Aquaculture Extension Manual No. 36

Tilapia Farming

in cages and ponds

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Foreword

Tilapia farming contributes significantly to the aquaculture production in the Philippines (122,000 metric tons in 2002), all countries in Southeast Asia, and many other countries around the world. The *Oreochromis* spp. tilapias have been called the 'aquatic chicken' and the label is apppropriate and well deserved. More and more farmers are willing to try tilapia as primary or secondary crop in a variety of farming systems.

In 1996, the SEAFDEC Aquaculture Department (AQD) published two extension manuals on the hatchery and grow-out of tilapia, both written in Filipino by the husband-and-wife team, Ruel Eguia and Ma. Rowena Romana-Eguia, working with colleague Zubaida Basiao at AQD's Binangonan Freshwater Station. The two manuals were found by fish farmers to be very useful.

The tilapias have been identified by the SEAFDEC and ASEAN Member-Countries as appropriate species to promote in rural as well as commercial aquaculture. Thus it is fitting for SEAFDEC/AQD to produce an English version of the tilapia farming manual under its Integrated Rural Aquaculture Program (IRAP), part of the ASEAN-SEAFDEC Special Five-Year Program on the Contribution of Fisheries to Food Security. It is also very fitting that the Eguias wrote this new manual on the occasion of ISTA6, the Sixth International Symposium on Tilapia in Aquaculture, held in the Philippines on 12-16 September 2004.

I proudly endorse this tilapia farming manual to fish farmers, students, and other interested parties in the aquaculture sector.

Rolando R. Platon
AQD Chief

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introduction

Originally from Sub-Saharan Africa and the Middle East, several species of tilapias have been introduced into the Philippines for farming and stock enhancement by government agencies like the Bureau of Fisheries and Aquatic Resources, by research and academic institutions, and by private individuals. The first tilapia to be brought into the country, in 1950, was the Mozambique tilapia (earlier called *Tilapia mossambica* but more accurately *Oreochromis mossambicus*). The *mossambicus* turned out to breed very readily, becoming sexually mature at the age of 3-4 months, at sizes as small as 25 grams, and spawning at 2-3 week intervals. Many farmers were enticed to grow *mossambicus* even in backyard ponds. Soon *mossambicus* colonized the rivers, lakes, streams, and brackishwater areas in the Philippines. The traits that made *mossambicus* seem a highly suitable species proved to be disadvantageous after all to its commercial propagation and farming. Farmed stocks of *mossambicus* became stunted but quickly overpopulated ponds, becoming 'pests' particularly in brackishwater ponds for milkfish and tiger shrimp.

In 1972, the Department of Agriculture's Bureau of Fisheries and Aquatic Resources imported a different species of tilapia. This was the Nile tilapia (*Oreochromis niloticus*), commonly called 'plapla'. The *niloticus* has become very popular among fish farmers because it is better than the *mossambicus* in terms of growth, survival, and reproductive traits. Aside from *niloticus*, several other kinds of tilapia are now farmed in the Philippines. Production of tilapias in the Philippines has steadily climbed and reached 122,000 metric tons in 2002.

Different fishery agencies have focused plenty of effort on the development of culture technologies that would improve growth of the farmed tilapias, particularly the Nile tilapia. Sound husbandry techniques were developed to provide fish farmers the means of obtaining sustainable yields. The SEAFDEC Aquaculture Department conducted research and generated technologies for feeding, health management, broodstock selection and management, and hatchery and nursery operations on Nile tilapia and red tilapia.

This manual provides relevant basic information on tilapia farming, based on the authors' experience and published research, as well as those of colleagues at the SEAFDEC Aquaculture Department and other R&D institutions. Part 1 provides general information particularly about tilapia seed stocks, Part 2 about farming practices in cages, and Part 3 about farming practices in ponds.

tilapias in the Philippines

Nile tilapia (*Oreochromis niloticus*)

The Nile tilapia has vertical black bands on the body and caudal fin. The dorsal fin has a black outline and the caudal fin has a red margin.

The Nile tilapia is the most preferred species because it grows fast, is hardy, and well adapted for farming in warm tropical countries like the Philippines. Nile tilapia comprises about 70% of the world tilapia production. There are many genetic strains or stocks of Nile tilapia in the Philippines, for example, the SEAFDEC-selected tilapia (Sst), the domesticated Israel strain, the Thai Chitralada strain, the CLSU strain, and the GIFT tilapia.

Mozambique tilapia (*Oreochromis mossambicus*)

The *mossambicus* is generally black in color. The underside of the head is white, and dorsal and caudal fins have red margins.

The *mossambicus* thrives in a wide range of salinities from fresh water to sea water and it is the most common tilapia found in coastal waters upstream of the surf zone. This tilapia breeds in short and successive cycles. It is a commercial food fish, and the small sizes are also used as forage fish for carnivorous marine fishes like groupers, snappers, and sea bass. The *mossambicus* accounts for about 10% of world tilapia production.

Oreochromis mossambicus is commonly mated with other tilapia species to produce all-male fingerlings, which grow faster than females. When the grow-out enclosures contain only male fish, early breeding and stunting are prevented and yields are higher.

Blue tilapia (*Oreochromis aureus*)

The blue tilapia looks similar to the Nile tilapia with black blotches on the body and the caudal fin. An obvious distinguishing characteristic of the blue tilapia is its yellow underside and yellow margins on the caudal and pectoral fins.

The blue tilapia grows fast and thrives in colder waters, such as those found in mountain lakes and reservoirs. At present, the blue tilapia is maintained for experiments undertaken at research and academic institutions such as the Freshwater Aquaculture Center of the Central Luzon State University, Bureau of Fisheries and Aquatic Resources, and some private companies. One project is to improve the cold tolerance of the Nile tilapia through hybridization with the blue tilapia.

Red tilapias (*Oreochromis spp.* hybrids)

The red tilapias are hybrids produced from crosses between *Oreochromis mossambicus* and *O. niloticus* (Taiwanese red tilapia) or *O. mossambicus-hornorum* and *O. niloticus* (Philippine red tilapia). Red tilapias have no bars on the caudal fin.

Red tilapias grow as fast as the Nile tilapia and can be grown in brackishwater ponds and sea cages. They have become a popular choice for farming.

In most of Southeast Asia, red tilapia enjoys a good market in fresh chilled or live form. However, the fresh chilled form can hardly be sold in the Philippine wet markets because it is unfamiliar to the consumers. Instead, red tilapia is marketed as a premium fish at upscale Chinese restaurants, where they are given some other fancy names as 'King fish' or 'Pearl fish'. Red tilapia have good prospects in the export market. In Japan and the USA, the red tilapia is sold as fillets or other processed forms.

Jewel tilapia

The Jewel tilapia is an all-male hybrid produced from crosses between *Oreochromis mossambicus* and *O. urolepis hornorum*. A private company in the Philippines gave this hybrid its commercial name.

The saline-tolerant Jewel tilapia grows fast in brackish water. It has been used as biomanipulator to condition reservoir water and to produce 'green water' which is used for growing tiger shrimp. The green water encourages the growth of yellow *Vibrio* bacteria, which outcompete and control the growth of harmful luminous *Vibrio.* Marine fish species may also act as biomanipulators in shrimp ponds, but tilapias are easier to procure in large numbers.

all-male seed stock

One way of increasing fish yield in the farm is to use all-male seed stock for grow-out. Male tilapias grow faster and larger than females. The production of an all-male population is one of the goals in hatchery and grow-out operations. The following techniques have been developed to produce all-male progenies through stock manipulation:

Manual sexing. This involves visual identification and manual separation of male and female tilapia fingerlings prior to stocking in the grow-out ponds. Success of this method depends on the ability of the technicians and farm workers to accurately distinguish male tilapias from female tilapias. This method is extremely laborious and is subject to human error.

