Sustainable Integrated Tilapia Aquaculture: Aquaponics and Evaluation of Fingerling Quality in Tabasco, Mexico

Quality Seedstock Development/Experiment/09QSD02UA

Wilfrido Contreras-Sanchez, Mario Fernández-Perez, Carlos A. Alvarez-González,
Arlette Hernández Franyutti, Ulises Hernández-Vidal, and Alejandro Mcdonal-Vera
Universidad Juárez Autónoma de Tabasco
Villahermosa, México

Kevin Fitzsimmons
University of Arizona
Tucson, Arizona, USA

ABSTRACT

Integrated aquaculture and agriculture can provide a more sustainable production system in virtually any instance where plants are to be irrigated. In situations where resources are limited, provision of fresh fish and nutrient rich effluent to irrigate and fertilize vegetables can be even more important. Likewise, high quality fingerlings are required for farmers to be successful in their cultivation efforts. Having an unbiased evaluator of fingerling quality is something that is best done by a university of other entity with the resources and no particular interest in any one source or strain. In this two part investigation we collaborated with two indigenous communities to install and begin operation of integrated tilapia and vegetable plots, initially with Nile tilapia and habanero peppers. A third system was constructed on the campus of the Universidad Juarez Autonomo de Tabasco in Villahermosa, Mexico for training of students and to share with members of the indigenous communities when they were brought to the campus for workshops.

The first indigenous demonstration site at Caridad Guerrero was destroyed in a flood and had to be rebuilt. But after that, the projects have proven successful. The fish have grown quickly from fry to over 60 g and the peppers have begun to yield edible produce. The peppers had a limited value in the local community. However by assisting the community to pickle the peppers and sell in jars greatly increased the value and allowed the product to be sold to larger communities. A simple enterprise budget was prepared and demonstrated that the integrated system as built should have a pay-back period of 2.05 years.

The evaluation of fry is still underway. However, of the seven strains, four were found with parasitic loads that would reduce growth. All seven were found to contain one or more opportunistic bacterial infections that would likely decrease growth if the fish were stressed.

INTRODUCTION

Conservation and multiple use of water has become an important practice, even in parts of the world with large natural water resources. However, adopting water conservation principals sometimes requires a strong cultural education component. In this regard, multiple institutions must cooperate with the common goal of sharing information, ideas, and local cultural practices in which to develop water re-use practices. The sharing of cultural knowledge and development of best management practices is necessary to establish community support as well as monitoring protocols needed for long-term success. Water conservation efforts are readily adopted, especially in developing and at risk regions of the world, because of the demonstrated economic and environmental benefits. One area in which a greater level of cooperation and social-economic development can be achieved through water re-use efforts is in integrated aquaculture.

Integrated aquaculture/agriculture systems are increasingly being promoted as an environmentally sustainable method for producing aquatic and terrestrial crops. The main goal of integrated aqua-agro systems is to improve nutrient cycling and energy flow in the system to obtain maximum benefits in the production of food and fiber (Chan, 1993). In integrated systems, wastes from one system component are recycled as inputs to another system component. Through waste recycling, the use of pond sediment organic matter as a crop fertilizer, and of pond water for irrigation, establishes linkages between aquaculture ponds and crops.

The treatment and discharge of aquaculture effluent and resulting negative impacts on the environment remains a critical issue that is threatening the sustainable growth of the aquaculture industry. Even the discharge of effluent that has been treated to levels acceptable under limitation guidelines (ELGs) (EPA, 2002) through the use of dilutions, may pose long-term environmental risks. The resulting negative impacts will continue to intensify in the future if sustainable practices are not developed in commercial scale. A new model (Integrated Aquaculture/Agriculture System model or IAAS) has been developed in order to face the above issues reusing organic matter and nitrogen dynamics through aquaculture and integrated conventional agriculture. Integrated aquaculture/agriculture systems can be used to treat aquaculture effluents, increase farm productivity through efficient resource utilization, spread financial risk through diversification and reduce system nutrient losses (Singh et al., 1996; Williams, 1997).

The effluents from aquaculture have been shown to contain the necessary ratios and amounts of nutrients for many crop plants (Rakocy et al. 1993). Thus, significant economic and environmental benefits can be achieved by linking aquaculture and crop irrigation, as the environmental pollution from aquaculture is converted to a valuable source of fertilizers. This translates to a value-added process by which the nutrient laden effluents are converted to profitable plant biomass. A specific case has been identified for the proposed project with which to demonstrate the concepts of implementing water re-use concepts in indigenous local communities through the cooperation of multiple institutions and rural farmers. The Universidad Juarez Autonoma de Tabasco (UJAT) has already developed a partnership in aquaculture with several indigenous communities during the Condor-Eagle Project jointly supported by the Aquaculture CRSP and Heifer International. The proposed project will augment past efforts towards community based aquaculture, with the development and implementation of integrated agriculture-aquaculture practices. This project will provide a unique outlook on how water re-use in aquaculture-agriculture systems facilitate social-economic development. Determining the degree to which the system improves household income is an especially important aspect of adoption.

