has been developed to support the implementation of the National Fisheries and Aquaculture Policy 2016 which highlights sustainable aquaculture development as policy priority number 2 and the National Aquaculture Strategy (2021-2029).

There are several challenges that exist in the aquaculture sub-sector that need to be addressed for the benefit of fish farmers and extension workers. The major challenges include: lack of harmonised approaches and information to guide all players in the value chain, inadequate supply and access to inputs i.e. quality fingerlings and feed, unavailability of market structures to aggregate production and measures to increase the resistance of the sector against risks related to climate change.

It is expected that this aquaculture manual will become the necessary tool for all actors along the aquaculture value chain mainly for technical know-how regarding aquaculture production. Where possible, trainers or users may be guided by the aquaculture experts from the Department of Fisheries under the Ministry of Forestry and Natural Resources.

Friday Njaya, PhD.
Director of Fisheries

ACKNOWLEDGEMENTS

The Department of Fisheries (DoF) in the Ministry of Forestry and Natural Resources is grateful to all stakeholders, too numerous to mention, who contributed to the development of the nationally recognized Technical Manual for Trainers on Good Pond Aquaculture Practices. The DoF acknowledges the financial and technical support from the Aquaculture Value Chain Project for Higher Income and Food Security (AVCP) funded by the German Federal Ministry for Economic Cooperation and Development (BMZ) and implemented by Deutsche Gesellschaft für Internationale Zusammenarbeit GmBH (GIZ).

The Department also acknowledges the efforts and technical contributions from all the government officers, academicians, technicians and practitioners who took part in the development of this manual. Thanks should also go to the team that finally edited the manual.

Special recognition and gratitude are extended to the GIZ Food and Nutrition Security Program (FNSP) for contributing the chapter on nutritional benefits of fish and all individuals who were involved and contributed in the development of this manual.

INTRODUCTION

For improved fish growth and increased fish production, critical preparatory and pond management steps have to be carried out. Pond preparation before fish stocking is the first step for improved fish growth. These include draining the pond for weed and mud removal and lime it, fertilizing the pond for availability of natural feed for the fish. Stocking the pond with quality fingerlings at the recommended rate basing on the level of management follows. Continuous and excessive breeding of tilapia in culture ponds, especially at low stocking densities is one of the draw backs. This phenomenon often results in overpopulation and low production of marketable fish, mainly due to the competition for food and space. Controlling the reproduction and recruitment of tilapia in ponds is therefore essential for successful and profitable tilapia culture. All pond corrective measures to ensure the improved growth of the fish have to be followed. These include daily monitoring of water quality, feeding the fish with right feeds, right quantity and at the right time. Sampling of the fish to monitor on growth and to make necessary feed adjustments has to be done. Fish harvesting as a corrective measure has again to be practiced as a prolonged culture of the fish will lead to an economic loss.

CONTENTS

Pond Preparation

1

Introduction

A Grow-out pond will need careful preparation before it is stocked with fish seed. A well prepared pond will ensure good fish growth. Possible parasites and other small aquatic insects would be minimized. The main four important steps in pond preparation include draining and sun drying the pond, applying lime, filling the pond with water and fertilizing the pond. All possible ways of preventing and controlling predators are also put in place.

Aim

The aim of this chapter is to improve participants' knowledge and understanding of pond preparation practices and improve their skills in calculating lime and manure necessary to be applied or added in ponds.

Objectives

Participants know
How prepare pond ready for stocking
How to lime the pond
How to fertilize the pond in readiness for stocking
Importance of pond liming
Importance of pond fertilizing

Acquired skills
Calculating lime amounts for pond application
Calculating different fertilizers for pond application

Acquired attitudes
Pond preparation before fish stocking improves fish growth

Relevance to fish production
Fish farmers must prepare their ponds before a new set of fish seed is stocked. This helps to promote the productivity of the pond, kill unwanted fish seed and parasites.

Session Overview: This chapter has one session which is sub divided looking at maintenance of the pond, application of lime and pond fertilization. Their importance have also been outlined
Materials: Flip- chart paper, markers, study notes, posters, lime, manure
Mode of delivery: Lectures, group discussions, practical
Duration : 90 minutes

Maintenance of the Pond

Is your pond producing less than it should provide? One of the common causes can be insufficient nutrients to support fish growth, especially in semi-intensive and extensive pond systems. Pond preparation is a key element in any pond production system. Pond preparation involves liming and fertilization to provide an ideal environment for tilapia and catfish to grow. Some of the steps you need to follow include the following;

1.1 Draining, drying the pond and de-silting

The first step in pond preparation is to totally drain your pond after a harvest, removing any sludge from the pond bottom along with any mortality that may have occurred. Thereafter, you should let the pond dry for 10 to 14 days before or until the bottom is cracking dry before stocking. Exact period to when a period can dry will depend on the weather conditions of an area, water source (diverted or underground) and type of pond (whether drainable or un-drainable). Drying helps oxidize and break down chemicals and their residues in the mud, and eradicates all wild fish, remaining fish from the last harvest, insects and other predators from the pond. If complete draining and drying is not possible or very costly, it is recommended to use one of the commonly used pesticides, e.g. rotenone, tea seed cake or potassium cyanide on the remaining water in the pond.

1.1.1 Weed removal

Slash the pond bottom and the dykes to remove all the weeds. Weeds can be a hiding place for predators, parasites and other disease causing organisms. De-silt the pond so as to maintain the appropriate pond depth and shape of dykes. Removing of excessive mud helps in preventing turbidity in the pond. Cracks and holes in the pond dykes are filled in the process to prevent seepage and breaking of the dykes. Cracks and holes can be hiding places for predators too.

Fig 1.1: A harvested & drained pond with mud

Fig 1.2: A dried pond ready for pond mud removal

1.1.2 Maintain inlets and outlets

Water inlets and outlets are well maintained to ensure good water quality is being added to the pond and to prevent fish escapes through the outlet or over flow pipes. All ditches and screens must be cleaned.

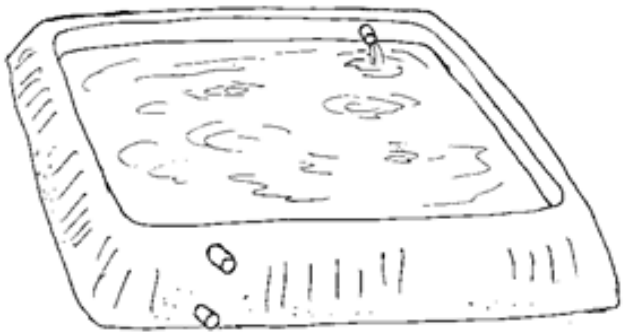


Fig 1.3 Cleared water Inlets and Outlets

Fig 1.4 Clearing pond dykes

Fig 1.5 Maintaining pond dykes

Fig 1.6 Clearing pond area

1.2 Application of Lime

1.2.1 Importance of pond liming

After draining, drying and de-silting the pond, before ponds are stocked with fish, they have to be limed. Liming will help improve pond soil quality, provides CO2 for photosynthetic organisms and will help combat parasites within the pond. If ponds cannot be dried out completely, they should still be treated to eliminate any predatory fish or other pests. One common practice is to use agricultural lime which is relatively cheaper and abundant. The lime should be applied evenly across the whole bottom. This can be done by manual broadcasting It is not necessary to disc the lime into the soil; however this will improve its effectiveness. The liming process will remove the majority of unwanted organisms from the pond and improve the effectiveness of fertilization. After the lime has been applied, you can fill your pond to approximately half to two thirds. Thereafter, fertilization can begin.

1.2.2 Why Lime your fishpond?

If your pond has been applied with manure or fertilizer and the pond does not respond or bloom to the effects of the manure or fertilizer (i.e. green water colour due to the growth of phyto and zooplankton) within seven

days, the problem could be that the pond water is low in alkalinity (is acidic) and thus requires liming. Clay soils are often acidic and because ponds are commonly constructed on these soils, they have low alkalinity and hardness and so require liming. If your pond is in a dry area or receives little rainfall, you may not need to apply lime to it because the pH is already high. Note you can buy simple cheap test papers or slightly more expensive water test kits which will tell you how alkali or acid (measured as pH – 1 very acid, 12-14 very alkali) your soil and also your water is. The water test kits will also allow you to measure other key water quality parameters. Liming is applied in a pond to;

Improve the structure of the soil in the pond
Improve and stabilize water quality
Facilitate manure's ability to efficiently increase the availability of natural food.
Unlock nutrients from soils
Reduce toxicity of harmful compounds including disinfecting the environment
Modify the total alkalinity of water in a pond
Supply calcium (as Ca2+) and carbonates thus increasing carbon dioxide in water
Prevent wide fluctuation of pH by establishing a buffer of CO2 -CHO- CaCO3.
Counteract toxic effect of excess magnesium, sodium and potassium ions.
Act as prophylactic by killing unwanted fish, bacteria and other fish parasites.

Types of liming materials

Three types of lime that could be used in the pond
Agriculture lime or powdered limestone (the kind used by gardeners),
Quick lime
Hydrated lime

These limes differ in strength so have different application rates.

Rates of application:

Limestone (powdered): 1000–2000 kg/ha or 50 to 200g per m2
Quicklime: 400 kg/ha or 20 to 60g/m2 of pond area
Hydrated lime: 600 kg/ha.

Note: If the soil at the bottom of a pond is too acidic, i.e. below pH 6, the amount of lime needs to be doubled.

Methods/ Types of applying lime
Lime should be broadcasted on dry pond bottom or pond with partially filled with water.
In a pond with water about 0.5m depth, apply lime at the rate of: 200g/m2.
Pond with little water about 10cm depth: 100 g/m2.

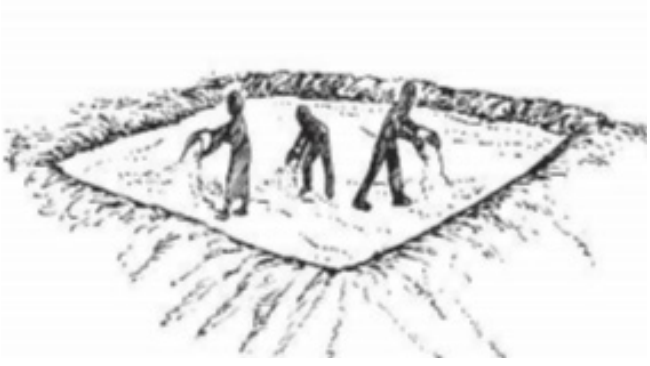


Fig 1.7 Lime application in a dry pond

Fig 1.8 Lime application in un-drainable pond

Record keeping is a good pond management practice. Before, during and after applying lime in ponds, records must be written. In pond liming, records for the following things should be made

Source of lime and type of lime
Date when procured
Price per kg or Unit (quantities must be specified)
Transport costs (amount)
Labor costs involved during transportation (cash, in-kind or own labor)
Application rate in pond and pond size
Labor costs involved during application in ponds (cash, in-kind, own labor)

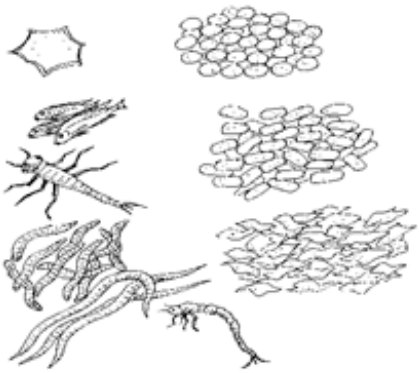
It should be noted that these costs will help in calculating profit and loss after each production cycle. If products have been bought in bulk for several ponds, amount used per pond should be recorded as it will help to calculate profit basing on each particular pond.