Sex reversal by hormone treatment. This method involves feeding newly hatched tilapia with diets containing the synthetic hormone 17–methyltestosterone for 4-5 weeks to induce sex reversal in the female fry. The hormone is mixed with the diet at rates of 10-60 milligrams hormone per kilogram of feed. Once the population becomes all-male, breeding of stocks in grow-out ponds will not take place. The success of this method varies from 90-100% males.

Hybridization. This method entails the mating of different species of tilapias that are known to produce all-male hybrids. This method has a limited commercial application for it is difficult to obtain pure genetic lines of the different species. The purity of the stock is necessary in obtaining consistent results. Some of the hybrid crosses that produce all-male tilapias are listed in the table below.

Crosses of tilapia *Oreochromis* spp. that produce all-male hybrids

Female parent	Male parent	Reference
O. mossambicus	*O. urolepis hornorum*	Hickling (1960)
O. niloticus	*O. urolepis hornorum*	Pruginin (1967)
O. spilurus niger	*O. urolepis hornorum*	Pruginin (1967)
O. niloticus	*O. aureus*	Fishelson (1962)

Genetically male tilapia (GMT) or YY technology. This technology was developed in the late 1980s by the University of Wales, Swansea, Wales, UK in collaboration with the Freshwater Aquaculture Center of the Central Luzon State University in Muñoz, Nueva Ecija, Philippines. The collaborative work was implemented to produce all-male Nile tilapia populations on a large scale. All-male populations are obtained through a series of genetic manipulation, feminization, and progeny testing to produce novel YY males. The genetically male YY genotypes, when mated with normal females XX can produce all-male XY progenies. This method has a mean success rate of 96.5% males.

genetically improved stocks

Another way to increase yields is to use genetically improved tilapia stocks. In the early 1990s, genetic improvement programs were implemented by SEAFDEC/AQD, the Central Luzon State University, the Bureau of Fisheries and Aquatic Resources, the GIFT Foundation International Inc., and PhilFishGen. Thus were produced several Nile tilapia strains from conventional selective breeding (items 1-5), or genetic manipulation (item 6).

- Supreme Tilapia
- Genetically Improved Farmed Tilapia or GIFT
- Freshwater Aquaculture Center Selected Tilapia or FAsT
- Genetically enhanced tilapia-EXCEL or GET-EXCEL
- SEAFDEC-selected tilapia or Sst
- Genetically Male Tilapia or GMT or YY-super male tilapia

These stocks are available to fish farmers who can pay for improved strains. Farmers get higher yields within a shorter period provided they practice efficient husbandry techniques. Some farmers prefer to improve their own stocks by on-farm selective breeding. Other farmers import improved commercial breeds from the USA and Taiwan.

buying quality seed stock

The success of any tilapia farming operation depends heavily on the quality of seed stock used. The main concern of farmers is to procure quality seed stock that can grow to marketable sizes within the shortest possible time. Farmers can procure seed stock from reliable reputable hatcheries, or operate a hatchery themselves to be assured of good quality seed. Another option is to obtain all-male stocks or genetically improved stocks from licensed farms, agencies, or research institutions.

Tilapias are normally stocked in grow-out enclosures at sizes ranging from 37 mm (size 17) to 46 mm (size 14) 'fingerlings'. Hatchery operators thus have to nurse 'fry' to the marketable fingerlings.

Operating a tilapia hatchery requires technical expertise. Knowledge in proper broodstock management is necessary. Genetically inferior or poorly managed breeders may produce poor quality fingerlings that grow slowly, have deformities, are diseased, or mature too early.

On the other hand, good quality fingerlings have the following traits:

- Fast growth in terms of length and weight
- Robust body
- Normal color
- No deformities
- Efficient feed conversion

Information regarding other criteria such as sexual maturity, resistance to diseases, and social behavior may be obtained from the hatchery operator. It is also important to obtain pertinent information on the seed stock number, age, strain, ancestry or parental cross from which they were derived, and survival rate from hatching to nursery stage.

Fingerlings of Sst tilapia (above) and red tilapia (below)

transporting fingerlings

Tilapia fingerlings must be starved for at least 24 hours prior to transport. Immediately after harvest from the hatchery, fingerlings should be stocked in a conditioning tank or cage with flowing aerated water to allow them to rest and defecate. Feces should be removed before transport. It is better to transport fingerlings in the early morning or after sunset.

Packing tilapia fingerlings in plastic bags for transport

Oxygen must be available to fish in sufficient amounts at all times during transport. **Water temperature** must be lowered to about 20°C to reduce the oxygen consumption of fish. Ice in plastic bags may be placed in the transport containers— this is especially important for long-distance transport by land or air. **Loading density** (number of fingerlings per transport container) must be adjusted according to fish size, water temperature or time of day, duration of transport, distance, and road condition.

- ***Oxygenated plastic bags*** are commonly used for long-distance transport of fingerlings. Double bags (each 75 cm x 40 cm) with water and oxygen in 1:1 volume ratio can hold about 500 of size 17 fingerlings. To protect against puncture, the plastic bags are placed in thicker bags for short-distances, or packed with bagged ice in styrofoam boxes or corrugated cardboard boxes for long-distance transport (both are required by the airlines).
- ***Transport boxes*** made of plywood are fitted inside a truck or van. The loading density can be as much as 20,000 of size 17 fingerlings per ton of water in the box. Battery-operated aerators and medical oxygen are provided.
- ***Transport boats*** are used in tilapia farming areas where lake farms get their fingerlings from lake-based hatcheries. The tilapia fingerlings are loaded into the hull of a boat in a compartment with small holes that allow free water entry as the boat moves along. To keep the boat from sinking, water is constantly bailed out by hand or by pump.

grow-out in cages

Cages are net enclosures much like oversized net boxes suspended from posts. Cage sizes range from 1 m^3 (1 m x 1 m x 1 m) to 2,700 m^3 (30 m x 30 m x 3 m) depending on the site, production target, and the financial and technical capability of the farmer. Tilapia farming in cages is practiced in lakes, dam reservoirs, and sometimes in sea water.

About 37% of the total tilapia production in the Philippines comes from cages. Tilapia in net cages set in eutrophic lakes like Laguna de Bay can subsist on natural food and reach marketable size reasonably quickly. However, tilapia in cages in oligotrophic lakes like Taal in Batangas, and in water reservoirs like Pantabangan, Magat, and Ambuklao, must be fed commercial diets to reach marketable size quickly. Net cages in these lakes and dams are stocked with as much as 50-100 fingerlings/m^3.

The best practices for tilapia grow-out in net cages are described in detail in Part 2 of this manual.

Tilapia cages in Pantabangan Dam, Nueva Ecija, Philippines

grow-out in pens

Pens are enclosures made of fenced sections of shallow lake, river banks, or coastal bays and lagoons, where the water is 2-7 meters deep. The fence is made of netting supported by bamboo poles or palm tree trunks staked into the bottom. Pens can vary in area from less than a hectare to as wide as 100 hectares.

Tilapia farming in pens is not as popular as in net cages. In Laguna de Bay, Philippines, tilapia is a secondary crop to milkfish and bighead carp in pens. Tilapia recovery rate during harvest is low. It is quite difficult to catch tilapia with seines and fish farmers use gill nets to harvest them from pens.

Tilapia net pen in Laguna de Bay, Philippines

grow-out in ponds

Ponds are earthen impoundments, either excavated or diked in, depending on the terrain, such that flooding and draining of water can be done with ease at any given time. Earthen ponds are the most widely used system for growing tilapia to marketable size. Pond compartments may be as small as 100 m^2 or as large as one hectare (10,000 m^2), and they may be from 0.5 to 3 meters deep, depending on the operators capability, preference, and production target.

