Adaptability and Growth Performance of Nile Tilapia (*Oreochromis niloticus*) Fish in Small Scale Water Harvesting Ponds, East Gojam and South Wollo

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Abstract

Irresponsible activities on the capture fisheries sector coupled with improper management has led over fishing of most terrestrial waters. Therefore, more attention has been given to fish farming (aquaculture) in the developing countries. Currently aquaculture contributes over 30% of the fish consumed throughout the world. The production target from this sector by the year 2030 is over 50%. A research was conducted in two zones of Amhara Region for two years (from 2009 to 2010) to integrate fish farming with backyard vegetable production to supplement family food source. Nile tilapia (O. niloticus) fish fingerlings have been stocked in concrete water harvesting ponds constructed by the Sustainable Water Harvesting and Institutional Strengthening in Amhara (SWHISA) project in East Gojjam and South Wollo zones of the region. The concrete ponds had two different kinds of shapes; circular and rectangular. A total of 9 farmers (3 circular and 6 rectangular) from the two zones had been selected. Each pond had a capacity to store 90 to 200 m^3 water. About 800 Nile tilapia fish (cichlid) fingerlings, 10 to 70 g in size, were stocked. The total number of fish stocked in each pond varied from 30 to 210. The experimental fish were supplemented (at a rate of 5% ofthe biomass of the fish) with mixed meal of bran, oilcake and fish milling. Fish samples were taken every two months to evaluate their growth performance through time. The ponds were supervised and managed regularly to keep the water at its optimum quality required for fish growth in a grow-out pond. The growth of fishes differed depending on place (altitude), structure, fish size and the pond water temperature fluctuations. The fish in circular shaped concrete ponds failed to grow very well, but 95% of the fish stocked in the rectangular ponds had faster growth performance. Bigger fingerlings (70 g) stocked at rectangular shaped ponds reached the recommended table size (180 g and more) within 7 months of time. But those with smaller and medium size (below 40 g) could not attain the expected size during one experimental time (7 months). The result of this research trial assured the possibility of integrating fish farming with backyard agricultural production in water harvesting practices to sustain the livelihood and availability of additional food for the family.

Key words*:* Aquaculture, Altitude, Fish farming, Water harvesting ponds,

Introduction

Water is a universal need and is considered as a limiting factor for human and other pshbojtnt! mjgf/! Eftqjuf! uif! xbufs! tpvsdf! bwbjmbcmf! jo! obuvsf!)xifuifs! tubhobou! ps! running), it is possible to trap water infiltrated from rain. Water harvesting is practice of collecting and storing water in ponds from different sources for beneficial use. It is the way to help assure adequate water supplies for household, agriculture, fish culture and other uses available to farms and communities. Those designed for livestock watering and irrigation must be built near the use they serve and also contain adequate water (Helfrich and Pardue, 1997). Ponds constructed for fish and wildlife production or recreation are designed and constructed for (1) easy access, (2) adequate volume and, (3) water level manipulation. Farm ponds can be designed and built to serve multiple purposes with advanced planning. Pond fish culture is the most popular method of growing tilapia. One advantage is that the fish are able to utilize natural foods (Rakocy and Mc Ginty, 2005) and farmers can receive higher net returns from fish farming integrated with crop cultivation using the harvested water. Even small ponds can contribute to farm income or reduce family spending as fish are sold, bartered or eaten.

The various types of aquaculture form a critical component within agricultural and farming systems development that can contribute to the alleviation of food insecurity, malnutrition and poverty reduction through the provision of food of high nutritional value, income and employment generation, decreased risk of production, improved access to water, sustainable resource management and increased farm sustainability (Little and Edwards, 2003). Aquaculture, especially integrated one, is sustainable because it makes use of locally available materials. Integration with other forms of agriculture diversifies farm productivity; provide opportunities for intensified production with more efficient allocation of land, water, labor, equipment and other limited capital than enterprises which run independently. Fish culture integrated with garden irrigation, livestock watering and various domestic uses are all possible.

Production cost of fish, if the ponds are constructed once, is lower when compared with poultry, beef and pork. According to Rakocy and Mc Ginty (2005) approximately 22 kg of fish can be produced from an acre of pond per year. Fish convert food in to flesh efficiently as they are essentially weightless in water, and thus expend little energy for locomotion or maintain a normal upright position. They are cold blooded animals and do not expend energy to maintain a relatively high body temperature as other warm blooded ones. Thus, the amount of energy required to produce one kg of fish is much less than the amount required producing an equal weight of terrestrial animal.