1.3 Pond Fertilization

1.3.1 Pond fertilization

Fertilization is another step in preparing your pond. It provides nutrients to the water, which stimulate the growth of algae and other organisms, such as insects that provide a nutrient source for your fish. The purpose of fertilization in open pond aquaculture is to provide exogenous elementary nutrients (carbon, nitrogen and phosphorus) to enhance natural food in the water. More natural food means faster fish growth, and less supplementary feed will be added. Natural food includes tiny plants called phytoplankton, which are nearly buoyant in the water column, giving the water a greenish color. Algae can be consumed directly by fish or be food for zooplankton (tiny animals and water insects), which the fish can also eat. Primary productivity in a pond can be augmented by increasing the availability of nutrients using fertilizer. Fertilizer increases nutrient concentrations to enhance plant growth. Tilapia feed on phytoplankton and zooplankton, as well as any supplementary feed added to the pond. When fertilizing your pond, you can use either inorganic or organic fertilizers.

Apply chemical fertilizers after filling the pond as this is the cheapest method of enhancing phytoplankton as natural food and has been very common around the world, which is indicated by the green colour of the water. Green water contains freshwater algae, which are a good source of protein and several vitamins, e.g. Chlorella and Spirulina contain 47.2% and 58.6% CP on a dry matter basis, respectively. As tilapia consumes plankton, they can be raised in a green water system cheaply. The suitable range of chlorophyll-a in the hatchery water is 100–300 mg/m3 of water. Organic manures, e.g. chicken and pig manure, and chemical fertilizers are commonly used. Animal (chicken) manure is normally applied at the rate of 500–2000 kg/ha/year, depending upon the fertility of the soil.



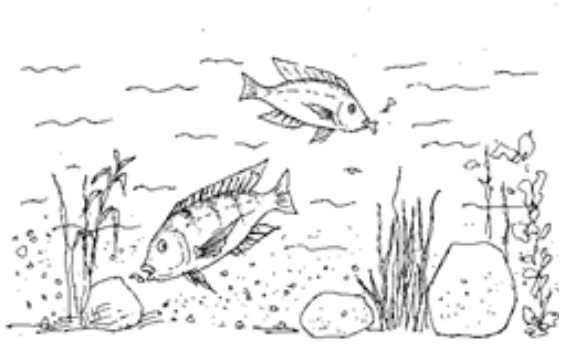


Fig 1.9: and Fig 1.10 Zooplankton presence and phytoplankton due to pond fertilization in ponds

There are two main types of fertilizers that can be used.

Natural organic fertilizers include manure of animals such as chickens, cows, goats, pigs, or horses. Inorganic fertilizers may be single element fertilizers that contain a single nutrient like nitrogen (in ammonium sulfate, urea) or phosphorus, incomplete fertilizers that contain two nutrients such as nitrogen and phosphorus, or complete fertilizers that contain the three important plant nutrients, nitrogen (N), phosphorus (P), and potassium (K).

Methods /types of fertilizing

Fertilising method depends on the type of fertilising agent used. If you are using composite manure, the heap of organic matter should be placed in an enclosure on the side where you have the inlet. If you are using inorganic fertilizer, mix fertilizer in bucket and stir using a stick until all the fertilizer has dissolved. Apply the fertilizer solution to the pond. For big ponds, fertilizers should be applied from different locations to get an even distribution.

When the pond is not properly manured, it may negatively affect the water quality leading to stress and occurrence of diseases.

Fig 1.11 Hanging of submerged manure bag on a pole Fig 1.12 Animal house on pond dyke for manure

1.3.4 Application Rates during production period (top dressing)

Apply inorganic fertilizer at the rate of 0.25kg per 200m2 every week.
Apply chicken manure at 50g/m2 in the pond.

However, the use of organic manure has been an issue in terms of health hazards, because chicken and pigs are fed with high levels of growth hormones and antibiotics. At the same time, animal manures have very low N and P concentrations. They are bulky and difficult to transport if they are to be procured from outside. On the other hand chemical fertilizers are nutrient dense and therefore easy to handle. They also create better water quality, thus ensuring higher survival of the fish, and they enhance plankton growth. The process will take about 1 week, after which time fish can be stocked. Chemical fertilizers are considered safe and available even in rural areas for the use of crops and vegetables, e.g. urea and TSP or DAP. They are very common and produce green water rapidly. Urea contains 46% nitrogen (N) while TSP and DAP contain 20% phosphorus (P). Weekly application of 28 kg N and 7–14 kg P/ha, which means about 60 kg of urea and 30–60 kg TSP/ha, is recommended. These fertilizers should first be dissolved in water in a bucket before spraying into the pond water. If not dissolved, fertilizers will sink and stay at the bottom, attached to the mud. Ponds need to be fertilized weekly after that, using the same fertilizers at the same rate. However, depending upon the greenness of the pond water, the rate can be altered. Calculating how much fertilizer is needed can be done as follows:

Amount of urea (kg) per week = daily rate/% of N in urea × 7 days = 4/46% × 7 = 61 kg/ha

Amount of triple superphosphate (TSP) = daily rate/% P in TSP × 7 days = 1 kg/20% × 7 = 35 kg/ha

If a farmer has a pond of 1000m2, he or she can calculate the amount required for weekly application to fertilize ponds:

Amount of urea (kg) = 61/10,000 × 1000 = 6.1 kg
Amount of TSP (kg) = 35/10,000 × 1000 = 3.5 kg
The amounts of other alternative fertilizers can also be calculated in a similar way using the percentage of nitrogen and phosphorus in them. For example, if NPK (16-20-0) fertilizer is available, farmers may choose it because it contains both N and P. First of all, the requirement to supply adequate P is calculated as:

Amount of NPK fertilizer required = 1 × 100/20 × 7 = 35 kg/ha/week

As it does not fulfill the N requirement, urea has to be added. This is calculated deducting the amount supplied by NPK, as shown below:
Urea = [4 × 7 – (35 × 0.20)] × 100/46 = 45.7 kg

This means the amounts of NPK and urea needed are 35 kg and 45.7 kg, respectively. The amounts of other alternative fertilizers such as DAP can also be calculated in similar way. As DAP has 18% N and 46% P2O5 or approximately 20% phosphorus, the DAP requirement for P is calculated first. Then the amount of nitrogen supplied from that amount of DAP is deducted from the amount of urea to be worked out.

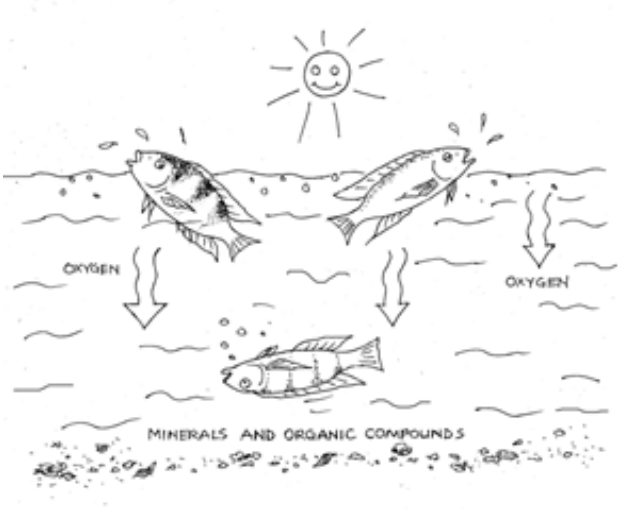


Fig 1.13 and Fig 1.14 Fish mortalities due to over fertilization of ponds and corrective a measure

As a good aquaculture practice, record keeping has to be maintained at all levels of fish management. Before, during and after applying fertilizer or manure in ponds, records must be made. In pond fertilization, records for the following things should be made

Source of fertilizer or manure (type of fertilizer or manure)
Date when procured
Price per kg or Unit (quantities must be specified)
Transport costs (amount)
Labor costs involved during transportation (cash, in-kind or own labor)

Application rate in pond and pond size
Labor costs involved during application in ponds (cash, in-kind, own labor)

It should be noted that these costs will help in calculating profit and loss after each production cycle. If products have been bought in bulk for several ponds, amount used per pond should be recorded as it will help to calculate profit basing on each particular pond.

1.4 Pond water filling and water quality monitoring

Fill water to some 20 cm to let mineralization of organic matter take place that cause plankton bloom. After 1 week complete filling pond water to capacity. Before stocking fish, measure and closely as the quality of the water we use to grow fish matters greatly. In water, fish gets food and oxygen for their survival and growth. The most important water quality parameters in tilapia and catfish farming are temperature, DO, salinity and pH. Remember to analyze other chemical properties of the pond water such as ammonia, nitrite and nitrate, dissolved solids, phosphorus and conductivity. Secchi disc visibility should be measured to assess the plankton growth in pond water.

Fig 1.15 Avoid turbid water into ponds

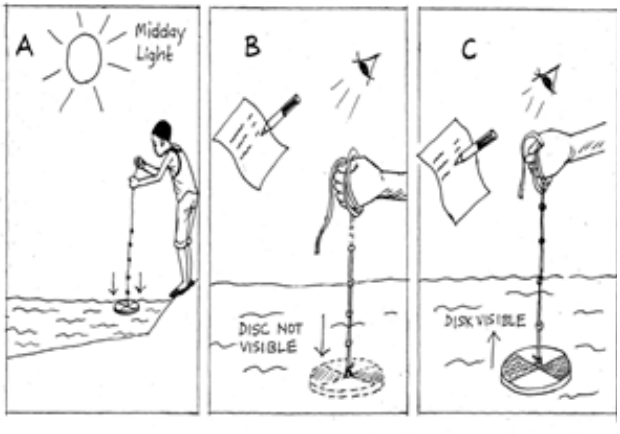


Fig 1.16 Measure water turbidity using a Secchi disc

Summary

For improved fish growth and increased fish production, critical preparatory and pond management steps have to be carried out. Pond preparation before fish stocking is the first step for improved fish growth. The four important steps in pond preparation are

Drain and sun –dry: Ponds should be drained and dried for at least 2 weeks or until cracks can be seen on the pond bottom. Drying helps oxidize and break down chemicals and their residues in the mud, and eradicates all wild fish, remaining fish from the last harvest, insects and other predators from the pond. If complete draining and drying is not possible or very costly.