Fingerling quality has become a significant concern among tilapia farmers in Southeastern Mexico during recent years. The problem goes to the basics, since several fingerling vendors are introducing fish at a lower price; however, there is no evidence that farmers are buying good quality fish, nor is there evidence of the effectiveness of the masculinization treatment used. Members of the Association of Tilapia Producers of Tabasco have expressed their concern to the personnel of the Tropical Aquaculture Laboratory (UJAT) regarding bad quality fingerlings. This low-quality product is mainly perceived as low growth and low survival. There are also concerns that the "purity" of the line sold is not trustworthy. Some fingerling retailers assure they are selling "GIFT", "YY males", "Chitralada", or Rocky Mountain" strains besides the local lines produced either by the State government ("Tabasco" line -supported through two consecutive A-CRSP projects-) or some private hatcheries ("Stirling").

In Latin America, broodstock and seed supply have been identified as one of the major constraints to production increases. In the 2001 expert panel meeting organized by the PD/A CRSP, inadequate availability and quality of fry (and broodstock) were listed as a researchable priority. Part of the problem was solved by supporting a line selection program that allowed the formation of the "Tabasco line" that supports the fry production in the State Hatchery "Mariano Matamoros". This is still an ongoing project supported mainly by the Tabasco Government and UJAT. However, the production of this hatchery is primarily used for restocking lagoons or ponds were the farmers do not require single sex populations (the government does not produce masculinized fingerlings). Some private farms have acquired the "Tabasco line" and they sell the masculinized fish. In the region, tilapia culture has become the principal aquacultural activity. Unfortunately, the introduction of different lineages of unknown origin and the lack of growth performance information has created disappointment and uncertainty. It is important to define a strategy to produce reliable information despite the origin of the fish. It is possible that the strains are originals, but the environmental conditions under which they were created may not favor performance under climatic conditions for Central America.

To help farmers in Southeastern Mexico solve these speculations, we propose to conduct an objective, unbiased experiment to contrast growth performance, time to reach market size (300 gr), survival, total biomass and cost of production. With this information in hand, farmers will have information to base their decisions and purchase the fingerlings based either in cost of production or growth performance.

OBJECTIVES

1. To build three demonstration aquaculture – agriculture units in indigenous communities.
2. To evaluate the success of local farmers adopting multi-use concepts to grow fish and plant crops.
3. To provide an enterprise model documenting the cost – benefits of the integrated system.
4. To compare at least five different tilapia strains used in Southeastern Mexico.
5. To provide a protocol for tilapia strain evaluation based on growth and economic variables.
6. To provide objective information for farmers to help decide which strains produce best results.

METHODS AND MATERIALS

Building three demonstration aquaculture – agriculture units in indigenous communities

We built two integrated systems at indigenous communities. There was a third indigenous site selected but this site was impacted with severe flooding, causing several damages at the community level and at the project level, these flooding events were caused by the modification the riverbeds, we had the most severe raining season in 30 years, these condition remained all year around. Besides the adverse condition at the selected site the access routes had severe damages, which hampered the access to the site. Due to all these causes, we decided to built the third system at UJAT, where is a high zone free of flooding and it is only 30 km away from the selected site, building the third system at UJAT increased the impact range through demonstration and training, UJAT site has been used as a training site for farmers and educational site for students.

Demonstration and Evaluation of an Integrated Aquaculture – Agriculture System for Indigenous Farmers in Tabasco, Mexico

To build three demonstration aquaculture – agriculture units in indigenous communities

Two workshops were held at UJAT facilities the first workshop was given by Dr. Kevin Fitzsimmons, Dr. Dennis McIntosh and Dr. Rafael Martinez-Garcia on Integrated aquaculture agriculture systems. The second workshop was given by Tracy Holstein on the use of biofloc systems.

Three integrated aquaculture agriculture systems in two indigenous communities and one educational and demonstration site were built. An integrated aquaculture agriculture system was developed in an indigenous Chol community at Caridad Guerrero, Tacotalpa county in Tabasco. The effluents of 1500 Tilapia, which were fed 2 twice per day at a rate of 5% biomass of Tilapia feed, contained in a 12 m^3 geomembrane tank were used to irrigate habanero peppers twice per day. The peppers were grown from seedlings in three agricultural beds (10 x 15m), constructed with a 3% slope to capture effluents for analysis. Sampling of Tilapia and habanero were made each month, total length and weight were taken for the Tilapia and length (height) for habanero pepper. Total product harvest was accomplished by weighing the total production (fruit) of each plant.

Assembling geomembrane tank for fish

Preparing aquaponics growing bed

The second site was developed at a Chontal indigenous community in Oxiacaque, Nacajuca county. Except for the agricultural unit measures (5 x 10m) most of the procedure was conducted as described for Caridad Guerrero.

The third site an educational and demonstrative system was built at UJAT, following the procedure as was conducted in Caridad Guerrero.

Tilapia and habanero seedlings were transferred to the sites at different times. Data for biomass crop production was analyzed in order to obtain mean values for each case. Analysis of water quality was performed monthly, only for the Caridad Guerrero system measuring nitrites, nitrates and ammonia in order to calculate total Nitrogen.

Evaluation of the success of local farmers adopting multi-use concepts to grow fish and plant crops.
The people performed a partial harvest of habanero peppers at the Caridad Guerrero site. Due to the delay suffered by flooding events the aquaculture system was reorganized and Tilapia are not ready to harvest yet.