About 48% of the total tilapia production in the Philippines comes from ponds, freshwater and brackish. The species farmed in brackishwater ponds are euryhaline tilapias such as the *mossambicus*, the hybrid red tilapias, and the hybrid Jewel tilapia. These species are either grown by themselves or in polyculture with tiger shrimps, milkfish, and other marine fishes. Numerous tilapia ponds are now found in Central Luzon since unproductive rice fields and milkfish ponds were converted into tilapia ponds. The tilapia harvests are transported live in aerated tanks by pick-up trucks to the wet markets in Metro Manila and some are sold live along the major provincial roads. Tilapias are also now widely grown in the Visayas and Mindanao.

The best practices for tilapia grow-out in ponds are described in detail in Part 3 of this manual.

A typical tilapia pond

grow-out in tanks

Tanks are concrete or plastic containers with provisions for water drainage and aeration. Tank grow-out systems are usually intensive systems that are stocked with 50-100 gram tilapia at 100-200 fish/m^3 and even as high as 250 fish/m^3 provided that proper life support systems (blowers, filters etc.) are in place. Where clean and adequate fresh water is available, the tank water is changed regularly to avoid pollution from feeds and feces. Where water is limiting, tank water is recycled or reused. The polluted water is passed through a series of mechanical filters, biological filters, and aerators and oxidants, and then returned to the tank. At harvest, sizes are usually bigger than 300 grams, survival is 70-85%, and the yield is 1-2 tons from 100 m^2 of tanks.

Intensive tank grow-out systems entail high initial capital investment, technical expertise, and large amounts of energy and commercial feeds. Though expensive, the tank grow-out system is efficient, especially if the purpose is to produce export-quality tilapia that can pass strict quality control standards in the world market. Many farmers in Saudi Arabia, USA, Canada, Israel, and Malaysia adopt intensive tilapia farming in tanks and often have computerized water quality monitoring and automatic feeding systems.

In developing countries, intensive tilapia farming in tanks may not be economically feasible when the local market price is low. However, because of tilapia's export potential (particularly the red tilapia) in Japan, Singapore, and the USA, several aquabusiness entrepreneurs have expressed interest in going into intensive tilapia farming.

Commercial grow-out tanks for red tilapia

Part 2
best practices for tilapia farming in cages

Tilapia cages in Taal Lake, Philippines

selecting the cage site

A suitable farm site is an important requisite for tilapia farming in cages. The following physical, biological, and social factors should be considered in choosing a farm site:

Peace and order. The neighborhood and the communities surrounding the farm must be peaceful. The farm must be acceptable to the community so that security and poaching do not become problems.

Proximity to markets and roads. The farm site must be near an urban center and major market where farm supplies (i.e. fuel, fish nets, rope, floats, food supplies, etc.) can be obtained, and the farm produce can be profitably sold. Access to roads and telecommunications would be an advantage.

Shelter from winds and waves. The farm site must be in areas protected from strong winds and large waves. Ideal sites are coves and inlets where the terrain of the surrounding shore areas weakens or deflects strong winds and waves.

Availability of fingerlings. The farm site must be near reputable hatcheries that could provide quality fingerlings for stocking anytime. Criteria for selection of good-quality fingerlings are given in Part 1 of this manual.

Natural food. Tilapia feed on phytoplankton and zooplankton and the farm site must be sufficiently rich in these organisms. Water abundant in plankton is brownish, bluish green, or grass green in color. Sites with frequent algal blooms must be avoided as these can become oxygen-depleted, and cause fish kills.

Water quality and circulation. The farm site must be free of harmful pollutants — for example, fertilizer and pesticide runoff from rice fields, heavy metals from industries, or sludge and decomposing organic matter from livestock farms. The farm site must have good water circulation so that the tilapia can have adequate oxygen all the time.

Type of bottom. The bottom soil type determines whether the cages can be the floating type or fixed type. Farm sites in shallow water with sandy to clay loam bottoms are better off with the fixed type cage modules, since soil will allow easy and firm penetration of bamboo poles and support for the cages. On the other hand, deep (>5m) lakes or water reservoir with rocky or loose bottom substrates favor modules of the floating type.

cage modules

Fixed module. A fixed module is made of bamboo poles or palm tree trunks staked 1-2 m deep into the bottom of shallow lakes, reservoirs, lagoons, or bays. The net cages are secured onto the bamboo poles, and are properly arranged to allow good water circulation.

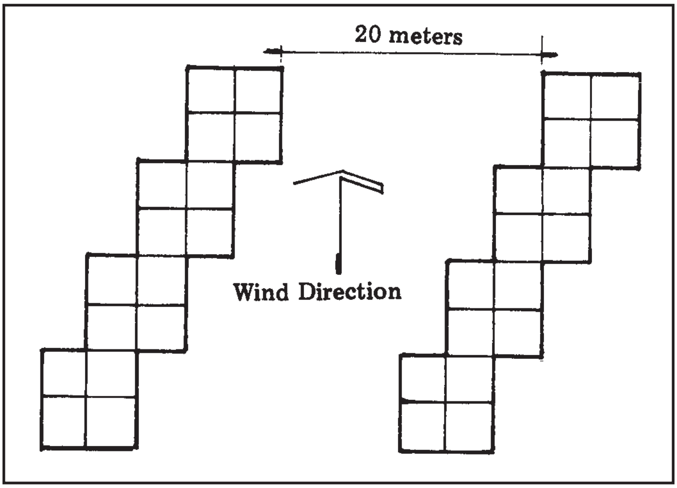
Floating module. This module stays afloat on the water but is anchored to the bottom of relatively deep lakes, reservoirs, lagoons, or bays. A floating module has four main components— the net cages that contain the tilapia stocks and exclude predators, the flotation system, the mooring system, and the module frame and working platform. The net cages are secured to the frame but move freely with the water level. The floats may be bamboo poles, empty drums, or hard styrofoam blocks. The anchors may be concrete blocks or specially designed structures attached to the bottom. The frame holds the components together and may double as floats and as working platform.

A fixed cage module

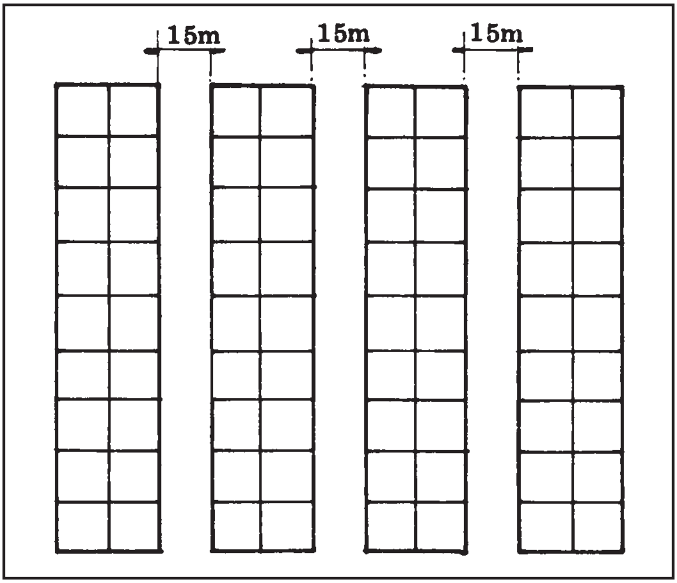
A floating cage module

arranging modules

In large-scale tilapia farming, cage modules can be arranged in rows either diagonally or parallel to each other. This way, order is maintained, water flow is not impeded too much, and operations can be done with ease — boat movements, harvesting fish, inspecting and repairing the net cages, etc.