Apply lime: After draining the pond, lime should be applied to the pond bottom. This can be done by manual broadcasting. This is the recommended practice in aquaculture as it neutralizes the pH of the pond and also kills disease-causing organisms. The amount of lime depends on the type and quality of soil and its ph.

Fill the pond: Before filling the pond, ponds and dykes need to be cleared out. Make sure that the

water source is reliable and of good quality.

Fertilize the pond: Apply manure or chemical fertilizers after filling the pond as this is the cheapest method of enhancing phytoplankton as natural food which is indicated by the green colour of the water. Green water contains freshwater algae, which are a good source of protein and several vitamins.

Stocking of Fish

2

Introduction

This chapter looks at stocking fish seed (fingerlings) after pond preparation. The carrying capacity of the pond and level of management determines the stocking rates. The stocking rate will also vary according to the common fish culture practices in the surrounding area and the financial capability of farmers. For example, if the farm is using formulated feeds and has a stable supply of water, stocking rates can be increased. Stocking rates vary depending on the quality and availability of water, soil and capital as well as the desired marketing size of the fish.

Stocking rates also vary between different areas of farming and farmers in the same agro-ecological zone. For example, fish farmers in the cooler areas like Nchena chena in Rumphi, Kaphuka and Bembeke EPA's in Dedza and EPAs of Nachisaka, Nalunga and part of Chabvala in Dowa which hits as low as between 5oC – 10oC in the cold season, prefer to use Coptodon rendalli and or have deeper ponds. Sources of and accessibility of fish seed (fingerlings) in other areas, management strategies and water availability also affects fish stocking and stocking densities.

Aim:

The chapter aims at improving participants' knowledge and understanding in the concepts of fingerling transportation, fish stocking and its effect on fish production. Skills in pond size measuring, fish seed stocking density calculation, fish transportation and stocking after traveling with the seed will be improved

Objectives

Participants know
Good sources of fish seed
Good fish handling practices
Methods of transporting fingerlings
The right time to transport and stock fish seed in the pond
Know appropriate number of fingerlings to stock
Understand the impact of stocking density

Acquired skills
Measure pond size
Calculate fish stocking density
Fish seed stocking to prevent mortalities
Pack fingerlings in plastics

Acquired attitudes
Quality fish seed and right stocking densities leads to improved fish growth and yields

Relevance to fish production
Fish farmers should not recycle fish seed but stock their ponds with new seed if they are to improve fish yields
Session Overview: This chapter has one session which is sub divided looking at importance of aquaculture in Malawi and its history, status of aquaculture in Malawi and its nutritional importance

in the country

Materials: Flip- chart paper, markers, study notes, posters, tape measure, ruler, oxygen cylinder, fingerlings, water, buckets, scoop nets, plastic papers, rubber bands, hand nets
Mode of delivery: Lectures, group discussions, practical
Duration : 90 minutes

2.1 Live fish handling and transportation

Fish handling is one of critical aspects as it stresses fish thereby reducing growth and increases incidences of parasites and diseases. As water temperature can vary significantly during the day, handle fish early in the morning or late in the afternoon when temperatures are low so as to minimize fish losses. It is even better to handle fish in a cool day. Never expose fish to the direct sunlight as this will stress and lead to fish mortalities.

2.1.1 Corrective measures when handling fish

- Make sure that all fish handling materials are properly washed or cleaned with clean water.
- Conduct activities in as fast and careful manner as possible so as to reduce the handling time
- Avoid handling fish in rusty materials as the rust compromises fish health
- Handle fish gently with a scoop net and not with hands
- Sedate the fish with anesthesia if you are to handle them for some time or when you would like to conduct some operations on them. (Many chemicals now are prohibited for use in fish as some are carcinogenic). (Use of clove as natural anesthesia is now gaining ground).

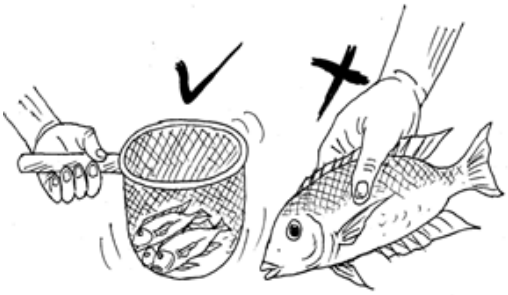


Fig 2.1 Use of hand net for handling fish

Fig 2.2 Holding fish in a hapa before handling them

2.2 Ways of transporting fish seed

2.2.1 Transporting fish in household containers

This method is ideal for the movement of fish from one pond to another or to a neighboring farm. The buckets should be covered with a wet sack to keep the water cool by preventing direct sunlight from reaching it. The number of fish per bucket depends upon the size of the fish and the volume of the bucket and temperature.

- This method is ideal for the movement of fish from one pond to another or to a neighboring farm. The buckets should be covered with a wet sack to keep the water cool by preventing direct sunlight from reaching it. The number of fish per bucket depends upon the size of the fish and the volume of the bucket and temperature.
- Relationship between the fish sizes, transportation time and temperature is shown in table 1.
- Number of fish transported in the containers depends on size of the fish.
- Transport fish at water temperature of between 250C and 30oC.
- Buckets are used to transport fish on short distances
- Fish in buckets can be transported by bicycles and motor vehicles.

Fig 2.3 Covered tins with leaves or hessian sack

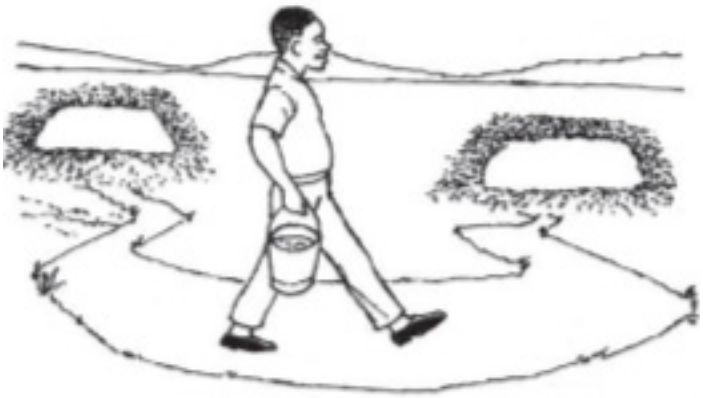


Fig 2.4 Transporting fish in plastic tins

Fig 2.5 Always keeping fish under shed

Fig 2.6 Checking water temperature whilst traveling

Fig 2.7 & 2.8 Transporting live fish on foot in tins

Fig 2. 9 Transporting live fish on a bicycle

2.2.2 Transporting fish in plastic bags - Packing fish in plastic bags (bagging)

The art of putting fish in plastic bags (bagging) correctly is very important. This therefore needs a good preparation as once the bag is sealed, the fish will need to survive without being stressed till it reaches the final destination. Therefore key considerations are oxygen, temperature and water quality.

Dissolved oxygen, is the most limiting factor for transporting fish. The amount of available dissolved oxygen is limited by the bag size and the amount of fish biomass load in the water. It is important to fill our bags with 1/3 water and 2/3 air. When transporting live fish for just a few hours, atmospheric air and controlling temperature, and limiting biomass in the bags are adequate for success.

Water quality, we need to ensure that where our fish is kept the water quality is correct. Good water quality must be maintained from netting fish to the time when they are being bagged. Clean water without suspended solids must be used during bagging. We should remember that once fish has been put in the bag and the bag sealed water quality parameters will begin to change. As the fish respire they will release carbon dioxide (CO2). High amounts of CO2 will drop pH. If the KH is at least 60ppm (3 degrees) the pH will be more stable. Ammonia and nitrite should be zero.

On temperature, the water temperature in the bag can change quickly and as fish are cold-blooded, they cannot regulate their body temperature. If the temperature deviates beyond the desired range they will become stressed. If it raises or drops too much the can die. The higher the temperature, the higher the respiration and the demand for oxygen increases and more CO2 and ammonia are released, deteriorating water quality in the bag.

Fish seed can be transported using various methods, but using polythene bags (5l capacity) is the easiest and most popular method. As counting of fry is a time-consuming and tedious job, three batches of 500 or 1000 seed are counted and or weighed. The average number or weight is used to estimate the remaining seed and transferred to each bag.

Another way of estimating number is by volume; a small cup can be used to record the samples of 500 to 1000 fish seed and the same volume can be used for the rest of the packing process.

Fig 2.10 Preventing fish from direct sunlight

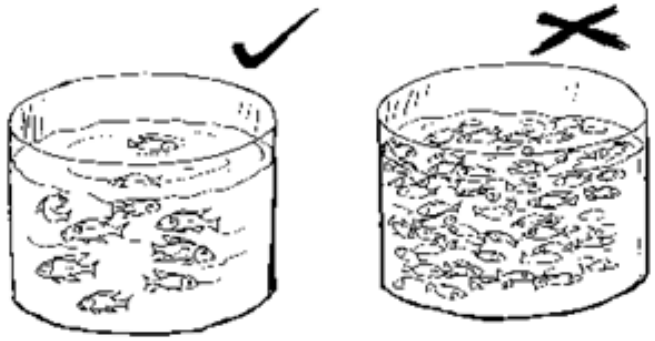


Fig 2.11Don't congest seed during transportation

The process of putting fish in bags: The steps of the method used widely by most of the tilapia hatchery operators are:

Step 1: Use two plastic bags for extra strength.

Step 2: Fill the inner bag with 2.5 – 3.0l of clean water.

Step 3: Estimate the fish seed by counting 500 or 1000 seed and use a cup of the right size to count by the number of cups for required seed order.

Step 4: Put in 1000 for a distance of less than 12h total transport time. But number should be only 500 if the transport time is over 15h.

Step 5: Add 3l of oxygen to each bag from a cylinder so that the plastic bag remains inflated.

Step 6: Use a rubber band to tie the neck of each plastic bag

Step 7: Float the plastic bags on the surface of the water in tanks or ponds, under shade (Fig. 2.12).

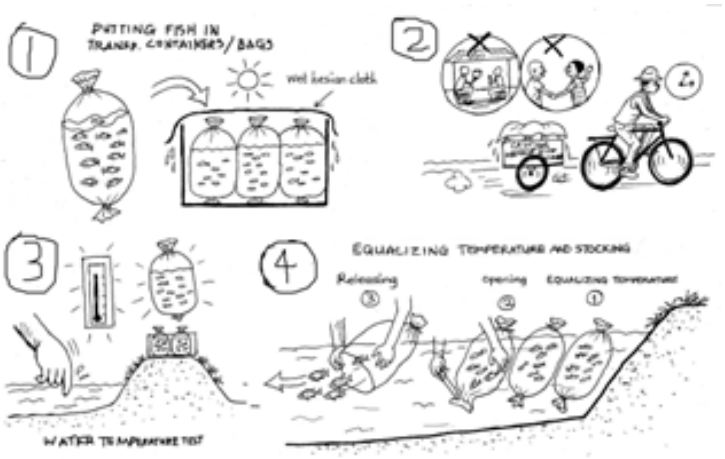


Fig 2.12 floating a bag of fish seed before releasing prevents mortalities

Step 8: If transportation is to be done by bicycle or motorbike, put each plastic bag with seed in an empty sack of feed or plastic tin to keep them safe.