Alejandro MacDonal prepared a financial analysis assuming a 1500 kg tilapia and 100 kg habanero production (average production of a cycle) having variables such as initial investment, sales, expenses and costs, profits, earnings and finally profitability and investment recovery period. He also conducted a survey of the families involved to determine how the system would integrate to the entire household budget (time and financial).

UJAT demonstration integrated system *Pickled habeneros*

We trained the group of Caridad Guerrero about producing a value added product with the habanero production. Specifically, we helped with a pickling process that preserves and increases the value of the habaneros from 40 pesos per kg to 200 pesos per kg. The peppers are put into bottles with oil, vinegar, local herbs and spices.

To provide an enterprise model documenting the benefits of the integrated system
A social economic evaluation of the community was performed at Caridad Guerrero, based on qualitative statistics with surveys and interviews. Final results are being tabulated and will then be translated to English.

Evaluation of Different Tilapia Strains used in Southeastern Mexico and Incorporation of a Pure GIFT Line as Reference to Determine Quality of Tilapia Fingerlings.
EXPERIMENT 1. Comparison of seven Tilapia lines used in South east Mexico
Five thousand fingerlings were purchased anonymously. Seven strains of Nile Tilapia (*Oreochromis niloticus*) were obtained including: "GIFT", "YY super males", "Chitralada", "Rocky Mountain", "Stirling", " Pucté" and Tabasco line, from different hatcheries and/or retailers. Tilapia sizes were from 0.3 to 1.3 g. Initial weight and total length among the lines was used as co-variables in order to avoid statistical bias. Monthly samples were made in order to evaluate growth in weight and length. 1000 Tilapias were placed randomly in mosquito-mesh hapas for a month, at the end of this period all fish were counted in order to evaluate survival and the tilapias were transferred to ½" mesh hapas. Tilapias were fed three times per day with a ratio of 5% total biomass. Feed ratio was adjusted each month. Water exchange was done at 10% ratio weekly. 2000 Tilapias were used to evaluate possible infections for most common bacterial pathogens and parasites (*Streptococcus, Trichodina, Columnaris,* or *Aeromonas*), ich disease (*Ichthyophthirius multifilis*), and parasites. Five fish were sampled for bacterial infection sampling skin, liver, spleen and kidney. Also five fish were analyzed for parasites diseases analyzing superficial tissue from body and gills. Samples were taken and analyzed by the personnel of the Aquatic Sanitation Laboratory (UJAT).

Statistical analysis
The experimental design contemplated for this experiment was a random block design. Three factors were considered to be blocked (length, weight and date of initiation). The response variables (Length and Weight) were tested to determine if the assumptions for parametric analysis were met; if so, contrasts will be performed using ANOVA, otherwise data will be transformed to meet the requirements. Total biomass

will be compared using an ANOVA test and Survival results will be compared among treatments by Chi square test using contingency tables.

EXPERIMENT 2. Evaluation of three Tilapia lines at commercial farming level
The three best Tilapia lines evaluated in the first experiment were tested at the farm El Pucte del Usumacinta S.A. de C.V., located in the Emiliano Zapata municipality, Tabasco. The fry size was dependent on the size of the system to be used, an estimate of 20,000 fish per line were placed in earthen ponds of 50 x 20 m with two replicates per line with a density of 10,000 fish per pond. The fish were kept in these ponds for six months for growth. Monthly samples were collected of each replicate for six months. Total length and weight were taken of a subsample of 100 fish of each replicate. Fish were fed three times per day at a ratio of 5% total biomass. The amount of feed was adjusted monthly. Water exchange was performed at 10% once a week.

Statistical analysis
The primary variables (weight and length) were tested in order to determine if data match parametric analysis assumptions. In case of matching an ANOVA was performed, in contrary the Kruskall-Wallis test will be performed. The total biomass will be compared using an ANOVA and survival results will be analyzed through Chi-square using contingency tables.

RESULTS

Demonstration and Evaluation of an Integrated Aquaculture – Agriculture System for Indigenous Farmers in Tabasco, Mexico

A total of 80 participants participated in the Integrated aquaculture agriculture and bioflocs workshops. The participants included; professors, students, local farmers, and extension government agents.

In Caridad Guerrero habanero harvest started with early producing plants, the rest are flowering and all still growing, Tilapia reached a medium of 45 g. Nitrogen analysis showed high retention from soil matrix and plants. Oxiacaque system is showing excellent progress, habanero plants reached 18 cm and Tilapia 34 g. At UJAT Tilapia achieved 20g and habanero plants 16 cm. Nitrogen analyses were carried out at Caridad Guerrero and Oxiacaque, where high amounts of nitrogen (around 70%) was retained by soil matrix and uptake by plants. Due to problems with soil compaction, some of the slope was lost and capture of effluents was not precise at the demonstrative site.

It turned out that the coconut husk material was especially useful for trapping the effluent and slowly releasing the liquid and nutrients to the sand/silt/husk mix. The peppers, and other vegetables, quickly grew and the root mass helped to bind the materials and further enhance the effluent capture and nutrient availability. The mix eventually formed a type of soil much faster than were seen in the other vegetable plots that had been scoured in the flood. Nitrogen analysis showed high retention from the soil matrix and plants.

Two surveys and one interview were carried out to 80% (100 families) of the population in Caridad Guerrero in order to achieve data for the social economic analysis and describe the impact of the project at the community.