Cage module arrangements and recommended distances between modules (Bautista, 1984)

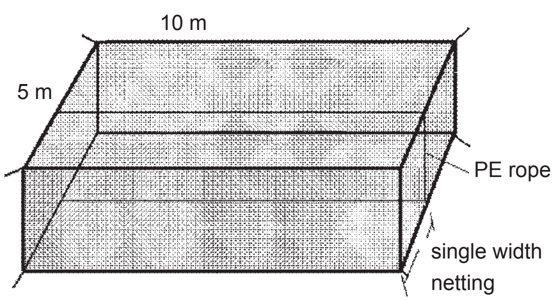


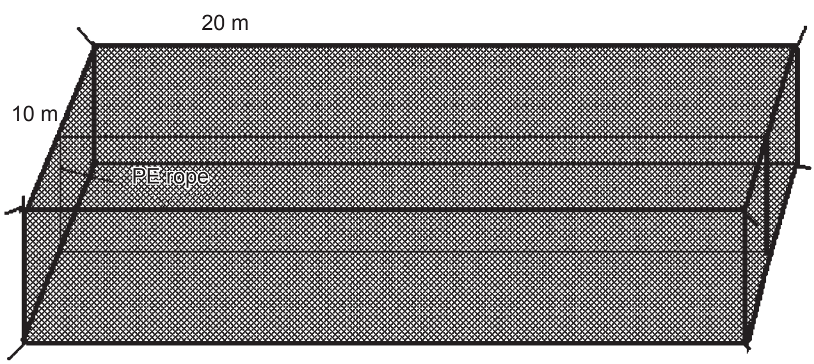
net cages

Most net cages are rectangular. Based on experience, it is easier to lift a rectangular net cage than a square net cage. It is easier for a small boat to fit and work inside a rectangular net cage especially during harvest. Moreover, it is easier and more economical to fabricate a rectangular net cage.

The cage size to be used depends on the financial and technical capability of the farmer and the requirements based on the production targets. For easy operation and management, the recommended cage sizes for tilapia grow-out range from 50 m^2 (5 m x 10 m) to 200 m^2 (10 m x 20 m). The depth of the net cage depends on the depth of the water layer with sufficient natural food. Since plankton thrive near the water surface, it is recommended that the depth of the net cages not exceed 5 meters.

A small cage measuring 5 x 10 x 2.5 m is easy to manage. One or two persons can readily lift the cage during harvest or routine inspection. Another advantage is that when a small cage gets damaged, fish loss is minimal. However, one can go for a cage as big as 10 x 25 x 2.5 m and save on materials and cost for net and frame, compared to several units of small cages.





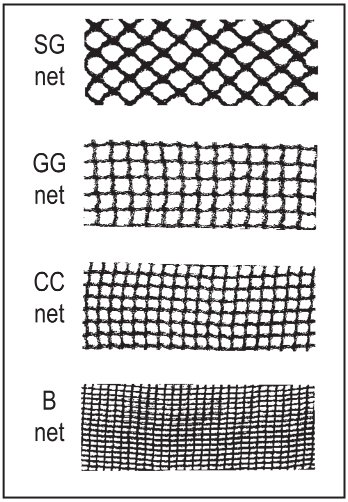
making the net cage

A net cage is made from netting sewn together to form an oversized net box suspended from the module frame. The cage has a removable net cover to keep the stocks in place. The netting material to be used depends on the intended use of the cage. For spawning net enclosures, fine-mesh netting is used. For grow-out cages, the netting is selected according to the size of the fingerlings to be stocked in the cages.

Netting materials are classified by the number of knots it has or by its mesh size. Four types of nettings are used for tilapia grow-out cages.

Nettings used for tilapia grow-out cages

Type of netting	Knots in 6 inches	Mesh size (inches)
SG net (size 12)	12	1.09
GG net (size 14)	14	0.92
CC net (size 17)	17	0.75
B net		0.19

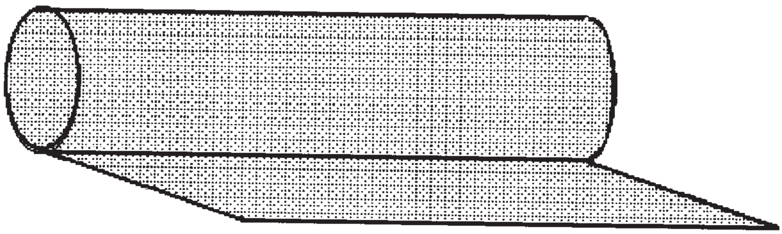


One roll of a size 17 netting is 2.5 meters wide and about 90 meters long. For one unit of net cage 5 m x 10 m x 2.5 m, 70 meters of CC net (or about one roll) is needed—30 m for the sides, 20 m for the bottom, and 20 m for the cover.

Materials for a 5 m x 10 m net cage:
- 1 roll netting, CC size 17
- 1 roll polyethylene rope, #8 or 4 mm
- 3-5 rolls nylon twine, #210/18

Materials for a 10 m x 20 m net cage:
- 2 ½ rolls netting, CC size 17
- 2 ½ rolls polyethylene rope, #8 or 4 mm
- 8 - 10 rolls nylon twine, #210/18

Materials for net cage



CC net size 17

#8 polyethylene rope

#210/18 nylon twine

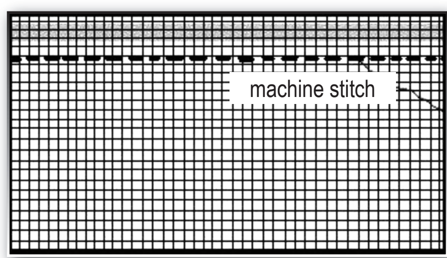
needle

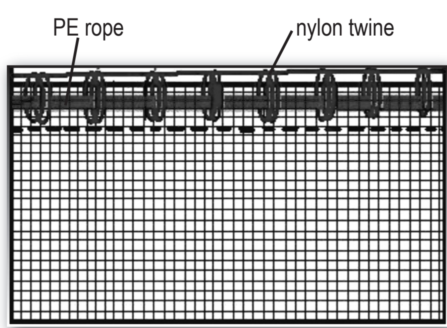
Scissors or shears

Sewing the net cage

1. Measure the desired length of netting material, add a 2 cm allowance at both ends, then cut with a pair of scissors.
2. Machine-stitch along the edges of the netting.
3. Thread a polyethylene (PE) rope through the mesh at the edges of the netting.
4. Sew together the side, bottom, and cover nets, piece by piece, until a net box is formed. Sew the edges of the nets by using clover stitches with overhand knot (see diagram).

In the Laguna de Bay area, net cages are sewn by local workers for a standard fee per unit length of material.