Step 8: If transportation is to be done by a car, pick-up or truck, cover the bags with thick cloth or hapa, or the same sacks that are holding the bags and spray water on top of the plastic bags with fry. After transporting for a few hours, stop and spray water on the cover again. This can be done several times if travelling a long distance.

Remember, fish transportation should be avoided during the daytime, especially in hot and dry seasons. If necessary, plastic bags should be covered with thick sacks. Water can also be spread over the bags to keep temperatures down before and during transportation.

Fig 2.13 and Fig 2.14 Fish packaging in oxygenated plastic bags tied with rubber bands

2.2.3 Transporting fish in tanks

Tanks can be used for transporting fish. Fish could be transported in tanks of 1m3 in volume. The open side is covered with Hessian sacks and tied around with a rope. The sack protects the tank from direct exposure to the sun. It is advisable to minimize heavy shaking of water in the tank when the vehicle is in motion as this stresses fish. Reduce speed to avoid instant breaking. Check and change water along the way if you observe that some fish are coming on the surface

Although tanks are used, it should be noted that oxygen consumption is higher in tanks if the fish are young because younger fish consume relatively more oxygen (for the same biomass as larger fish). Stressed fish and higher temperatures will result in increased oxygen consumption. Oxygen consumption in the tank decreases if the water temperature is lower or if the fish are tranquilized during transportation. To have additional oxygen in the tank system, oxygen is diffused, in the form of small bubbles, from the bottom of the tank into the water. The smaller the bubbles, the larger their relative surface area, and the more oxygen is dissolved. Smaller bubbles also move more slowly to the surface, which transfers oxygen into the water more effectively.

When using an oxygen cylinder to supply oxygen in the tank, sometimes the flow of oxygen is uncertain because of the following:

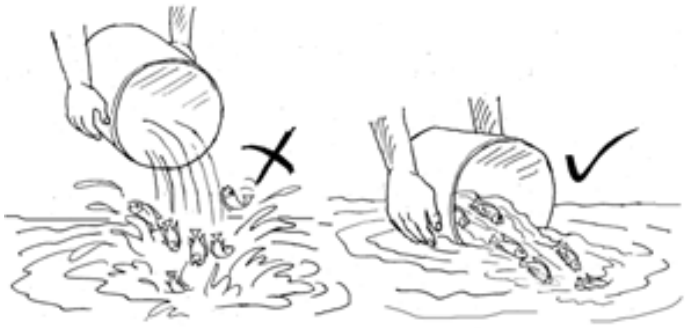
- Flow of oxygen can be changing due to shaking of the cylinder during transportation; this can result in a faster flow and therefore leading to oversaturation of oxygen. This affects the fish and they can die a few days later from gas embolism (a blockage of blood supply caused by air bubbles in a blood vessel or the heart).
- The cylinder can empty too fast because the driver cannot see it when driving resulting in fish mortalities.
- The flow of oxygen can be reducing due to reduced pressure in the cylinder. This may result fish mortality
- If the cylinder has no gauge, a significant amount of oxygen can be wasted and killing fish on the way.

2.3 Releasing fish after transportation

Remember to condition fish gradually to a lower temperature, at the rate of 20 minutes for every 5oC. Warm water fish such as tilapias should not be transported in water cooler than 15oC.

- Difference in water temperature in the tank and pond causes shock to fish.
- Submerge transporting container for 10 -15 minutes in the pond before releasing the fish into the pond.
- The water need to be moved gradually from the pond to the tank until the temperature is reasonably close to that of the pond and let the fish flow out voluntarily into the pond.
- Remember not to feed your fish on the day you have stocked them

Fig 2.15 Condition fish before releasing them Fig 2.16 Don't leave fish in an empty tin



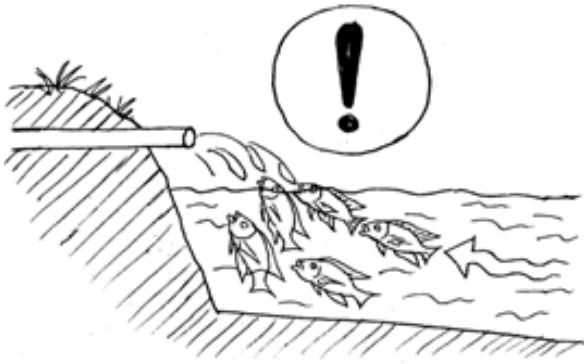


Fig 2.17 Good practice on releasing fish into pond Fig 2.18 adding fresh water if possible

2.4 Sources of fingerlings

2.4.1 Certified Hatcheries

When planning to stock your ponds, ensure you obtain the fingerlings from the right sources like recognized hatcheries. Fish hatcheries are places for artificial breeding, hatching, and rearing through the early life stages of fish. They are a reliable source of fish seed. Hatcheries produce larval and juvenile fish, primarily to support the aquaculture industry where they are transferred to on-growing systems, such as fish farms, to reach harvest size (refer to chapter on fingerling production). In Malawi, you can obtain fingerlings from Government owned hatcheries which includes;

Northern Region

Mzuzu Fisheries
Ntchenachena and Mphompha (Rumphi),

Central Region

Bunda (Lilongwe)

Southern Region

National Aquaculture Centre in Domasi and Chinseu (Zomba),
Kasinthula (Chikwawa),
Chisitu (Mulanje)
Kunenekude (Mwanza).

Fingerlings can also be sourced from other localized and certified private hatcheries who are spread across the country. It is advisable to stock new fingerlings for each and every production cycle to ensure good fish growth. It is not a good aquaculture practice to recycle fingerlings that remained during harvesting as stunted fish which may look like fingerlings can be stocked.

2.4.2 From the wild

Another source of fingerlings can be from the wild, however there is little or no guarantee that adequate number can be captured and stocked in the time corresponding to optimum production conditions. Stocking of fingerlings from rivers should be checked as different species can be stocked and also the fish can be of different ages and sizes which might compromise their growth.

2.4.3 From the own ponds

A proper fingerling breeding arrangement can be made at one's farm. A number of ponds can be used for fingerling production; some for fry/fingerling nursing and some for grow out production. This setup is common amongst farmers who are far from well-established fingering production centers. Having your own fingerling production system helps to minimize fingerling procurement costs.

2.5 How to measure pond size

2.5.1 Pond size measuring

Pond area is usually measured as area used for rearing fish. In most cases, ponds are rectangular in shape. Measurements are taken on the length and width of the ponds by using pacing or by using measuring tape. Some computer based applications are also used to calculate area.
Area of the pond is thus calculated as follows;

$$A=L*W$$

Where a: A = area of the pond
L= Length of the pond
W= Width of the pond

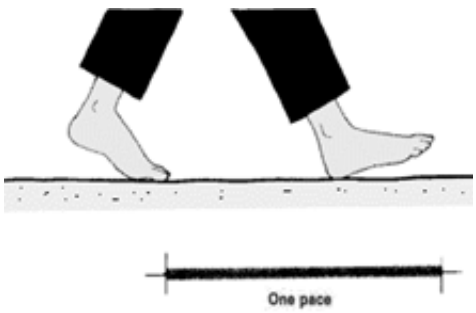


Fig 2.19 Pacing method

2.6 Determining the stocking size, density and impacts of stocking density

2.6.1 Stocking density

Stocking density is defined as the number of fish seed (fingerlings) stocked per unit area or volume. Production costs will increase with increasing stocking density. If fish are stocked at higher densities, then the type of feed will be determined by fish price. For successful grow-out, it is necessary to stock recently produced fry or seed (fingerlings) and not the stunted fingerlings from a previous crop that would breed early and cause overpopulation and stunting of stocks.

All-male stocks eliminate many of the problems of tilapia culture. They can be grown to a larger size of 400–600g weight to suit consumer acceptance. The longer grow-out period is compensated by the higher prices that large tilapia fetch in the market. Stocking densities of hybrid or all-male populations depend on the level of inputs and management. At even low stocking densities of 3000–5000 per ha, with supplementary feeding of protein-rich feeds, individual weight increases of up to 3–5 g per day have been recorded. There is an inverse relationship between stocking density and individual fish growth. The farmer should carefully identify his target consumer (i.e. he or she should decide whether to produce a higher yield but smaller fish or a lower yield with larger fish size). And with better pond management and stocking density, the annual production/ha can reach 10 Mt or more. Over-wintering of fry during the cold season and stocking in open ponds during the colder periods is a common practice in other agro-ecological zones and it has to be enhanced to promote seed availability.

As a good aquaculture practice, record keeping has to be maintained at all levels of fish management. Before, during and after fish stocking, records must be made. In fish stocking, records for the following things should be made

- Source of fingerlings, name of species and size at stocking
- Date when fingerlings were bought and stocked
- Price per fingerling and total cost of all fingerlings
- Transport costs (amount)
- Pond size where fish are stocked
- Stocking density (how many fish per meter square)
- Observed mortality after stocking

Recording all these parameters will help in following good fish management which will include right amounts of feed being given to the fish. It will further help the farmer in calculating profit and loss after the production cycle.

2.6.2 Example of stocking density

Examples of stocking density in relation to farmers' resources

A farmer's choice of the stocking density will depend on the production systems that one follows. These production systems depend on levels of intensification which are Extensive, Semi- intensive and Intensive production systems.

- **Extensive production system**

Under extensive production system or culture conditions, fish depend exclusively on natural food, through fertilization, while both natural foods and supplemental feeds are normally used in semi-intensive farming systems. Farmer uses animal manure, compost manure or inorganic fertilizers. Under this system, the ideal stocking density is 1 fish /m2

- **Semi-intensive production system**

Semi-intensive production system (SPS) or Semi-intensive culture (SIC) is simply the production of fish, and other aquatic animals, using natural food, through pond fertilization, or fertilization and supplemental feeding. In other words, SPS or SIC is a means of producing low-cost fish, through low production inputs, which contributes to hunger alleviation and food security, especially in rural area. The farmer in this case, feeds the fish supplementary feed in addition to the manure. In Malawi the common supplemental feed used are brans in form of maize bran, rice bran and sometimes wheat bran. The recommended stocking density range is from 2 to 3 fish per m2

- **Intensive production system**

Intensive production system is simply the employment of high stocking densities of cultured species ranging from 5fish/m2 and can even go higher than 10fish/m2, in order to maximize the production with the minimal use of water. Such systems depend exclusively on artificial feeding and water reuse and/or exchange. Intensive systems yield high production, ranging from 100 to > 500 Mt/ha/year (Muir et al., 2000). However, they require high capital and operating costs as well as high levels of technology and management tools. Therefore, fish farmers should fully consider a steady flow or availability of quality water, feed, aeration and awareness on the environmental impact of the system.

2.6.3 Example of calculating stocking density for semi intensive production system

Assume the farmer has 400 m2 of ponds and would like to engage in intensive fish production and intends to produce 6 tonnes per Hectare. The farmer has fenced the ponds and employed a guard to ensure that there is minimal predation and theft. The market is looking for fish with table size fish with average weight of 200g.