Tilapia are growth rates at temperatures between 25 and 30°C (Bocek, 2003), making them more likely to become established extremely tough fish that can thrive in poor quality water on low-cost feeds (Bronson, 2005). They exhibit maximum and invasive in tropical climates. Nile tilapia (O. niloticus) is the least cold tolerant of the farmed tilapia and prefers tropical to subtropical climates. Nile tilapia (O. niloticus) is the most predominant species of tilapia in aquaculture (Gupta and Acosta, 2004) and well adapted to artificial culture environments, gain weight quickly at optimum conditions and reproduce on the farm without special management or infrastructure. Nile tilapias (O. niloticus) reach sexual maturity at about 5 to 6 months (Gupta and Acosta, 2004). The usual fingerling size supplied for grow-out ponds is mostly 1- 3 g. Growth rate is very rapid during fingerling stages. During these stages they have different biological characteristics from adults, especially in terms of feeding habits, growth and habitat preferences. The growth rate declines as the fish gets older.

If the natural productivity of a pond is increased through fertilization or manuring significant production of tilapia can be obtained without supplemental feeds. To maximize fish production, manure should be added daily to the pond in amounts that do not reduce dissolved oxygen (DO) to harmful levels as it decays. The ponds were fertilized by using organic fertilizers mostly from livestock sources at a rate of 10 kg for cattle, equine and sheep/goat manure and 6-8 kg for chicken in a 100 m^2 ponds every week. The maximum rate was determined on the quality of manure, oxygen supply in the pond and water temperature.

The rate of manuring should be increased gradually as the fish grow (Rakocy and McGinty, 2005). Lime was applied at a rate of 1500 kg/ha to neutralize the pond water and promote the growth and multiplication of important planktons for fish.

The communities in many tropical food insecure areas basically lack water for drinking and irrigation. Apart from lower crop production, livestock productivity is getting low up! ui f! fyufou! ui bu! dpvmeo u! n eet the protein requirement of the household. This leads malnutrition to be the single greatest cause of child mortality in Ethiopia, caused 470 Ethiopian children to die every day because of protein-energy malnutrition (Linkages project, 2001).

To minimize this health hazard, alternative protein sources should be sought and fish could potentially be integrated with the water harvesting structures. Fish culture using these structures could be one of the best options among the possible integrations. Thus, this experiment was conducted to evaluate the adaptability of Nile Tilapia on water harvesting ponds and demonstrate the possibility of integration of fish farming in these tusvduvsft! voefs! tn bmm! ipmefs! gbsn fst! dpoejujpo/

Materials and Methods

Study areas

The project was done in two zones of the Amhara region; namely East Gojjam and South Wollo. Six ponds among the other ones constructed by SWHISA were selected and stocked with target species of fish; three ponds from Goncha Siso Enesie and the other three from Were-Illu weredas. NileTilapia male fingerlings reared from on-station ponds were stocked to the ponds. The pond water in both study areas were fertilized using animal manure prepared by farmers.

Methods

Lime was applied at a rate of 1500 kg/ha before stocking. Fish fingerlings were packed in a 50 l polythene bag filled with half water and half oxygen. Each polythene bag that held fish were placed in big plastic bucket and transported. Water parameter readings and fish weight had taken before and after stocking. The fish were kept for 7 months from September till March.

The fish were supplemented with mixed feed of oil cake, bran and fish millings at a rate of 3:3:1 for the first three months where the fingerlings are expected to grow faster. Feeding rate was adjusted on a monthly basis by estimating the fish biomass in the pond. To determine the fish biomass, fish fingerling samples were caught and weighed. The average weight of fish in the sample was multiplied by the number of fish stocked and alive.

Nile Tilapia fingerlings of different sizes, 10 - 20, 21 - 40 and 41 - 70g were used to test the growth performance and demonstrate the integration of tilapia fish in water harvesting ponds. The ratio of small, medium and big sized fingerling was 1:1:1 and the stocking density was 2 fish per square meter. The total number of fish fingerlings stocked in all experimental ponds was 600. Measurement has been made, every two months, on the biological and physical parameters of pond water using probes and kits as well as growth of fish using measuring board and balance. During sampling, as it is very difficult to count the whole fish stocked in the pond and compare with the original population, 20% of the fish was taken randomly for sampling (weight and length measurements). The experiment was conducted for 7 months in 2009 and 2010 (September to March) and all the fish in a pond were harvested at the end of the experimental period.

Result and Discussion

Effectiveness of the pond water for fish

Rectangular shaped concrete ponds were very good; rich in plankton, easy to add supplemental feed, easy to manage the fish, reliable to fertilize the pond water and take samples of water and fish compared to circular ones. The rectangular pond has got fertilized within 5 to 7 days after the addition of manure. The plankton species number, abundance and distribution was better than circular ones. This could be due to the larger surface area of the pond water exposed to sunlight which in turn helps an active photosynthetic activity to take place.