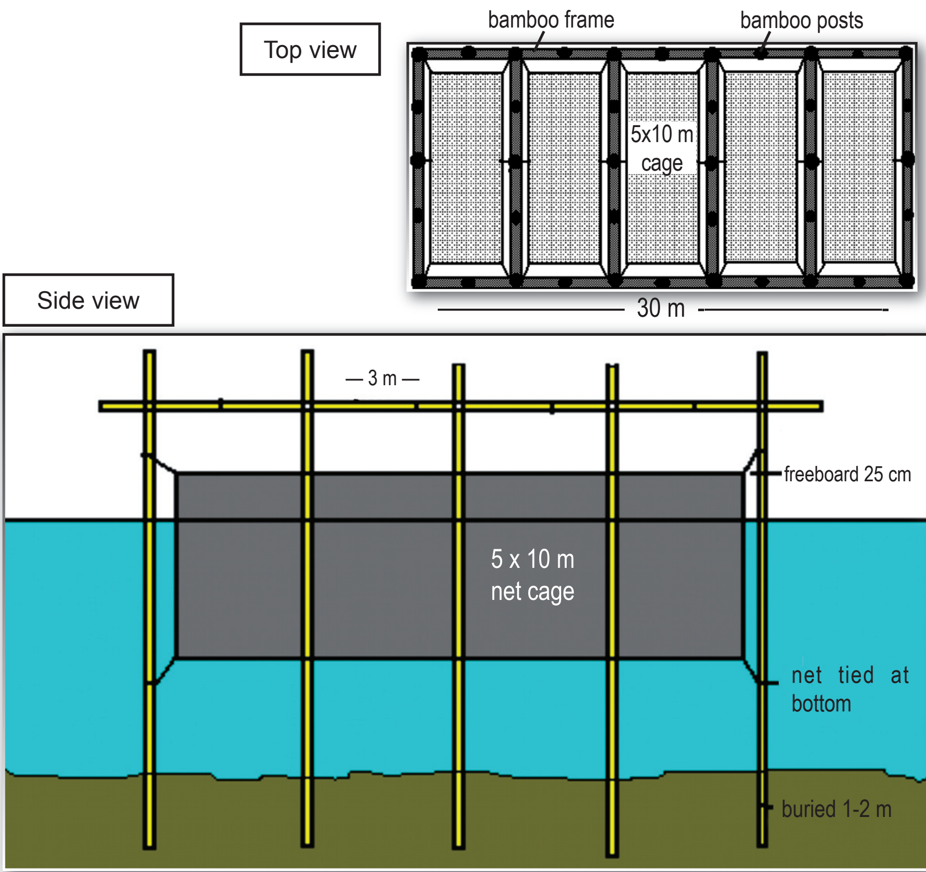
fixed bamboo modules

Bamboo poles are the most commonly used materials for fixed cage modules, at least in the Philippines, where bamboos are abundant. Bamboo poles are easy to procure and stake into the bottom manually. However, they have become more expensive, last only 3-4 years, and do not make for a very sturdy and stable working platform.

A bamboo fixed module is usually 30 meters long and 12 meters wide, and holds 5 net cages, each 5 m x 10 m (see diagrams below). The vertical posts are staked 3 meters apart and 1-2 meters deep into the sediment. The horizontal frame is kept 2 meters above the water. Each net cage is secured to six posts.

Materials needed:

- 40 bamboo poles (for vertical posts)
- 10 bamboo poles (for horizontal frames)
- rope for securing bamboo poles in place



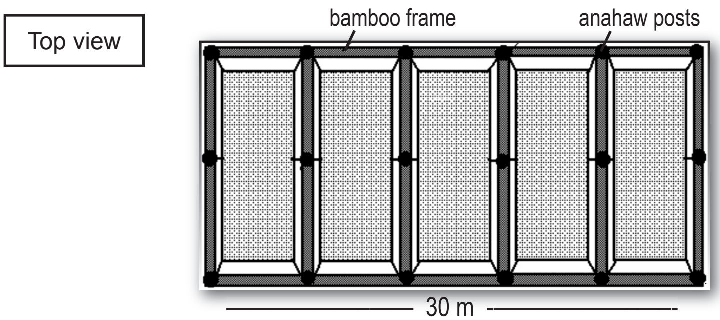
fixed anahaw modules

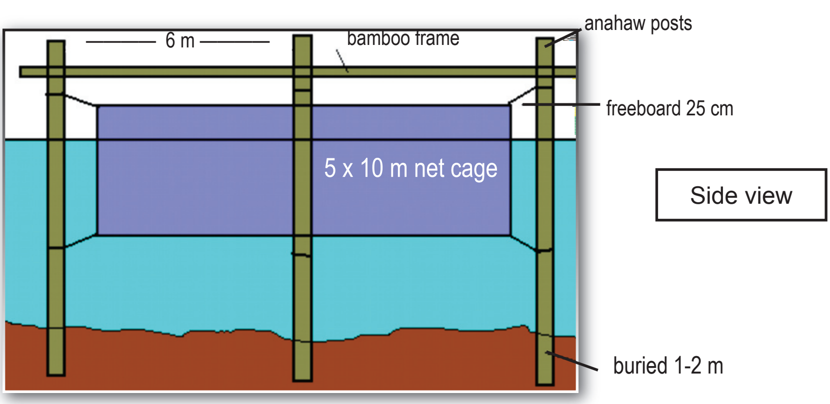
Anahaw trunks (from the palm tree *Livistonia rotundifolia*) are cheaper, sturdier (especially during typhoons), lasts longer (10 years), and provide a more stable working platform than bamboo poles. However, anahaw trunks have limited sources and require special equipment for staking into the bottom.

An anahaw fixed module is 30 meters long and 12 meters wide, and holds 5 net cages, each 5 m x 10 m (see diagrams below). The anahaw vertical posts are staked 5 meters apart and 1-2 meters deep into the sediment. The bamboo horizontal frame is kept 2 meters above the water. Each net cage is secured to six posts.

Materials needed:

- 18 anahaw trunks (for vertical posts)
- 10 bamboo poles (for horizontal frames)
- rope for securing bamboo poles and anahaw trunks in place





stocking fingerlings

When the cages are ready for stocking, the tilapia fingerlings are transported from the hatchery to the farm. The fingerlings are allowed to adjust gradually to the water temperature and salinity in the cages before they are released —in order to prevent stress and diseases. So the sealed transport bags are allowed to float in the cage until the water temperature in the bags becomes equal to that in the cage. If transport boxes or boats are used, the water in them must be gradually diluted with water from the cage.

A cage 10 x 20 x 2.5 m may be stocked with fingerlings (3-4 cm or 10 grams) at densities of 10-15/m^3 of net cage. After stocking, the fingerlings need very little care, at least in plankton-rich farming areas where feeding is not necessary. Higher stocking densities may be used, as high as 50-200/m^3, but feeding then becomes necessary.

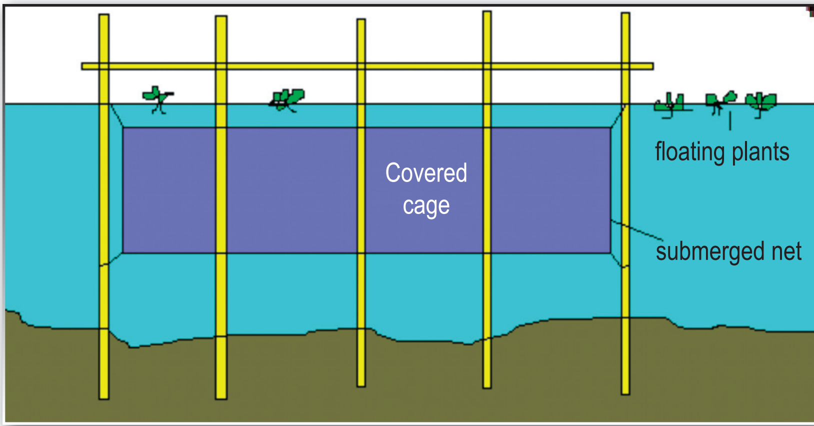
feeding tilapia

Tilapias are omnivorous— they eat almost any available food, from microscopic phytoplankton to zooplankton, bottom invertebrates, and detritus. They also readily eat rice bran, copra meal, stale bread or pastries, and commercial feed pellets. They eat frequently and digest their food thoroughly. Because of their feeding behavior, tilapias grow fast and survive well in different farming systems.