If expected total weight at harvest (W) = (6 tons/Ha) i.e. 0.6 Kg/m2
a=90% (i.e. 0.9)
w=0.25 Kg
N=W/ (w ×s) =0.6/ (0.2×0.9) =3.33 fish/m2)

Number of fish stocked in the pond will be
400 m2 * 3.33 fish/m 2 = 1,332 fish

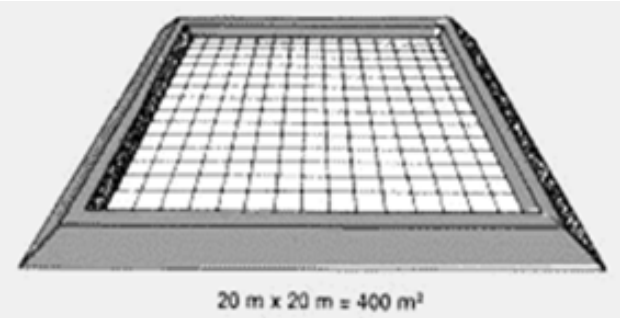


Fig 2.20 calculating a pond area

2.7 Impacts fish stocking density

Fish stocking density of the pond will affect water quality, fish growth and yield. When there is low stocking density (under stocking), most of the feed will not be eaten and will be wasted. The wasted feed will increase cost of production as very little of the feed will be consumed. The unconsumed feed will decompose leading to oxygen depletion. This will result in stressful condition of the fish that result in slow growth. Increased carbon dioxide will lead to formation of acidic condition. Acidic conditions are stressful to fish and make fish to be susceptible to diseases.

On the other hand, high stocking density will lead to reduced space, increased oxygen demand, and competition

for food. This will lead to stressful condition and lead to stunted growth. This is worsened if there are young recruits into the pond. These recruits create competition for food, space and oxygen demand. In addition, the increased population increase wastes in form of ammonia that result in deterioration of water quality.

Overwintering is a common practice in agro-ecological zones where winter temperatures are generally below 20°C, in which fish do not eat and grow normally. The main objective is to save the fry/fingerlings during these cold season periods. Overwintering of fry/fingerlings can be done in several ways: using warm water from a heating facility or geothermal water, greenhouses or plastic coverings for insulation, and stocking in deep ponds and tanks, or deep hapas in ponds. The former methods are cost intensive although survival is usually higher. The most popular overwintering method used by farmers in some parts of Malawi (where winter temperatures can be around 12°C) like some of parts Dowa, Ntchisi, Dedza and Ntcheu in Central Region, most parts of northern region and some parts of Zomba, Mulanje and Thyolo in southern region, is stocking seed in deep ponds. This method can be summarized as follows:

- A pond is constructed in a position where the maximum light intensity can be received.
- The pond depth is more than 2.5 m.
- Prior to stocking, the pond is limed and filled with fresh clean water.
- After stocking, feed and fertilizers are not usually applied.
- Fry/fingerlings are fed at a rate of 1–2% body weight per day when the water temperature rises above 16°C.

Summary

The chapter has looked at stocking fish seed after pond preparation. Good sources of fish seed include government set hatcheries and other recognized hatcheries in the country. Good fish transporting methods and all the necessary practices like conditioning seed before and after transporting them, right quantities when packing them for transportation have been highlighted. The carrying capacity of the pond and level of management determines the stocking rates. The stocking rate will also vary according to the common fish culture practices in the surrounding area and the financial capability of farmers. For example, if the farm is using formulated feeds and has a stable supply of water, stocking rates can be increased. Stocking rates vary depending on the quality and availability of water, soil and capital as well as the desired marketing size of the fish.

Methods of fish seed transportation like use of oxygenated plastics bags, tanks and clay pots has been presented. Fish has to be transported early in the morning or late in the afternoon. This is to make sure that they are not exposed to direct sunlight as this increases mortalities. Knowing right number of fish seed to be stocked and their impacts on fish growth has been elaborated. Simple calculations on knowing number of fish to be stocked in a culture facility have been made

Pond Management and Corrective Measures

3

Introduction

Successful pond management requires more than just stocking fish. It is important to maintain the proper environmental factors for good fish growth, check for successful fish reproduction, the quality and quantity of feed being used, eating habits of fish, keeping out predators from fish ponds and even unwanted fish and other aquatic living things. Whenever something is not in line with the requirements for good fish growth or reproduction, corrective measures must be applied as soon as possible.

Aim

To improve the knowledge and understanding of corrective measures in fish pond management and improve skills in measuring water parameters like pH, turbidity, oxygen and good feeding practices

Objectives

Participants know

- Maintenance activities on daily basis
- Measures to deal with stunted fish
- Measures to deal with low and high pH
- Measures to deal with low oxygen
- Measures to deal with nutrient imbalance
- Measures to estimate growth and production of fish

Acquired skills

- How to measure fish growth
- How to measure pH

Acquired attitudes

- Pond corrective measures are key to increased fish yields

Relevance to fish production

- Good husbandry practices leads to improved fish growth hence good economic returns to a fish farmer

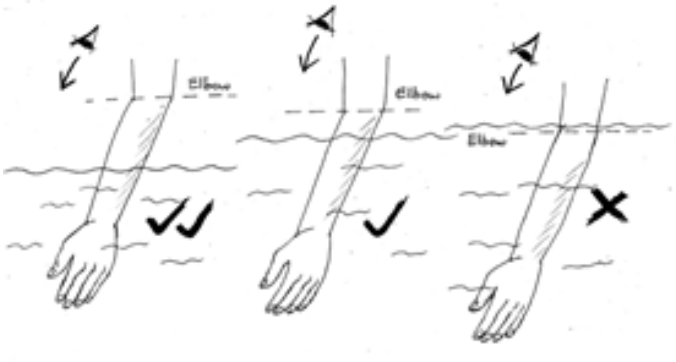
Session Overview: This chapter has one session which is sub divided looking at importance of aquaculture in Malawi and its history, status of aquaculture in Malawi and its nutritional importance in the country

Materials: Flip- chart paper, markers, study notes, posters, secchi disc, thermometer
Mode of delivery: Lectures, group discussions and practical
Duration : 60 minutes

3.1 Maintenance activities on daily basis

3.1.1 Check the pond, hapa or tank for changes in water quality as follows;

- Dip a hand in the pond to the elbow level.
- If you clearly see the palm of the hand, then water quality is poor, fertilize the pond.
- If you faintly see the hand, then its good water quality.
- If you don't see the hand after dipping, the pond is over-fertilized. You need to flush the water or topping up. You can also use a Secchi Disk (Fog 3.2) to measure the turbidity of water



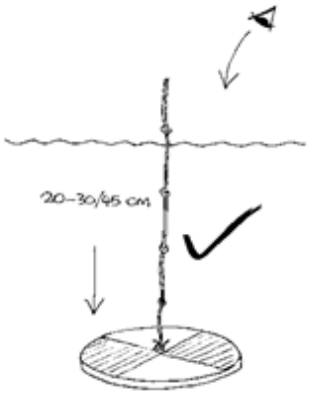


Fig 3.1Using a hand to measure water quality Fig 3.2 Using Secchi disc to measure water quality

3.1.2 Monitor water levels in the pond to see whether it has gone down or flooded

- Top up water if water level has dropped.
- Check for any water leakage on the pond dyke or tank.
- Check pond dykes to see if water is not flooding.
- Ensure over flow pipes are not clogged

3.1.3 Check temperature and dissolved oxygen levels

The clear sign of low oxygen levels is when you see fish gulping for air on the water surface or swimming towards the inlet where water will be carrying fresh air.

- Measure Dissolved Oxygen (DO) and temperature in the pond in the morning (preferably at 6.00 hrs) and afternoon (14.00 hrs).
- If water quality is not good, stop adding fertilizers instead add more water into the pond.

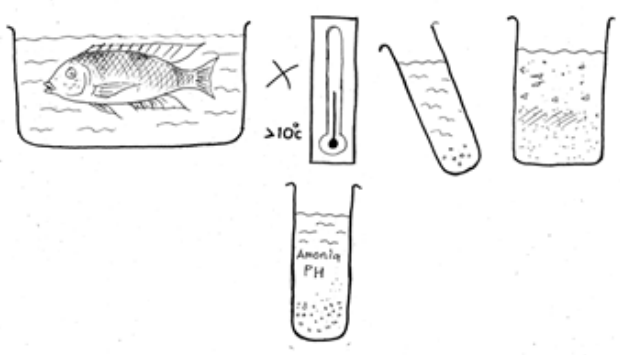


Fig 3.3 Measuring water temperature

3.1.4 Check for predation and control measures

- Every day walk around pond facility before you start any activity
- Check and observe any possible predation activities such as foot prints of otters, alligators, birds.
- Check for otter droppings as this is a sign of predation by otters
- Spot check on the sieve at the inlet and outlet of ponds to see whether they are removed or torn apart.
- Plan to replace the screens. Most screens are made of netting material with 180 µm mesh size and are placed in the inlet and outlet to prevent predators from entering the pond.
- Remove any frogs, tadpoles and weeds as soon as they are seen. Frogs eats young fish and fish feed
- All observations made as you are checking for predation must be recorded. Predators brings about stress on fish, mortalities, wounds, pathogens and causes diseases

Fig 3.4 Birds and Fig 3.5 Otters are some of the predators to be controlled

3.1.5 Monitor feed and feeding practices

- Check on the quality of feed by smelling, feed with bad odor must not be given to fish.
- Don't feed your fish rodents infested feed.
- Feed the fish daily on recommended feeding rates and feeding times.
- Closely observe the feeding behavior of your fish as you are feeding.
- Always know what you are feeding and how much you are feeding them

Fig 3.5 Observing fish during feeding

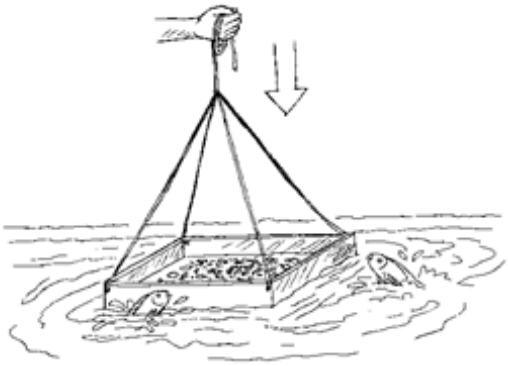


Fig 3.6 Feeding trays helps to save fish feed

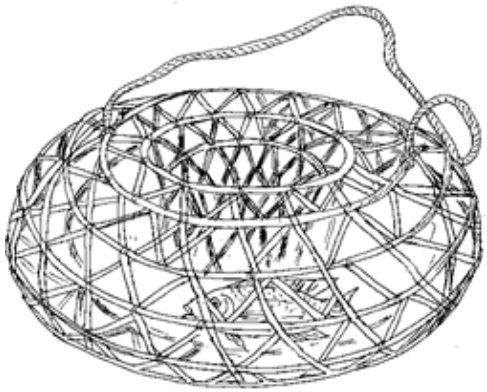
Fig 3.7 and Fig 3.8 Good fish feeding practices must be followed at all times