Evaluation of the success of local farmers adopting multi-use concepts to grow fish and plant crops.
The value added product developed in the Caridad Guerrero project (Fig. 8) together with the commercialization of the raw habanero and the Tilapia production are the final products of the system.

The results of the financial analysis showed that the investment recovery period will be in the second year of production, there is a profitability of 0.48 and a average earnings of $23, 308.33 (Fig. 9)

Evaluation of Different Tilapia Strains used in Southeastern Mexico and Incorporation of a Pure GIFT Line as Reference to Determine Quality of Tilapia Fingerlings.
All seven lines were bought that are available in the region: “GIFT”, “super males YY”, “Chitralada”, “Rocky Mountain”, “Stirling”, “Pucté” and “Tabasco line”. Tilapias (1000 per hapa) were placed in mosquito mesh for a month. At the beginning Tilapia were sampled in order to determine differences in length and weight among the lines. At the end of the first month a sampling was conducted in order to evaluate growth. Fish were counted and placed in a ½” mesh hapas.

In the present study the statistical analysis indicates the existence of statistic differences among the different Tilapia Lines at the beginning of the trial (ANOVA; $p<0.01$; Fig. 1). The line three showed initially the best results in weight with 1.38 ± 0.01 g and the line with the lowest weight was the four with 0.28 ± 0.01 g. Length showed the same pattern (ANOVA; $p<0.01$; Fig. 2) with 4.28 ± 0.01 cm for line three and 2.41 ± 0.01 cm for line four.

The multifactorial analysis indicated that there is no statistical difference among Tilapia lines (ANCOVA; $p < 0.87$) for the first sampling month, being the line three the highest on weight with 1.68 ± 0.97 g, while line four showed the lowest value with 0. 31 ± 0.34 g. However, the covariable initial weight of the experiment did not have any effect on the organisms weight (ANCOVA; $p = 0.87$; Fig. 3). In the case of length, results showed that there is statistical difference among lines tested in this study (ANCOVA; $p < 0.04$ Fig. 4) due to best initial length was on fish of line three with 9.19 ± 0.36 cm and the lowest the line four with 6.57 ± 0.14 cm. The covariable initial length did not have an effect over length (ANCOVA; $p = 0.77$).

In the second month of sampling the results showed that there is no statistical differences among the Tilapia lines (ANCOVA; $p < 0.35$; Fig. 5), line three showed the best growth in weight with 27.80 ± 2.98 g and line four showed the lowest weight with 15.26 ± 5.91 g. This statistical analysis allow to identify that initial weight did not affect growth in weight among the different Tilapia lines tested (ANCOVA; $p = 0.32$). The analysis for length indicated that there is an effect highly significative among Tilapia lines of this study (ANCOVA; $p<0.01$; Fig. 6). The line three showed the best results with 11.48 ± 0.60 cm length and line four the lowest results with 9.02 ± 1.05 cm. The covariable initial length did not affect the results of growth (ANCOVA; $p = 0.13$).

For the third month of sampling the statistical analysis showed significant differences (ANCOVA; $p = 0.04$; Fig. 14) the Tilapia line one showed the best growth in weight with 82.79 ± 6.26 g. The line with the lowest growth weight was the line six with 52.08 ± 8.30 g. The analysis also indicated that there was no effect of the initial weight with respect to fish growth (ANCOVA; $p=0.22$). For length the analysis indicated that there are significant differences (ANCOVA; $p=0.05$; Fig. 15) between the different Tilapia lines, the best line with length growth was the line three with 16.71 ± 1.63 mm and the lowest length for line six with 13.24 ± 1.23 mm. The covariable initial length did not had an effect on fish growth (ANCOVA; $p=0.22$).

For the fourth month of sampling the statistical analysis indicated that there is statistical differences between the Tilapia lines (ANCOVA, $p<0.01$; Fig. 16 and 17) for weight and length, the line one (118.40 ± 14.35 g) showed the highest weight and the line seven showed the lowest growth (64.93 ± 6.32 g). For length the results are similar with 18.24 ± 0.70 cm for line one having the best results and 13.83 ± 0.29 cm for line four showing the lowest length. There was no effect of density over growth (ANCOVA, $p= 0.09$). For the fifth month of sampling the analysis indicated statistical differences between the Tilapia lines (ANCOVA, $p<0.01$; Fig. 18 y 19) for weight and length. There was no effect of density over growth (ANCOVA, $p= 0.42$) for weight and length. The line one had the best growth (224.41 ± 18.37 g) and the lowest line was the four (91.47 ± 15.46 g) the line one had the best length with 24.88 ± 1.06 cm and the lowest was the line four with 12.57 ± 0.69 cm.

The average value of temperature, pH and dissolved oxygen were 29.9 ± 4.52 °C, 7.22 ± 0.31 y 3.86 ± 4.41, respectively.

The results of the bacteriology tests showed the constant presence of two types of bacteria *Pseudomonas fluorescens* y *Aeromonas hydrophila* in most of the Tilapia lines tested on this experiment (Table 1).

A Chi-square with contingency tables analysis was carried out in order to determine differences in percentage of masculinization rates of the seven Tilapia lines tested in the study. The analysis showed that there is statistical differences among Tilapia lines for percentage of masculinization (X^2; $p < 0.0$), being line six the best result in masculinization with 98%, while line with the lowest percantge of masculinization was line five with 82% (Fig. 7).