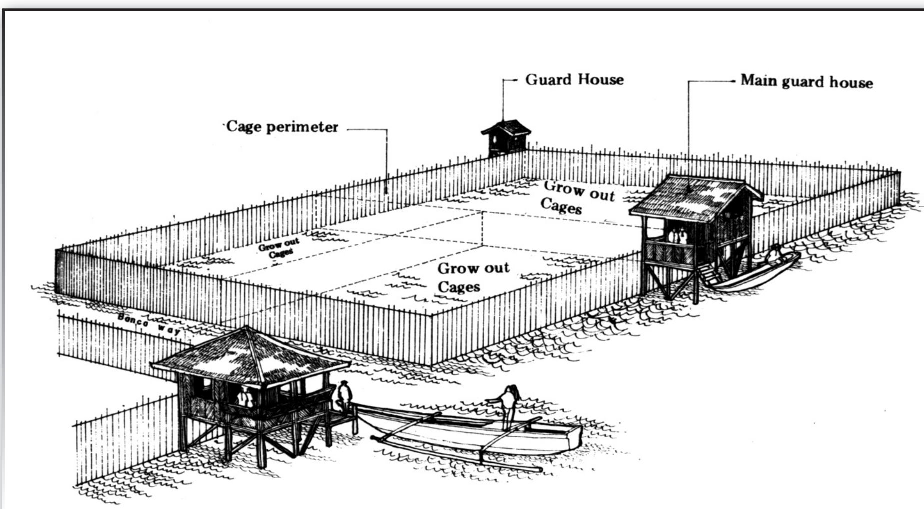
The SEAFDEC-formulated diet for Nile tilapia consists of fish meal (18.25% of the dry diet), soybean meal (25%), copra meal (10%), rice bran (6%), cassava flour (36.42%), vitamin-mineral mix (4.33%). This diet contains 28% crude protein, 4% crude fat, 4% crude fiber, 54% carbohydrate, and 10% ash. A variety of formulated diets for tilapia are now commercially available, mostly containing 25-30% crude protein. The recommended feeding rate is 3-7% of the fish biomass per day, given in 2-3 rations. Tilapias prefer dry pelleted diets than moist or ground diets. The water temperature, fish size, feed quality, and presence of natural food affect feed intake in tilapias. It is best to observe the fish eating, and give only as much feed as they eat.

maintaining cages

Net cages are regularly inspected for torn and worn out portions that must be repaired immediately to prevent escape of the fish stocks. The net cages must be cleaned at least once every two weeks depending on the extent of clogging. During bad weather, the net cages must be covered with netting and submerged 30-60 cm below the water surface so they will not be destroyed by floating debris and water hyacinths. Some farms have strategically located guard houses to protect the fish stocks from poachers.



Net cages covered with netting and submerged 30-60 cm below the water surface



A lake-based tilapia farm with a guard house (Bautista, 1984)

harvesting

In most countries, the preferred market size for tilapia is 350-500 grams, but in the Philippines, 150-200 grams is considered already marketable. Under favorable conditions in eutrophic lakes such as Laguna de Bay in the Philippines, it takes about six months for caged tilapia to grow from 10 grams to 150-200 grams (about 5-7 fish /kg), feeding only on natural food. However, in oligotrophic lakes such as Lake Taal in the Philippines, it takes full feeding with commercial pellets for four months to reach the same size. When the market price allows good profit, larger tilapia may partially harvested (this also usually improves the growth of the remaining fish).

At least two persons are needed to lift a 5 m x 10 m net cage during harvest. For bigger cages, at least 3-4 persons are needed to lift the cage from a small boat.

To lift large net cages from a small boat

1. Untie the net cages from the frames, posts, or anchor.
2. Get the banca inside the cage and position it at one end of the cage that is of the same length as the boat.
3. Slowly pull the net cage towards the hull of the banca.
4. Lift the net onto the banca, making sure no fish gets stuck in the net.
5. When fish are gathered in the remaining submerged part of the net cage, carefully scoop out the marketable-size fish.
6. After all the large fish have been harvested, return the net cage into the water.
7. Tie the net cage back in place.
8. Sew back the cage cover to keep the remaining fish for further on-growing.

Harvesting red tilapia from net cages

Part 3

best practices for tilapia farming in ponds

selecting the pond site

A suitable farm site is an important requisite for tilapia farming in ponds. The following physical, biological, and social factors should be considered in choosing a farm site:

Peace and order. The neighborhood and the communities surrounding the farm must be peaceful. The farm must be acceptable to the community so that security and poaching do not become problems.

Proximity to markets and roads. The farm site must be near an urban center and major market where farm supplies (i.e. fuel, fish nets, rope, floats, food supplies, etc.) can be obtained, and the farm produce can be profitably sold. Access to roads and telecommunications is an advantage.

Topography. The farm site must be safe from flooding, soil erosion, waves, and storms. The lay of the land must be such that water can easily flow in and out of the pond without need for a water pump.

Water supply. The farm site must have an abundant supply of clean water. Water may come from rivers, streams, irrigation canals, etc. It is also advisable to have a deep well with pump. The water source must be free of harmful pollutants — fertilizer and pesticide runoff from rice fields, heavy metals from industries, or sludge and decomposing organic matter from livestock farms.

Soil type. The clay loam type of soil is best for ponds. This type of soil is ideal for natural food production and has properties that prevent leakage of water out of the pond. To determine the soil type, soil samples may be taken for analysis at a soil laboratory normally associated with agriculture agencies or universities. The laboratory personnel can also give advice on the kinds of fertilizers to use for given soil types.

Availability of fingerlings. The farm site must be near reputable hatcheries that could provide quality fingerlings for stocking anytime. Criteria for selection of good-quality fingerlings are given in Part 1 of this manual.

farming intensity

Pond systems vary in the level of inputs and management invested by the farmer, and in the resulting yields.

The **extensive system** entails proper pond preparation to get rid of unwanted species and promote the growth of natural food, on which the tilapia feed. Periodic application of fertilizers is necessary to sustain the growth of natural food. Fertile ponds can support stocking densities of 1-2 tilapia fingerlings/m^2 for 6 months until harvest. Water exchange is minimal. Yields per unit area depend on pond productivity, relatively low, but so are the costs.

The **semi-intensive system** uses moderately high stocking densities of 3-4 tilapia fingerlings/m^2. Adequate pond preparation and periodic application of fertilizer are necessary to produce sufficient natural food. Supplemental food or commercial tilapia diet is provided on the third at 2-3% of the total fish biomass daily. Regular water exchange is necessary to maintain optimum water quality. Additional costs are incurred for feeds, but the yields are higher, 1-3 tons per hectare, of 150-200 gram fish.

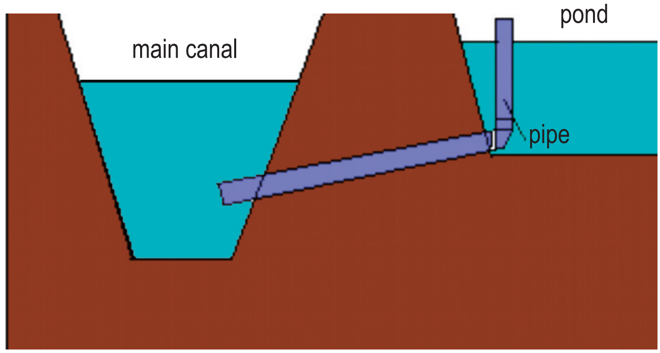
The **intensive system** is ideal where land is limited or expensive. Stocking densities are 5-10 fingerlings/m^2 and commercial feeds are given at 3-5% of fish biomass daily throughout the growing cycle. Life support systems are essential for water quality management— paddlewheels to maintain high dissolved oxygen and pumps to allow daily water change (5-10% of the volume). Some farms use probiotics to maintain good pond conditions. Production costs are high, but the yields are also high, about 5-15 tons per hectare, usually of 300-gram fish. Without proper management, intensive ponds become polluted, diseases may set in, and mass kills may occur.

Intensive ponds for tilapia

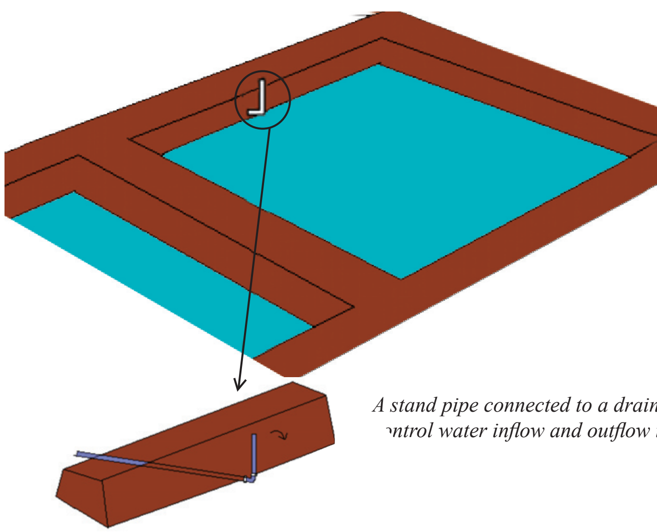
making ponds

For large-scale farms, it is important to consult a civil engineer for the proper pond design. Fish ponds greater than one hectare require digging equipment (backhoe, etc.). For smaller farms, ponds may be dug or diked manually, given enough workers. A depth of at least 1-1.5 meters is ideal for small fish ponds. The elevation of the main water canal must be lower than the elevation of the fish pond, so that water outflow is easier.