There was no any record of over fertilization of pond water in all areas. But, in a circular pond from East Gojjam, the level of water dropped to 40 cm during the 4th month after stocking and this event resulted temperature fluctuation. The pond water temperature had fluctuated frequently from the optimum level for Nile Tilapia. It had even dropped to lethal level (below 2 ^{0}C) and all fish died within a day.

Once manure (cow dung) was applied, the pond has got fertilized and become rich in plankton. Circular ponds with limited entrance of sunlight had very low plankton biomass. The population of phytoplankton and zooplankton in rectangular ponds was much greater than circular ponds (Fig.1) indicating the suitability of rectangular ponds for fish production. Among the zooplankton, moina were the dominant species and their number varied in between 37 and 80 per milliliter, with an average of 55/ml of water. The average population of phytoplankton in circular ponds was 26/ml of water. The zooplankton diversity and population was higher also in rectangular wider ponds than circular ones.

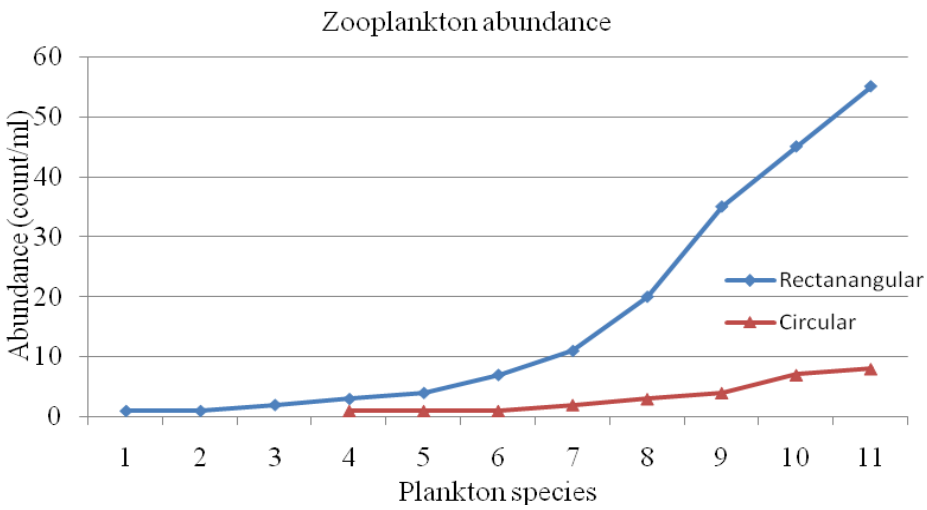

Figure 2 Zooplankton diversity in different structures. *Note:- 1 = Mytilia, 2 = Keratella, 3 = Cyclopoid, 4 = Filinia, 5 = Diaphanosoma, 6 = Nuplia, 7 = Branchionus, 8 = Diffuligia, 9 = Lepadela, 10 = Asplanchna and 11 = Moina.*

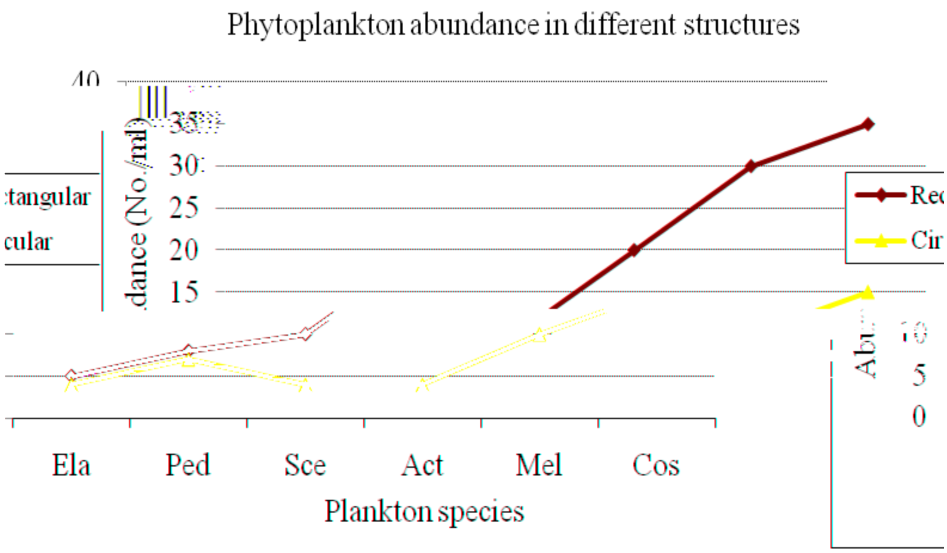

Figure 3. Diversity of phytoplankton genera. **Note:-** *Mel = Melosira, Cos = Cosmarium, Ped = Pediastrum, Act = Actinastrum, Ela = Elakatathrix, and Sce = Scenedesmus.*