3.2 Measures to deal with stunted fish

3.2.1 Don't recycle seed

Stunted fish are a waste of resources such as feed and all the efforts that farmer can make. If one finds small fish within the fish sample that were stocked at same time and sizes, then those small fish are stunted. They have to be removed. Avoid fish stunting by doing the following;

- Never use small fish left at harvest as fish seed for the next cropping. Don't use recycled fish seed.
- Stock quality fingerlings from reliable sources like Government Stations such as Domasi, Mzuzu, Kasinthula, Mphompha and other approved fish hatcheries.
- Grade fish and stock the desirable sizes and remove the smallest in sizes.
- In mixed culture, remove (skim) the fry and fingerlings from production ponds during sampling



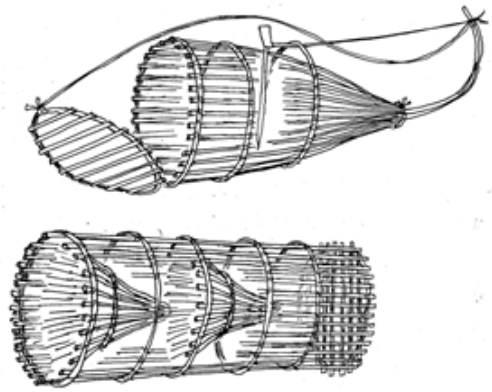


Fig 3.9 and Fig 3.10 Fish traps can be sued for skimming fish in ponds

3.2.2 Growing all males or mixed tilapia with catfish

- Separate male fish from females and stock only males as they grow fast. The farmer needs to be experienced to be able to separate fish according to sex.
- Stock tilapia species, (Oreochromis shiranus and mossambicus) together with catfish

(Clarias gariepinus) so that catfish can feed on the undesirable fingerlings produced in the pond.

- Stock the fish in the ratio of 1 catfish for every10 tilapia. Catfish should be two thirds the size of Tilapia. In other words, stock 5g catfish together with 7.5g tilapias. Another benefit of stocking catfish together with tilapia allows for more intensive use of pond surface area.

3.3 Measures to deal with high or low pH

A pH is the level of acidity or alkalinity in the water and is described by the pH scale, which ranges from 0 -14 with acid substances having a pH from 0-7, pH 7 as neutral and pH 7-14as alkaline .Fish grow better at pH range between 6-8). Low pH affects the fish's gills, making it difficult for them to extract oxygen from the water.

- Maintain proper pH by applying agriculture lime at a rate of 100g/m2 when the water is acidic. Lime should be applied at least a week before stocking fish. It should not be applied after stocking as it can kill the fish.
- Sometimes you can apply firewood ash at 1 Chibuku packet every week for a 200m2 pond to replace for alkalinity loss.

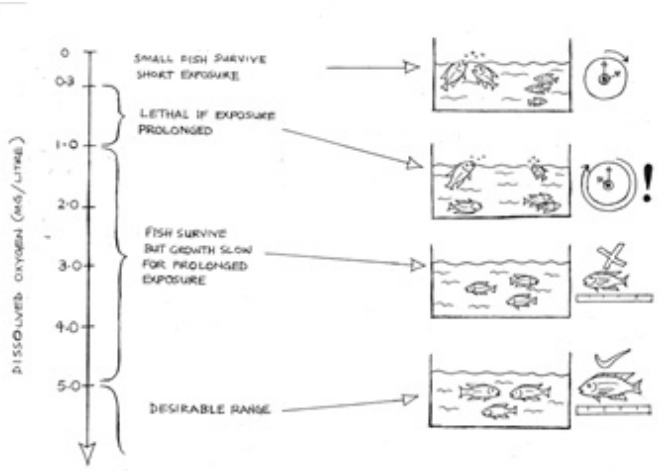


Fig 3.11 Impact of pH on fish

Before and after liming our ponds, we should make sure that the following records are kept;

- Quantity (kgs) of lime purchased and its cost
- Transport costs and any associated labor costs
- Amount of lime applied in a pond and the pond size
- Labor costs involved during lime application
- Any observations being made in the pond after liming

3.4 Measures to deal with low oxygen

3.4.1 Dissolved oxygen

Dissolved oxygen is the second most important water quality parameter, measured as ppm or mg/l. DO in pond water varies throughout the day, being lowest in the morning at around 5 – 6 am (at dawn) and highest in the afternoon (2 – 3 pm). If the Dissolved Oxygen drops below 3 mg/l, aeration may be needed. Similarly, if DO rises above 12 mg/l in the afternoon it may cause fish to suffocate and cause gas bubble disease;

churning of the water is needed so that excessive oxygen is released into the atmosphere. For this purpose a pedal wheel aerator is re commended. However, it is only necessary to run it for about 3 –4 hours early in the morning (say 2–6 am) and for another 3 – 4 hours in the afternoon when the temperature and DO are highest at around 1 – 4 pm. Similarly, pH indicates some chemical property of the water. If pH drops below 6.5, liming is necessary. If pH shows a higher reading than 9.5, fertilization may help to reduce it. Monitoring of salinity (ppt) is necessary if the site is in a brackish water area. As salinity affects tilapia growth and reproduction, and it fluctuates during dry and rainy seasons, monitoring of salinity and planning fish stocking and harvesting is important in order to maximize production and profitability.

3.4.2 Causes of low oxygen in ponds, tanks or hapas

Low oxygen levels can also be caused by too much uneaten feed which decomposes on the pond bottom and too much waste released by fish. To minimize feed wastage and maintain good levels of dissolved oxygen, it should be noted that during larval stages, the fish require a daily ration of about 20–30% of their body weight, divided into six to eight feedings. Fish fingerlings require 3–5% of body weight, dispensed three to four times daily. It has been indicated that increasing feeding levels above fish requirements may reduce feed digestibility and utilization efficiency. Ensure that the pond has adequate oxygen levels by doing the following;

- Always, feed fish at recommended feeding levels and times. Fingerlings should be fed at 3- 5% of their total weight. Big fish should be fed at about 2.5% of their total weight.
- Observe the fish as they are feeding. If you notice they have stopped eating you stop feeding them.
- Do not feed fish at lower temperature below 20oC; below this temperature fish stop eating and the uneaten feed sinks on the bottom and starts rotting after some time.
- Apply manure to the ponds at the recommended rate (200g/m2 fortnightly or when need be) to ensure that adequate quantities of planktons are available for photosynthesis.
- Don't apply manure when temperatures are very high or when they are very low as these negatively affects the presence of dissolved oxygen in the pond water.
- If the oxygen levels get too low, flush the ponds but in case of water scarcity and in case that flushing may deplete water level, consider topping up the ponds to dilute the water.

Fig 3.12 An over fertilized pond can lead to DO depletion Fig 3.13 Feeding fish in rings to maintain good water quality

The best temperature range is 28–32°C. Although they can survive, growth and breeding are negatively affected if the water temperature is higher than 35°C and lower than 20°C and fish become stressed outside their comfort zone), which favors the bacterial infections or diseases.
To further maintain good water quality, there is a need to analyze other chemical properties of the pond

water such as ammonia, nitrite and nitrate, dissolved solids, phosphorus, conductivity, etc. Analysis can be done in a simple laboratory but in some countries simple test kits are also available similar to litmus paper to roughly measure the pH. These are quite important if tilapia is cultured at high densities, especially in a water recirculation tank system.

3.5 Measures to deal with nutrient imbalance

3.5.1 Factors influencing nutrition quality in the feed

Proper nutrition is necessary for fish growth. Any imbalance in nutrition will reduce the fish growth. Nutritional imbalance could be caused by inadequate amounts of specific nutrients in specific feed ingredients, poor mixing of ingredients, presence of anti-nutritional factors and poor processing procedures.

3.5.2 Corrective measures if any imbalance is noted

The following measures should therefore, be taken to deal with nutritional imbalances;

- Add energy feed sources such as brans to supplement fertilization in the pond so as to balance protein- energy ratio.
- Determine the nutritional content of the feed ingredients and make proper mixing of ingredients to balance nutrients in the fish diets.
- Process the feed ingredients to neutralize some anti-nutritional factors. For instance, roast soya before milling to remove trypsin inhibitor.
- Store fish feed in dry areas to avoid spoilage through oxidation (rancidity) that will lead to the development of aflatoxins.
- Feed the fish the right amounts of feed based on estimated fish weight in the pond.

Fig 3.14 Feed ingredients like soya needs to be roasted

3.6 Measures to estimate growth and production of fish

3.6.1 Fish sampling

Monitoring of fish growth is very important as it allows one to estimate existing fish total weight. The fish weight value is used to estimate the amount of feed that will be used before the next sampling. The following steps should be taken to estimate fish growth:

Procedure for estimating fish growth per day

- Harvest some fish from the pond every month.
- Measure the weight of the sampled fish then count them.
- Calculate average weight of fish by dividing weight of sampled fish by their total number
- Estimate fish growth per day by subtracting initial mean fish weight from current mean fish weight and divide the result by total culture period.
  For example stocking weight = 5g and current mean weight = 100g culturing period = 100 days then growth per day = (100g-5g)/ 100 days = 0.9g/day
- Calculate fish production by multiplying mean final fish weight with estimated number of stocked fish in the pond.

The number of fish in the pond should be estimated to give allowances for mortality based on farmers experience after considering level of security that the farmer has put in place. For instance, fenced ponds with well fertilized water are likely to have very low mortality levels, though some mortality could arise from poor water quality condition.

It should always be remembered to record all the observations being made during our routine fish monitoring exercise. Parameters to be recorded will include

- Date when the exercise is being carried out
- Number of fish sampled, individual and average weight
- Data on average daily growth rate
- Number of days fish have been in the pond till the day of sampling
- Labor involved

Summary

Daily pond corrective measures are essential for the proper growth and survival of fish in a culture facility. The major things that have been highlighted for frequent monitoring include the following;
Measures to deal with stunted fish: a farmer has to monitor whether the fish is growing or not. If fish are not growing, feed quality has to be checked and also check if quality seed were stocked.

Measures to deal with low and high pH: A pH is the level of acidity or alkalinity in the water and is described by the pH scale, which ranges from 0 -14 with acid substances having a pH from 0-7, pH 7 as neutral and pH 7-14as alkaline. Fish grow better at pH range between 6-8). Low pH affects the fish's gills, making it difficult for them to extract oxygen from the water.

Measures to deal with low oxygen: Dissolved oxygen is the second most important water quality parameter, measured as ppm or mg/l. DO in pond water varies throughout the day, being lowest in the morning at around 5 – 6 am (at dawn) and highest in the afternoon (2 – 3 pm). If the Dissolved Oxygen drops below 3 mg/l, aeration may be needed. Similarly, if DO rises above 12 mg/l in the afternoon it may cause fish to suffocate and cause gas bubble disease

Measures to deal with nutrient imbalance: Proper nutrition is necessary for fish growth. Any imbalance in nutrition will reduce the fish growth. Nutritional imbalance could be caused by inadequate amounts of specific nutrients in specific feed ingredients, poor mixing of ingredients, presence of anti-nutritional factors and poor processing procedures.