Fish ponds must have a structure to control the flow of water in and out. For ponds smaller than 500 m^2, a stand pipe connected to a drain pipe by an elbow may be installed at the deepest end of the pond. Or a culvert may be used. Ponds larger than 500 m^2 must have a sluice gate to control the inflow and outflow of water .

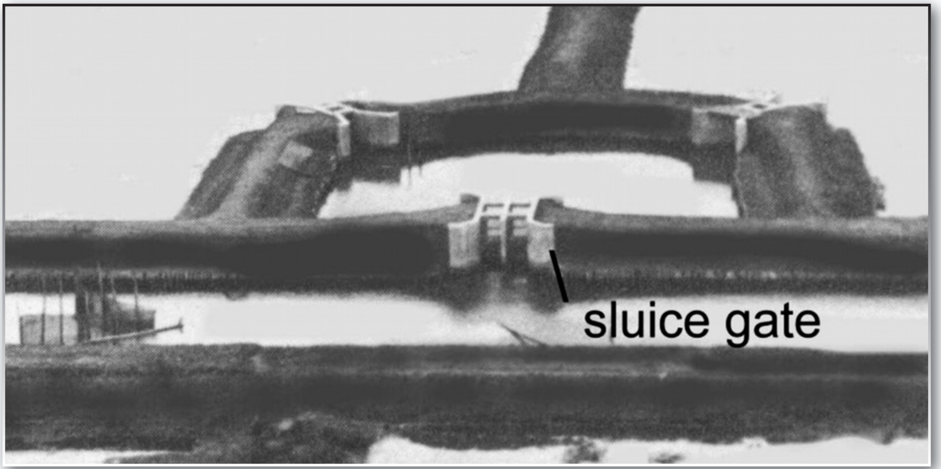


Pond must be at least 1 m deep and elevated higher than the main canal



A stand pipe connected to a drain pipe by an elbow can ntrol water inflow and outflow in a small pond

Small pond with water inlet; drained for pond preparation



Large ponds have sluice gate to control water inflow and outflow

pond reservoir

If the pond water comes from irrigation, river, or stream, it is advisable to construct a water reservoir. The reservoir should have an area of at least ¼ the total area of the grow-out ponds to ensure sufficient water supply in the farm. The reservoir may be stocked with a few tilapia to serve as indicators that the water is safe.

preparing ponds

To prepare fish ponds for stocking, the pond bottom is sun-dried to kill unwanted organisms. Lime is applied to stabilize the soil and water pH (but lime is unnecessary when the pH of the bottom soil is above 7.5, and the alkalinity of the pond water is above 50 mg/liter of $CaCO_3$).

To protect the farmed stock and ensure a good harvest, farmers get rid of unwanted organisms—potential competitors, predators, pests, and parasites. Natural toxins such as derris root, teaseed cake, rotenone, saponin, tobacco dust, as well as lime and ammonia fertilizers, work against pests. Twelve hours after application of the toxins, all dead organisms are collected. A two-week period is allowed for the pond to be rid of the toxins. To test for residual toxicity, fish are stocked in a cage set in the pond. If the test fish survive and show no adverse reaction, then the pond is ready for stocking.

Natural toxins, doses, and application

Toxin, Dose (g/m^3)	Ways to prepare and apply
Derris root 20-40	Cut fresh derris roots into small pieces. Soak in water overnight, extract rotenone by squeezing, dilute, and mix with pond water.
Tea seed cake 50-70	Soak dried and finely ground tea seeds in lukewarm water for 24 hours. Dilute and mix with water in ponds.
Rotenone 20	Dissolve amount required in pond water.
Saponin 2-5	Dissolve amount required in pond water.
Tobacco dust 30	Dissolve amount required in pond water.
Quick lime 200-300 g	Mix 1 part quick lime to 4 parts water and spread mixture over the pond bottom.
Hydrated lime 300-460 g	Broadcast lime over the dry pond bottom. In partially irrigated ponds, apply as uniformly distanced heaps.

From Coche et al. (1996)

natural food

In extensive and semi-intensive ponds, production of natural food is very important. Fertilizers are applied to the pond to promote growth of plankton, the food of tilapia. Commercial inorganic fertilizers provide ammonia, nitrate, phosphate, potassium, and other limiting nutrients for algal growth. Natural fertilizers are usually agricultural and livestock wastes that contain a mixture of organic matter and mineral nutrients. Farmers usually apply both kinds.

Basal fertilizer application is done after draining, plowing, and liming and before introducing water into the pond. Organic fertilizer (poultry droppings or cow and pig manure) is broadcast over the pond bottom at a basal rate of 2-3 tons/ha. Water is gradually allowed into the pond (over three days) to a depth of 20 cm. The pond is left to stand for 2-3 days until algae are seen growing. The water level is then increased to 75-100 cm. The pond is ready for stocking when the color of the water becomes green.

Periodic fertilizer application is done every two weeks, at a lower than basal rate to sustain the plankton production. There are four methods of periodic application:

- Broadcast: commercial fertilizers are broadcast at 10% of the basal rate
- Heap method: fertilizer is distributed in heaps along the dikes
- Hanging method: sacks half-filled with organic fertilizer are hung in the corners of the pond to be distributed by wind-induced waves or currents
- Platform method: fertilizer is submerged 10-20 cm below the water surface from a platform

Pond being prepared to grow natural food

stocking fingerlings

When the ponds are ready for stocking, the tilapia fingerlings are transported from the hatchery to the farm and must be gradually acclimated to the pond salinity and temperature. The sealed transport bags are allowed to float in the ponds until the water temperature inside the bags is equal to that of the pond water. The bags may also be opened and pond water gradually added to the bags.

Fingerlings of GIFT tilapia

water quality

Pond conditions must be maintained within the optimum range for tilapia to ensure good health and fast growth. Tilapias tolerate wide ranges of salinities and water temperatures. Nile tilapia tolerates temperatures from 8ºC to 42ºC but the normal tolerance range is from 17ºC to 35ºC. Although mainly freshwater species, many tilapias can grow in saline environments. Red tilapias grow faster in sea water.

Tilapias are generally hardy and tolerate poor water quality. In fact, some tilapias are able to survive in habitats with dissolved oxygen as low as 1 mg/l or 1 ppm. Some tilapias live and reproduce in swamps and shallow lakes where oxygen depletion occurs regularly.

Water quality requirements of farmed tilapia (Balarin and Haller, 1982)

Water variable	Tolerance range
Temperature (ºC)	8-42
Salinity (ppt)	<20-35
Critical oxygen level (mg/l)	0.1-3.0
pH	4-11
Lethal ammonia levels:	
Total (mg/l)	>20
NH_3-N (mg/l)	2.3 (0.5*)
Lethal CO_2 concentration (mg/l)	>73
Nitrite tolerance limits: LC_{50} (mg/l)	2.1

* level at which growth is affected

maintaining ponds

Aside from the capital investments and seed and feed inputs, farmer practices help ensure successful tilapia production. Some of the DO's:

- Maintain water depth at 100 cm — shallow water is conducive to the growth of natural food, which supports tilapia growth.
- Prevent entry of predators into the ponds by installing screens at the water inlet and outlet. Predators reduce the tilapia yield.
- Remove aquatic weeds — they compete with phytoplankton in ponds, and reduce fish growth.
- Prevent contamination of pond water with agricultural pesticides, especially in water from an irrigation system.
- Maintain the growth of natural food by applying fertilizers periodically.
- Monitor water quality and ensure adequate dissolved oxygen and low ammonia.

harvesting

Tilapia may be harvested from ponds when the fish reach marketable size (150-300 grams; 3-7 fish/kg). There are two methods of harvesting marketable size tilapia from fish ponds:

Total harvest. This is done on the sixth month after initial stocking. All the fish are harvested regardless of size. Harvesting is done after the pond has been totally drained of its water.