DISCUSSION

The results in the present study indicated that the growth of the seven Tilapia lines evaluated and which initiated with differences in weight and size was not significative, by contrary Orozco 1998 and Castro et al., 2004 found statistical differences using Tilapia frys of weight under 0.5 g when comparing three different lines of Tilapia.

In which respect to the growth in weight of the seven Tilapia lines there was no significative differences at the thirty first days of the experiment between the different lines, the Tabasco line had the best growth in weight and size. For the second month of sampling (60 days) the obtained results were very similar for growth, the Tabasco line had the best growth in weight and size, Castro et al., 2004 found statistical differences during the first and second month of experiment in growth of the three Tilapia lines evaluated being for this case *Oreochromis mossambicus* the best in growth in weight and size.

Orozco 1998 described that smaller sizes could be associated with mortalities caused by predators and parasites, this could explain the mortalities we had in our study where Tilapia mortalities were associated to parasites and bacterial infection during the first month of the experiment.

We plan to publish these results in a peer reviewed science article once the trial is completed in the Oxiacaque village and supported with additional data collection of soil quality and nutrient levels. We were asked to present our findings at an aquaponics conference in Cancun, Mexico. Fitzsimmons made one presentation on September 22, 2011 and two graduate students from Universidad Juarez Autonoma de Tabasco made a separate presentation on September 23, 2011. The presentations specifically mention the support of USAID and the AquaFish Collaborative Research Support Program.

Mercado Mundial en la Producción de Tilapia (World Market Tendencies of Tilapia Production). – Dr. Kevin Fitzsimmons, USA

and

DESARROLLO DE PRACTICAS DE ACUACULTURA SUSTENTABLE EN TABASCO, MÉXICO USANDO TECNOLOGÍA DE SISTEMAS INTEGRADOS AGRÍCOLAS – ACUÍCOLAS (Developing Sustainable Practices for Aquaculture in Tabasco Mexico, Using Integrated Agriculture-Aquaculture Integrated Systems Technology). – María Fernanda Cifuentes Arroyo and Maria Contreras.

In January 2012, Fitzsimmons returned to Tabasco to attend Rafael Martinez's wedding and was interviewed by local newspaper regarding the project. See appendix.

http://www.diarioavancetabasco.com/Default.aspx?ClaveIdioma=1&Noticia=6&Clave=1&Fecha=10/01/2012

Aquaponics bed with habanero peppers

Tilapia at first sampling date

LITERATURE CITED

Chan, G.L. 1993. Aquaculture, ecological engineering: lessons from China. Ambio 22:491-494.

Rakocy, J., Hargreaves, J. and Bailey, D. 1993. Nutrient accumulation in a recirculating aquaculture system integrated with hydroponic vegetable production. pp. 148-158 In: Techniques for Modern Aquaculture (J.K. Wang, Ed.) St. Joseph, MI:ASAE Pub. 02-93.

Singh, S., Marsh, L.S., Vaughan, D.H., Libey, G.S., 1996. A computer simulation model to optimize greenhouse size for an integrated (fish production, hydroponics) system. Transactions of the ASAE 39, 2241–2248.

U.S. Environmental Protection Agency (USEPA). 2002. Development Document for Proposed Effluent Limitations Guidelines and Standards for the Concentrated Aquatic Animal Production Industry Point Source Category. U.S. Environmental Protection Agency, Washington, DC.

Williams, M.J., 1997. Aquaculture and sustainable food security in the developing world. In: Bardach, J.E. (Ed.), Sustainable Aquaculture. Wiley, New York, pp. 15–51.