Measures to estimate growth and production of fish: Monitoring of fish growth is very important as it allows one to estimate existing fish total weight. The fish weight value is used to estimate the amount of feed that will be used before the next sampling. Procedure for estimating fish growth per day is by harvesting some fish from the pond every month. Measure the weight of the sampled fish then count them. Calculate average weight of fish by dividing weight of sampled fish by their total number. Estimate fish growth per day by subtracting initial mean fish weight from current mean fish weight and divide the result by total culture period

Harvesting Fish

4

Introduction

Aquaculture can be defined as a sustainable practice of fish harvesting that strives to keep aquatic biodiversity and ecosystems intact. And fish harvesting is one of the important pond corrective measures or practices in aquaculture. Fish must be harvested after a production cycle and farmers must adhere to a production cycle. If fish is not harvested the farmer will not get any benefits in return as feed and other resources will just be wasted. The duration of the cultivation is varied upon the agro-ecological zone, intensity of the farming, purpose of production, preferred market size for fish, seasons and by opportunities to achieve good volume of sales and market prices. Some fish harvests are influenced by for example, fortnight pay days and markets, paydays, festive times. For Tilapias, harvests can be done starting from about 3 – 6 months from the date fingerlings have been stocked.

Aim

To improve the knowledge and understanding of fish harvesting practices

Learning Outcomes for the chapter

At the end of this chapter, learners should be able to;

- Explain various types of harvest
- Describe materials for harvesting
- State methods of fish harvesting
- Explain maintenance of fish harvesting equipment
- Describe pre and post harvesting activity

Session Overview

The Chapter is comprised of five sessions as follows;
Session 1: Types of harvest, Materials for harvesting
Session 2: Methods of fish harvesting and Maintenance of fish harvesting equipment
Session 3: Pre and post harvesting activity

4.1 Types of harvest

4.1.1 Partial harvest

A partial harvest is the removal of only some of the fish from a pond or any grow-out facility during a production cycle. For example, a farmer may wish to take only some big size fish for a special occasion; sell in the market, for home consumption or pay for labour.

The harvesting can start at about 3 months after stocking the fingerlings, or when the fish are big enough to eat (150–300g size). Partial harvests can be continued until the fish have been in the pond for 4 –8 months, (depending on the area) or until there are only few left. A renovation of the pond and restocking of the pond with new seed will follow after harvesting.

Some partial harvests are done just because the pond has a lot of fish. In order to ease selling of the fish and to minimize losses, a fish farmer can have several partial harvests till all the fish are harvested and sold

4.1.2 Complete harvest

This is when a pond is to be harvested completely and this is usually carried out 4 - 8 months after stocking. Water is lowered a day or some few days before the actual harvesting day depending on the size of the pond. On the day of harvesting, a seine net is passed is the pond while the pond is draining to speed up the harvesting process. When the pond is drained completely, fish are confined in the catch pit or in basin and these remaining fish are scooped or collected by hand. A net bag can be held on the outside of the outlet pipe to catch any fish that escape down the pipe, or the inside of the pond can be screened around the outlet pipe or monk to stop fish from escaping.

4.2 Materials for harvesting

There are several types of materials, tools or gears that a fish farmer can use to harvest fish. The check list for the materials is as follows: depending on the scale of operation, type of operation and resources

- Seine Net
- Gill Net
- Lift Net
- Scoop Net
- Cast Net
- Hand net
- Fish traps
- Wheelbarrow
- Buckets
- Scale
- Hoes
- Hook and line

4.2.1 Seine Net

When harvesting is to be done by seining, the shape and size of ponds in farms are designed with this in mind. Usually the length of a seine net is about one and a half times the width of the pond and the depth about two to three times the pond depth. A preferred and economic length is not more than about 150m.The mesh size of the net depends on the size of the fish to be harvested. Too small a mesh will make dragging the seine net

more difficult due to increased resistance in water and so a larger mesh size is preferred when the size of the fish permits it. In nursery ponds smaller meshed seines are used but then the smaller pond dimensions enable easy fishing.

Generally, wooden brail poles are attached to both ends of the seine for convenience in pulling and keeping the net stretched vertically (Fig. 4.1 to 4.4).The poles can be used for attaching hauling lines. The head line has floats made of cork, Styrofoam or other suitable floating material and the lead line has lead sinkers or lead cores. Traditional lead lines have a tendency to sink into muddy bottoms and allow the net to roll up, resulting in loss of fish caught in the net. To avoid this, the use of 'mud lines' is recommended. They consist of a number of relatively thin ropes tied loosely together, made of a material (such as jute or cotton) that readily absorbs water. Mud lines skid on the bottom, without digging or lifting the mud. This reduces escape under the seine.

Seine Net in summary;

- A long shallow net that is pulled through the pond by 4 to 6 people. The size of the mesh sizes in the net will depend on the size of the fish you want to catch.
  a. Use a 1" mesh size net for capturing big fish,
  b. Use a 1/4 inch to ½ inch mesh size for fingerlings
- Thickness of twine (Ply number) determines the net's strength and lifetime.
  a. For seine net used for handling small fish, thick twine (ply number 6 or 9)
  b. Use nets of low ply (2 or 4) are efficient for catching big fish but damage fish and break often.
- The length of the seine net required for harvesting pond fish efficiently depends on the pond size and shape. The length should at least cover across the pond's narrowest side. This is to avoid escaping of fish when the net is being hauled from one end of the pond or tank to the other
- The height of the seine net depends again on the depth of the water in the pond or tank. Sinkers and floats should be put on the seine net for it to easily move on the bottom of the pond and the floats mounted on the upper rope to improve on the drag of the net and prevent fish escapes.

Fig 4.1 and 4.2 Seine net in use

Fig 4.3 Harvesting with local materials

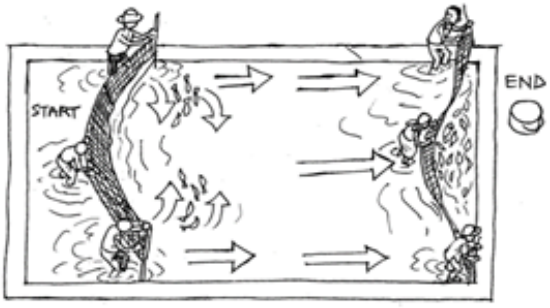


Fig 4.4 How to use a seine net

4.2.2 Gill Net

A Gill Net is shaped like a seine net, but it is made of very fine twine. Fish are caught by their gills. It is not pulled through the pond, but set in one place. The fish swim into the net and get caught in it. A 2 inch to 3 inch mesh size is common for gill nets.

4.2.3 Lift Net

Lift Net is made of seining material. It can be any shape and size, and is set on the pond bottom. When the fish swim over it, it is lifted up, capturing the fish. It is called a Lift Net as fish are caught by lifting once they are swimming over it.

4.2.4 Scoop Net

A Scoop Net is a small net with a handle that you hold in one hand. It is used to scoop up the fish in a seine, container, etc. It is helpful when counting and weighing fish and fingerlings. It is called a scoop net as fish are just scooped from wherever they are being held.

4.2.5 Fishing with hook and line

Hook and line catch fish by hooking after attracting fish with bait.

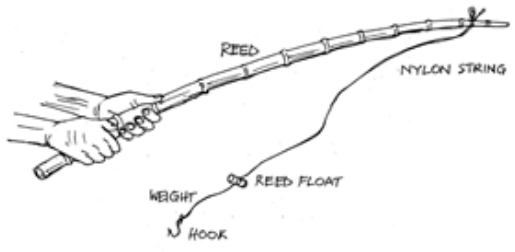


Fig 4.5 Hook and line

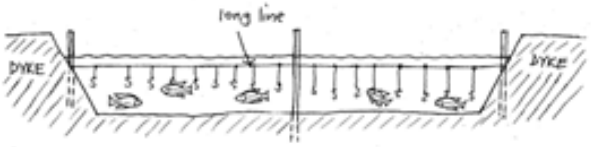


Fig 4.6 Long Line

4.2.6 Fish traps

Fish traps are usually made of bamboo or reeds. Traps are always baited like with roasted maize bran. The bran is made into molds which are carefully put inside the trap when it is being put in the water.

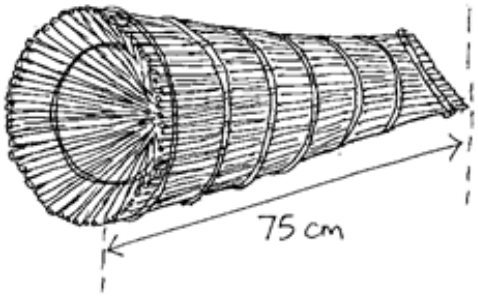


Fig 4.7 locally made fish trap Hook and line

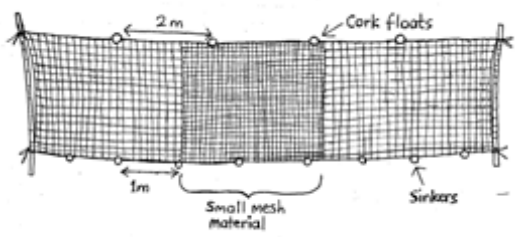


Fig 4.8 Making a seine net

4.3 Harvesting methods

Methods of harvesting naturally depend on the culture system, the species cultured and the form in which the product is to be marketed. Properly designed fish ponds have special provisions for draining and easy harvesting. A farmer therefore needs to have suitable nets and other fishing devices that can be used. Harvesting is usually the most labor-intensive operation in an aquaculture farm, apart from its construction, so there have been attempts to introduce as much mechanization as possible in order to reduce labor.

4.3.1 Draining by cutting the dike

For smallholder farmers, draining by cutting dike is the most common harvesting method. This is so common amongst farmers that have not put draining pipes in their ponds. Cutting of the dike should always be done at the lowest side of the pond to empty the pond completely. When using this method, care should be taken to avoid stirring mud at the pond bottom. In this scenario;

- Fish are collected from inside the pond. Fish are hindered from escaping through the cut dike by a screen, a short net or a basket.
- For easy collection of fish, a 30 to 40 cm deep a harvesting depression of 1m x 3m size (depending on the size of the pond) should be built in front of the depression.

4.3.2 Draining with a drainage pipe

Harvesting from drainable ponds is relatively easy, if there is a harvesting sump or similar device. In a nursery or fry-rearing pond it is almost essential to have a harvesting sump to avoid injury to fry or fingerlings during harvest. Drainage is performed at a rate suited to the size of the outlet and the drainage channels, and the fish are concentrated in the harvesting sump. From the harvesting sump, the fish can be collected by loading equipment, if necessary with the help of a net. In case the harvesting sump is considered too small for the quantity of fish, it may be necessary to combine seining and draining to harvest the fish in good condition. Some of the fish may be seined and the rest caught in the sump. When live fish are to be marketed, it is useful to spray fresh water or aerate the water in the sump, to avoid weakening or mortality of the fish.