Selective harvest. Selective harvesting is done when the market demand for tilapia is not high. The larger fish are harvested on the fourth month from stocking. More fish may be harvested every 2-4 weeks. The smaller fish are able to grow until the next scheduled harvest.

Different sizes of tilapia can be marketed.

packing for market

It is the responsibility of fish farmers to ensure that they produce and market wholesome products. Harvested tilapias must be handled properly to maintain the freshness of the product all the way to the market and the consumer's kitchen. One way to keep fish fresh is to pack or stack the fish alternately with ice in galvanized iron buckets, or insulated plastic fish boxes. Another way is to place newly harvested live tilapia in aerated transport tanks.

Pickup trucks transporting live tilapia in aerated tanks

agencies for tilapia r&d in the Philippines

[1] **Southeast Asian Fisheries Development Center Aquaculture Department** (SEAFDEC/AQD)
Binangonan Freshwater Station
Tapao Point, Binangonan, Rizal 1940
Email: bfs@aqd.seafdec.org.ph

[2] **Aquaculture-Based Countryside Development Enterprises Foundation, Inc.**
(ABCDEF Inc.)
ABCDEF Farm and Training Center
Brgy. Punta, Jalajala, Rizal

Bureau of Fisheries and Aquatic Resources (BFAR)
Department of Agriculture
860 Quezon Avenue, Quezon City 3008
Tel (02) 374-2065, (02) 371-1173, (02) 927-7075

Philippine Council for Aquatic and Marine Resources Research and Development (PCAMRRD)
College , Los Baños, Laguna 4031
Tel (49) 536-5578, Fax (49) 536-1582

University of the Philippines-Visayas
Brackishwater Aquaculture Center (BAC)
Leganes, Iloilo

[3] **BFAR National Freshwater Fisheries Technology Research Center (BFAR-NFFTRC)**
Central Luzon State University Compound
Muñoz, Nueva Ecija 3120

Central Luzon State University
Freshwater Aquaculture Center
Muñoz, Nueva Ecija 3120

[4] **Phil-FishGen**
Freshwater Aquaculture Center
Muñoz, Nueva Ecija 3120
Tel (044) 456-0682, Fax (044) 456-0683
Email: p-fishgn@mozcom.com

[5] **Aquatic Biosystems**
Calauan, Laguna

[6] **Bioresearch**
Dr. A. Santos Ave.
Sucat, Parañaque City

[7] **GIFT Foundation International Inc**.
Tilapia Science Center
CLSU Campus
Muñoz, Nueva Ecija 3120
Tel (044)456-0673

[8] **FYD International Corporation**
VY Domingo Bldg.
6th St., Bacolod City 6100
Tel (034) 4339501, Fax (034)433-9507
Email: fyd@mozcom.com

[9] **Genomar Supreme Philippines, Inc.**
Rm. 604, SEDCCO I Bldg.
Rada corner Legaspi Streets
Legaspi Village, Makati City
Tel (63-2) 8938478, Fax (63-2) 8938517
Or: Barangay Prado Km 98
Lubao, Pampanga

WorldFish Center-Philippines
Khush Hall, IRRI
College, Los Baños, Laguna 4031
Tel (63-49) 536-2701, Fax (63-49) 536-0202
Email: worldfish-philippines@cgiar.org

[1,2] produces SEAFDEC-selected tilapia (SST); conducts training courses in tilapia breeding, hatchery, nursery, and grow-out in tanks and lake cages
[3] produces GET-EXCEL Tilapia; conducts training courses in tilapia hatchery operations
[4] produces GMT Tilapia
[5] promotes SRT (sex reversed) tilapia and the sex reversal method
[6] produces red tilapia
[7] produces GIFT tilapia
[8] produces Jewel tilapia
[9] produces Supreme tilapia

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RUEL V. EGUIA has been with the SEAFDEC Aquaculture Department for almost two decades, starting as a Technical Assistant and now as Aquaculture Research Specialist. From the job, Ruel acquired extensive knowledge in the breeding and farming of freshwater fishes such as carps and tilapias.

At present, Ruel is overseeing the commercial tilapia hatchery operations at the ABCDEF Inc. in Jalajala, Rizal. He also serves as lecturer and practical instructor in Freshwater Aquaculture and other training courses at SEAFDEC/AQD.

Ruel completed his MSc Aquaculture at the Universiti Putra Malaysia in 1999 and his BSc Inland Fisheries at the Central Luzon State University in 1982. He trained in fish genetics in Canada in 1990 and in freshwater aquaculture in Malaysia in 1995. Ruel also learned on-farm skills from working in various private fish farms and hatcheries, including a stint as Fish Hatchery Supervisor at the Saudi Fisheries Company in Dammam, Kingdom of Saudi Arabia.

MARIA ROWENA R. ROMANA-EGUIA has been with the SEAFDEC Aquaculture Department since 1982 and is now an Aquaculture Research Specialist engaged in tilapia genetics. Her publications on genetic characterization and stock comparison and selection in Nile tilapia and red tilapia have won two Elvira O. Tan Memorial Awards as Best Published Paper in Aquaculture in 1995 and 2004 from the Philippine Council for Aquatic and Marine Research and Development of the Department of Science and Technology.

At present, Rowena is developing methods for increased tilapia seedstock production and the use of molecular markers in the management and selective breeding of farmed tilapias. She is also the Training Coordinator at the Binangonan Freshwater Station of SEAFDEC/AQD and serves as lecturer on topics like fish genetics and tilapia hatchery and nursery operations.

Rowena finished her BSc Zoology at the University of the Philippines in 1982, and her MSc Genetics from the University of Wales, Swansea, United Kingdom in 1984, the latter through a scholarship grant from the International Development Research Centre of Canada. Rowena obtained her PhD Agricultural Science (major in Fish Population Genetics) from the Tohoku University as a Ronpaku Fellow of the Japan Society for the Promotion of Science from 2001 to 2003. Rowena also had some training in biotechnology in Japan and local research agencies.

The Southeast Asian Fisheries Development Center (SEAFDEC) is a regional treaty organization established in December 1967 to develop fisheries and aquaculture in the region in response to the global food crisis. From the original five Member Countries — Thailand, Singapore, Philippines, Malaysia, and Japan (as the Donor Country) — SEAFDEC now includes Brunei Darussalam, the Socialist Republic of Viet Nam, Myanmar, Indonesia, and the Lao People's Democratic Republic, or the same ten countries as in the ASEAN, the Association of Southeast Asian Nations.

The policy-making body of SEAFDEC is the Council of Directors, representing the Member-Countries. The chief administrator of SEAFDEC is the Secretary-General, whose office, the Secretariat, is in Bangkok, Thailand.

SEAFDEC has four Departments to carry out its objectives:

TD — Training Department in Samut Prakan, Thailand, established in 1967, for development of marine capture fisheries, mostly through training of fishermen and technicians

MFRD — Marine Fisheries Research Department at Changi Fisheries Complex in Singapore, established in 1967, development of marine fisheries, mostly through research and technologies in post-harvest processing

AQD — Aquaculture Department in Iloilo, Philippines, established in 1973, for development of aquaculture, through research, technology verification and demonstration, training, and information dissemination

MFRDMD — Marine Fishery Resources Development and Management Department in Kuala Terengganu, Malaysia, established in 1992, for development and management of the marine fishery resources in the exclusive economic zones of the SEAFDEC Member Countries.