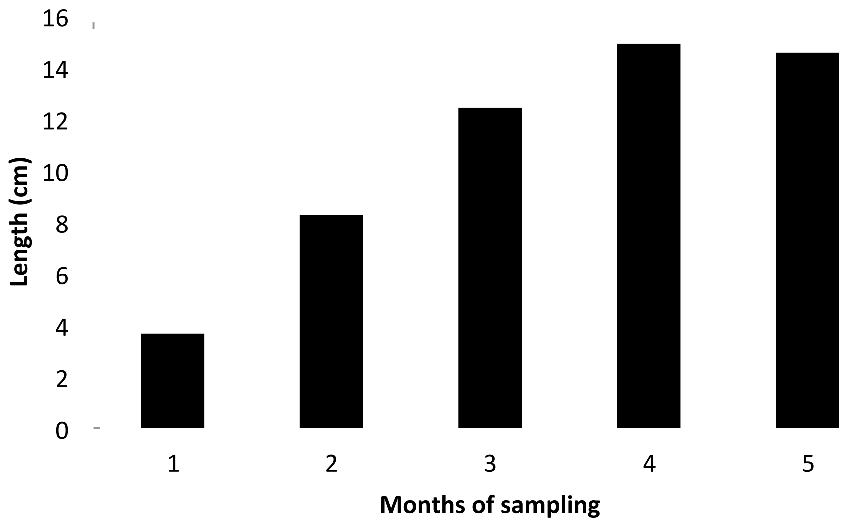

Figure 1. Total growth length of Tilapia from Caridad Guerrero system

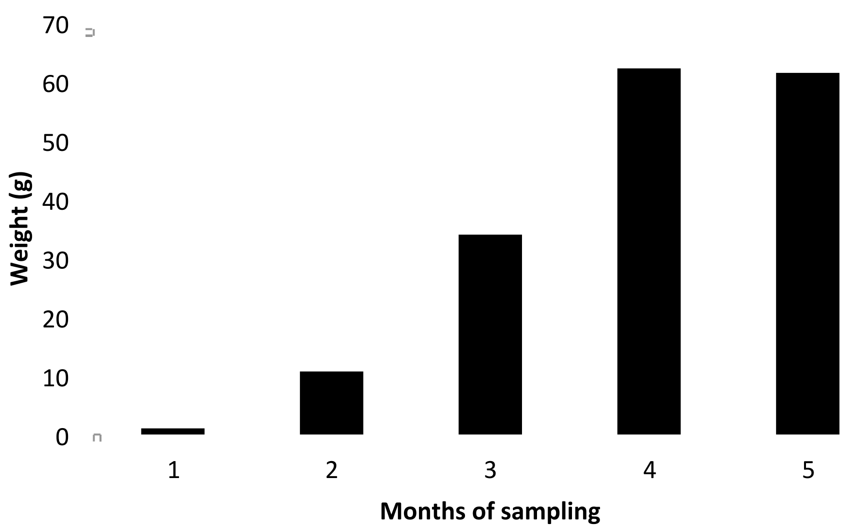

Figure 2. Total growth weight of Tilapia from Caridad Guerrero system

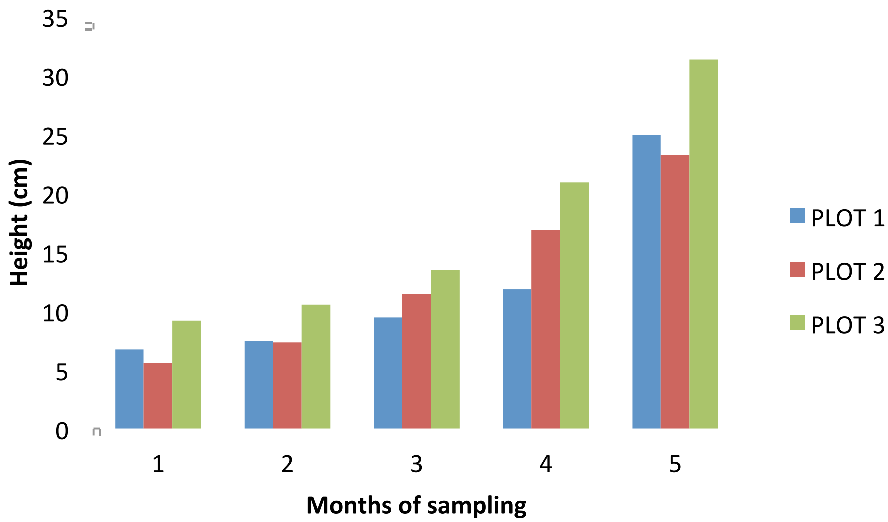

Figure 3. Growth in height of Habanero plants for the five months of sampling at Caridad Guerrero system

	NITRATES mg/L	NITRITES mg/L	AMMONIA mg/L
Tilapia tank	0.0	0.16	0.45
PLOT 1	4.0	0.13	0.74
PLOT 2	3.5	0.10	0.74
PLOT 3	4.0	0.13	0.46

Figure 4. Water quality parameters from different source at Caridad Guerrero system for August