Small to medium-size ponds of up to 1000m2 size can be efficiently drained with pipes. Two different systems of pipe drainage devices are used. A stand on pipe, connected to the outlet by a 90-degree elbow can be used. The position of the stand on pipe determines the water level of the pond. Excessive water spills over into the open pipe (overflow) and drains out of the pond. Dropping the standpipe laterally empties the pond.

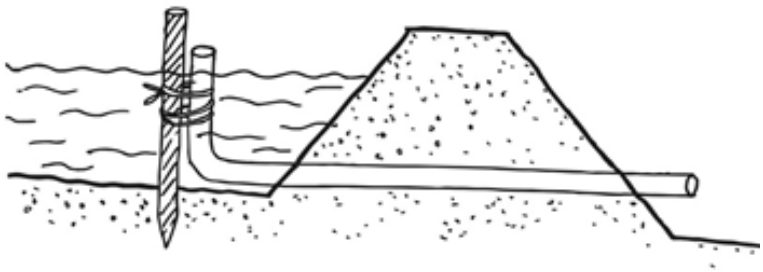


Fig 4.9 Outlet PVC pipe is set at the deepest part of the pond

During pond water draining, care must be taken not to cause turbidity as this might compromise fish quality through its smell. Efforts should be made to avoid stressing the fish by:

a. Not stepping inside the pond and avoiding whirling up mud from the pond bottom.
b. Where possible, flush off additional fresh water through the harvesting basket to improve water quality.
c. The drained pond should be left to dry for at least two weeks until the mud is cracked.
d. Excessive mud on the pond bottom should be removed and be taken to manure vegetable gardens. Dikes should be repaired if necessary

Before refilling, the dried pond bottom should be slightly tilled in order to bring up nutrients, which got locked in the sediments. At this stage, manure may also be applied. Ponds should be refilled in stages. This favors faster warming up of water and hence growth of plankton (primary production).

4.3.3 Draining with a monk

Monks are mainly designed for large ponds and are constructed on the deepest part of the pond. A Monk consists of a U-shaped tower with the opening towards the pond. It is made of bricks, wood or concrete. A solid platform is needed as foundation for the monk.

Depending on the water level required in the pond, more or less planks are put at the monk. Excessive water spills over the top board and flows out the pond through the connected drainage pipe. Fish are prevented from escaping by a screen.

When harvesting, all planks are gradually removed. Fish are collected in a harvesting basket fixed at the outside of the drainage pipe.

Harvest fish is during the cooler early morning hours, the draining process should start well in advance, depending upon the estimated drainage time.

Fig 4.10 a monk for draining a pond

4.3.4 Harvesting from un-drainable ponds

The so-called un-drainable ponds require pumping to drain. For economic reasons they are drained only very occasionally, if at all. In such cases, and when multiple harvesting and stocking are practiced, it is necessary

to resort to fishing with commercial fishing gear. The most common fishing equipment for pond farms is a seine net. It is well suited for harvesting tilapia and catfish.

4.4 Maintenance of fish harvesting equipment

- Clean all equipment to remove entangled fish in the netting material. These would attract rats to tear off the net
- After use, nets should be cleaned, repaired and spread out to dry. A special facility can be made where nets can be kept to protect them from rodents or sharp objects
- Put all equipment on a dry place to avoid being destroyed
- Disinfect the netting material if it is to be used in another pond
- Put netting materials on the shade to avoid losing strength

4.5 Pre harvest Activities

4.5.1 Preparation for Harvesting

Fish should be closely and more frequently watched near to harvesting. As for any agricultural crops or vegetables, use of antibiotics should be avoided for at least 2 weeks beforehand to avoid any risk of residues in the products. Fish mortality can occur during this period because some farmers tend to feed their fish more and fertilize their ponds more in the hope they will gain additional weight. This may create problems with water quality at a time of highest biomass in the system when a better quality of water is needed. Near harvesting time, farmers should explore the market before taking any bookings – comparing prices and transport costs can add a huge profit for them and farmers may lose out if they do not make some effort.

4.5.2 Tilapia and catfish Harvest

As fish are perishable products, fish farmers need to find suitable and reliable markets before harvesting. Keeping fish for an extra day or two in ponds, tanks or hapas may lead to farmers making a loss because they need to feed large amounts of feed as the fish get bigger and provide extra care. The final stage is very critical because the fish are more vulnerable to adverse environmental conditions. Finding a market at the same time as the fish harvest may be easy, and if farmers sell fish locally, most of them will have their own contacts. However, if they find it difficult, they may advertise, targeting specific groups in schools, estates, and places of worship, on radio, extension workers or via any government or NGO run market information systems. As with any other fish, tilapia has three distinct growth phases. When about to harvest fish;

- Do not fertilize ponds in the month we are going to harvest the fish. Instead allow fresh and clean water to get into the pond and allow the excess to go out of the pond. This allows the fish to clean themselves of the odd flavor such as the muddy, earthy smell and taste. Selling fish with an off-flavour could lead to a drop in the market acceptance of fish.
- Stop feeding the fish two days before harvesting to save on the feed thereby reduce costs.

4.6 Fish harvesting

In order to maintain good quality fish, minimize turbidity during harvesting. If it is planned to sell fish alive, then handle them gently and avoid overcrowding them in containers. Overcrowding will damage the fish (bruise the skin) and a lot of fish will die the following day. The following guidelines will help keep the fish in good condition.

- Handle the fish in the cool of morning or under shade, and use aeration and lots of flowing water.
- If fish are to be crowded in containers for a time, ensure water is clean, has air bubbling or running water flowing through it.
- Fish in small containers should not be too overcrowded. A sign of overcrowding is when fish come to the surface to gulp air (piping).
- Scoop nets used for handling fish should be of soft material to avoid bruising of the fish. Seine nets should be fine-mesh, as coarse-mesh nets will trap the fish by their gills and cause injury.
- Handle fish gently: avoid dropping fish on the ground, or leaving them out of water.

4.7 Post-harvest treatment

4.7.1 Holding fish for Market

If you are to meet a large order, harvest the fish required a day before and keep the fish for the market in a cage within the pond for easy loading of fish later on. Holding fish enables deliveries to be done on time.

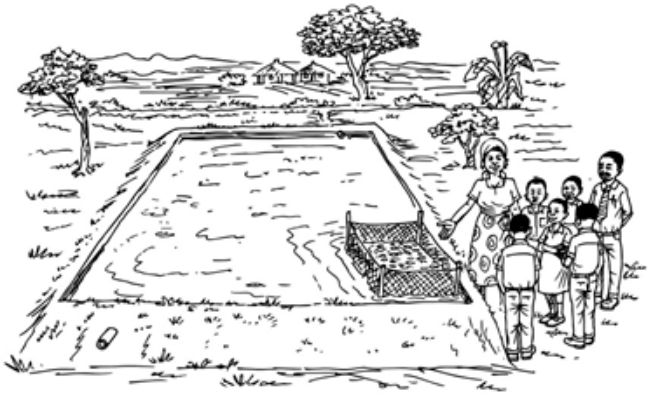


Fig 4.11 Holding fish in a small pond, tank or hapa for market

4.7.2 Post-harvest management

The advantage with fish farming is that one has the ability to control and improve quality right from the start of the production process. Some of the factors that affect fish quality in fish farming are:

- Quality of the feed and feeding regime which affect flesh composition, flavor and texture. Avoid using feeds with higher energy and fat than is recommended because the flesh becomes fatty.
- Minimize fish stress that result in extreme reduced feed intake as it increases water content of the flesh and poor texture.
- Reduce (a week) and then stop feeding (2 days before harvest) allowing the gut time to empty.
- Slaughter the fish rapidly once the consumer gets it. Do not allow them to jump all over the place before slaughter as the violent body movements result in poor texture.

4.7.3 Post-harvest Handling, Processing and Value Addition

The handling of fish after harvesting and before it reaches the dining table is important. Consumers want fish as fresh as possible and as fast as possible because quality deteriorates with time. It is best to transport live fish wherever possible. Common salt (5 ppt or so) is often added to reduce stress to the fish so that they can survive longer after harvest and quality can be maintained. However, in most cases this is costly because of the weight and volume of the water. Therefore, some farmers transport whole fish using ice in foam boxes;

others do more preparation, such as degutting the fish (taking viscera and gills out), deheading (cutting off the head) and more recently even filleting the tilapia because fillets are becoming very popular because of the lack of bones in tilapia. These activities require sophisticated handling and hygienic conditions and many farmers may not wish to, or are unable to, carry out these activities, and they are mostly done by specific groups of farmers or other business groups as specialized businesses.

4.7.4 Before storage and the market

Remove the fish quickly and wash them to prepare them for consumption or market. Avoid contamination when preparing your fish for market. Use clean water and containers and avoid placing fish directly on the ground. Grading your fish is important as offers you better prices.

If fish are to be sold fresh, guarantee freshness by selling the fish alive or deliver it live to the customer, if possible. When table-sized tilapia is being transported live to the market, ensure there is aeration in the container. Troughs or buckets, preferably with a wide opening can be used. For fish not to jump out, cover the tank with netting. If fish cannot be kept alive, keep them iced. The fish can be partially processed by gutting (i.e. removing the insides). Tilapia above 400 g can also be filleted for sale.

Aquaculture as a business, it should be remembered that record keeping must be done at all the stages of fish production till they are sold. All the recorded activities will help in calculating profits and losses that might have been incurred during the just ended production cycle. In this regard, some of the parameters to be recorded during fish harvesting will include

- Date of fish harvesting and pond size
- Number of people involved and labor costs involved (cash or in-kind payments)
- Amount of fish (pieces and kilograms) harvested
- Calculation of fish predation or mortality
- Selling price (per piece or kg)

Summary

Fish harvesting is one of the important pond corrective measures or practices in aquaculture. Fish must be harvested after a production cycle and farmers must adhere to a production cycle. If fish is not harvested the farmer will not get any benefits in return as feed and other resources will just be wasted. There are two main types of fish harvesting and these are partial harvest where only some of the fish from a pond or any grow-out facility during a production cycle are removed. The other one is complete harvest where all fish is harvested from the pond or tank. Seine nets and fish traps are the common materials used for fish harvesting.

As a biosecurity measure, after fish harvesting clean all equipment to remove entangled fish in the netting material and dry them properly. To maintain quality of fish, it is advisable to closely monitor your fish before harvesting. Stop applying manure in the pond and flashing the pond with clean water helps to remove the off-flavor.

As fish are perishable products, fish farmers need to find suitable and reliable markets before harvesting. Keeping fish for an extra day or two in ponds, tanks or hapas may lead to farmers making a loss because they need to feed large amounts of feed as the fish get bigger and provide extra care. If you are to meet a large order, harvest the fish required a day before and keep the fish for the market in a cage within the pond for easy loading of fish later on. Holding fish enables deliveries to be done on time.

GROW OUT AND PRODUCTION

Module VI of 8