Fish growth

More than 97% of the total fish stocked in a pond adapted and reached for harvesting. Adaptation of fish in the rectangular ponds was relatively good. There was no pronounced dissolved oxygen (DO) depletion. The total number of fish stocked (fish biomass) in the different ponds varied depending on the size of the pond. Those water harvesting ponds which had an area of 100 m^2 received 100 fishes of different size. Nile Tilapia fishes stocked in one circular pond at East Gojjam zone could not adapt because of the lower water temperature happened in the area. In the remaining eight ponds fish were growing continuously (Fig 3). The biggest size of fish recorded at the end of the experimental time was 220 g and the smaller one was 72 g. The overall average weight of a fish attained at the end of the 7^{th} month was 138 g, including those fish stocked at their smaller size (10 g).

Fish produced in ponds

An integration of fish farming with water harvesting ponds brought a new product to the farm family, edible fish. The total fish produced in a pond varied in between 5 and 16 kg depending on the size and shape of the pond. Rectangular shaped ones were suitable for management and best for fish growth so that enabled individual farmers to harvest an average of 16 kg of Nile Tilapia fish in a 100 m^2 pond. Farmers with the same size circular pond were able to produce 10 kg of fish. Bigger ponds (100 m^2) gave higher production (160 g m^{-2}) compared to smaller ones (50 g m^{-2}). The total maximum production in one 100 m^2 rectangular pond in East Gojjam Zone was 21 kg. This was possible as the average pond water temperature was 21.6 ^{0}C and the pond got fertilized within 5 days after manuring.

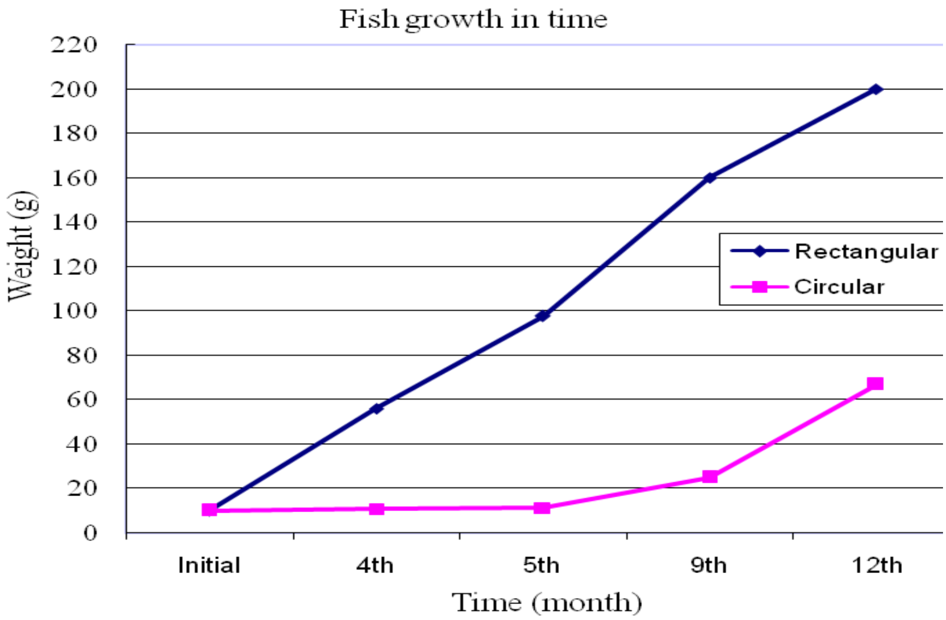

Figure 4. Average growth performance of the fishes

Conclusion and Recommendations

In most ponds fish were successfully grown and possible to have a harvest at the 7^{th} month. Both types of ponds can produce fish, but rectangular ponds were very suitable due to their larger surface area exposed to sunlight. According to this study, it is important for the farm family to stock different sized fingerlings, starting from 70 g, so that continuous and earlier harvest is possible.

According to the results of this study fish introduction (but not less than 70 g in weight) in water harvesting ponds is recommendable in food insecure areas of the region especially because people in these areas are suffering from scarcity of protein as well as malnutrition. The pond water temperature should not drop below 20 ^{0}C, it should not be turbid, no barrier for sunlight and should be rich in plankton (green in color). Training should be given to the farm family towards pond water and fish management as well as fish handling, processing and feeding since the technology and the fish itself will be new product for the family.

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PART 4

RAINFED WATER SUPPLY AND DEMAND IN MIXED FARMING SYSTEM: IN MOISTURE STRESS AREAS OF AMHARA REGION