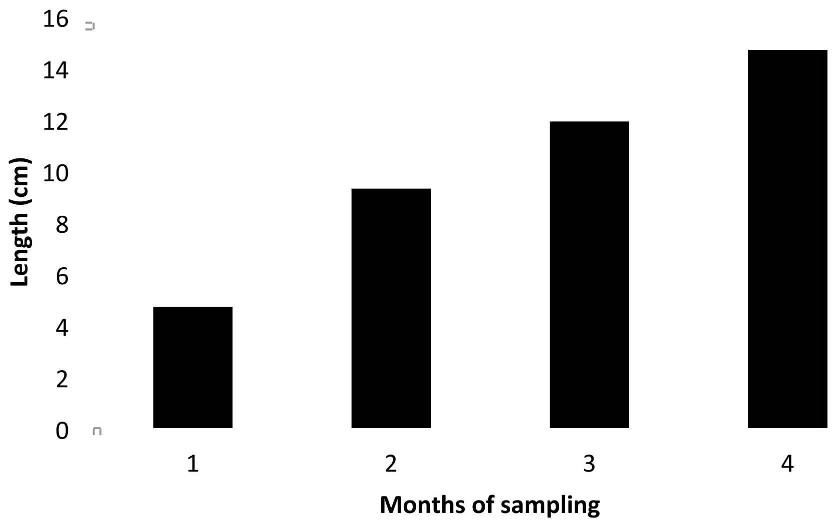

Figure 5. Total growth length of Tilapia from Oxiacaque system

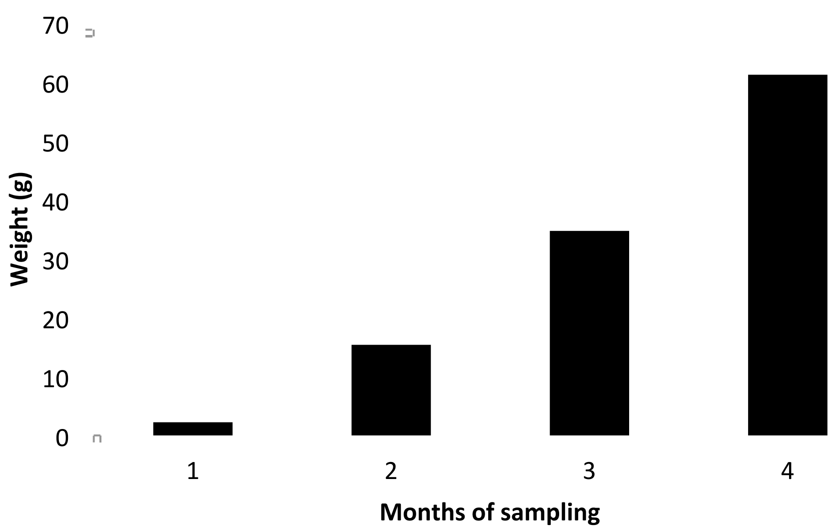

Figure 6. Total growth weight of Tilapia from Oxiacaque system

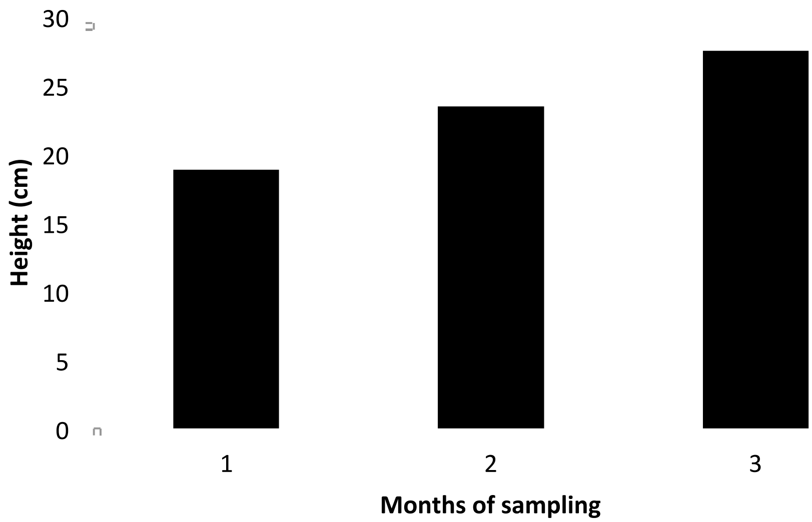

Figure 7. Growth in height of Habanero plants for the three months of sampling at Oxiacaque system

Figure 8. Pickled Habanero developed by farmers of Caridad Guerrero group

Concept	0	1	2	3	4	5
Initial investment	**$47,925**					
Sales	$38,220	$38,220	$64,470	$64,470	$64,470	$64,470
Expenses and costs	$47,925	$25,525	$30,250	$30,250	$30,250	$30,250
Profits	$-9,705	$12,695	$34,220	$34,220	$34,220	$34,220
Earnings	$-9,705	$2,990	$37,210	$71,430	$105,650	$139,850

Average earnings	$23,308
Profitability	0.48
Investment Recovery Period (years)	2.05

Figure 9. Financial Analysis of the aquaponia production for the Caridad Guerrero system

Table 1. Bacterial and parasitic diseases presents in the seven Tilapia lines of the experiment

Line	**Bacteria found**	**Parasites found**
1	*Pseudomonas fluorescens, Aeromonas hydrophila.*	Monogene and tricodina
2	*Pseudomonas fluorescens, Aeromonas sobria, Aeromonas hydrophila.*	Monogene and tricodina
3	*Pseudomonas fluorescens, Plesiomonas shigelloides, Aeromonas sobria, Moraxella spp y Aeromonas hydrophila.*	Monogene and tricodina
4	*Aeromonas hydrophila, Aeromonas sobria,Plesiomonas shigelloides y Pseudomonas fluorescens.*	Absent
5	*Aeromonas sobria, Pseudomonas putida, Plesiomonas shigelloides, Pseudomonas aeruginosa y Pseudomonas fluorescens.*	Monogene
6	*Pseudomonas fluorescens, Aeromonas hydrophila, Burkholderia cepacia, Pseudomonas putida y Photobacterium damselae.*	Monogene and tricodina
7	*Pseudomonas putida, Aeromonas hydrophila y Pseudomonas aeruginosa.*	Monogene, tricodina and other protozoa, unidentified parasites ciliates

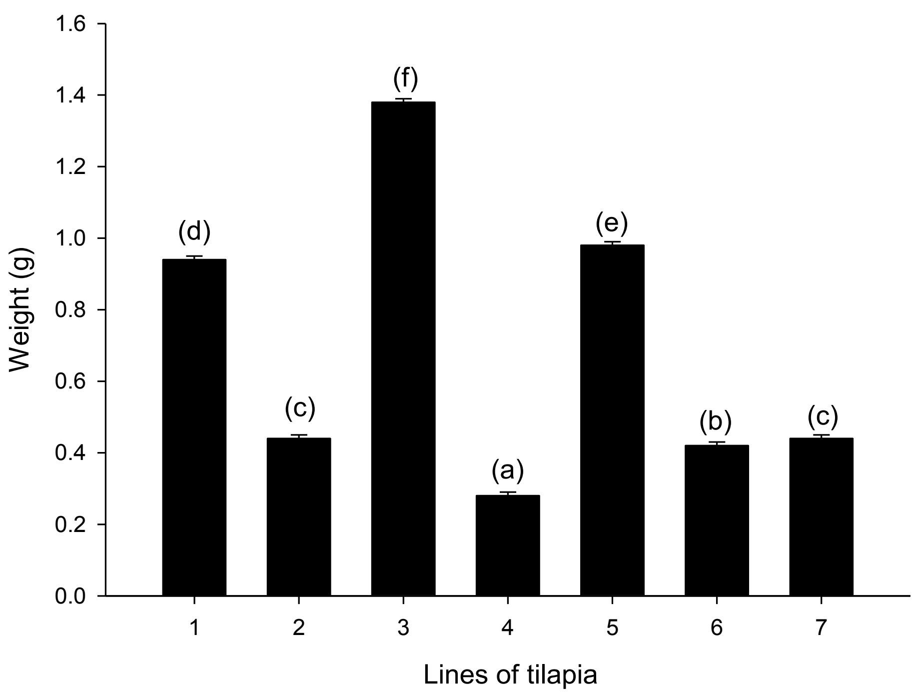

Figure 8. Initial weight of seven Tilapia lines tested in this study

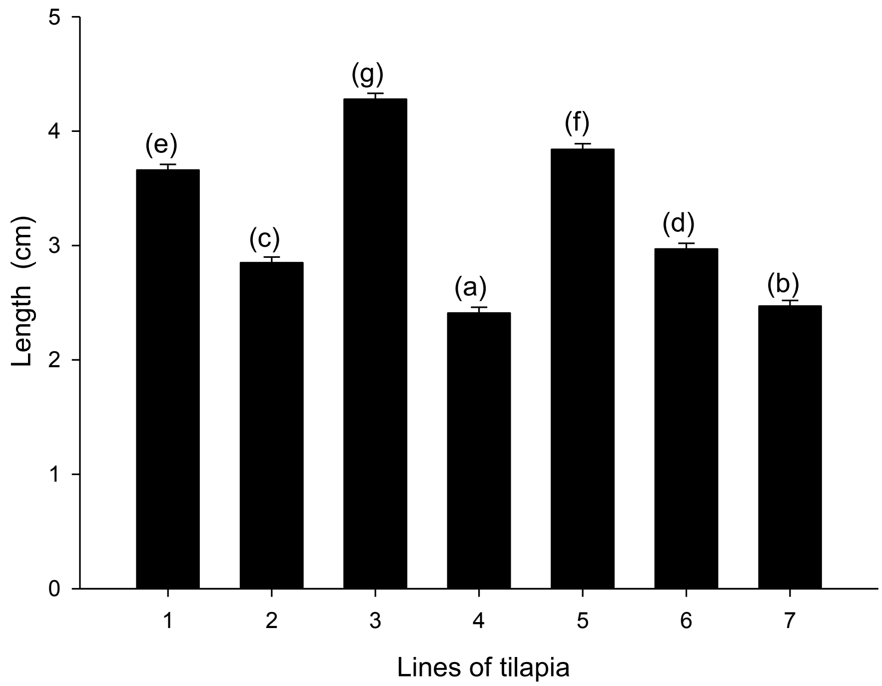

Figure 9. Initial total length of the seven Tilapia lines tested on this study

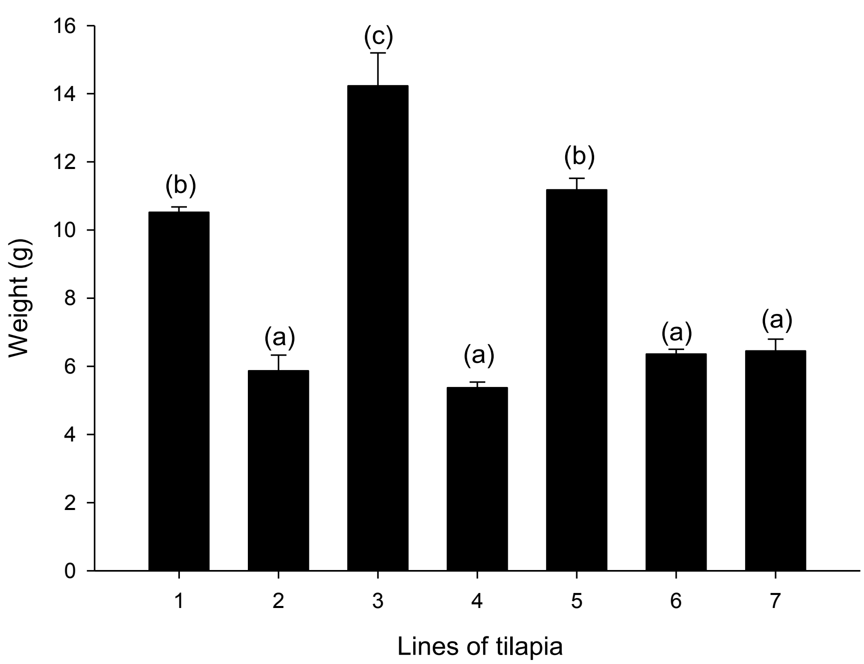

Figure 10. Weight growth of the seven Tilapia lines evaluated in this study during the first month of the experiment

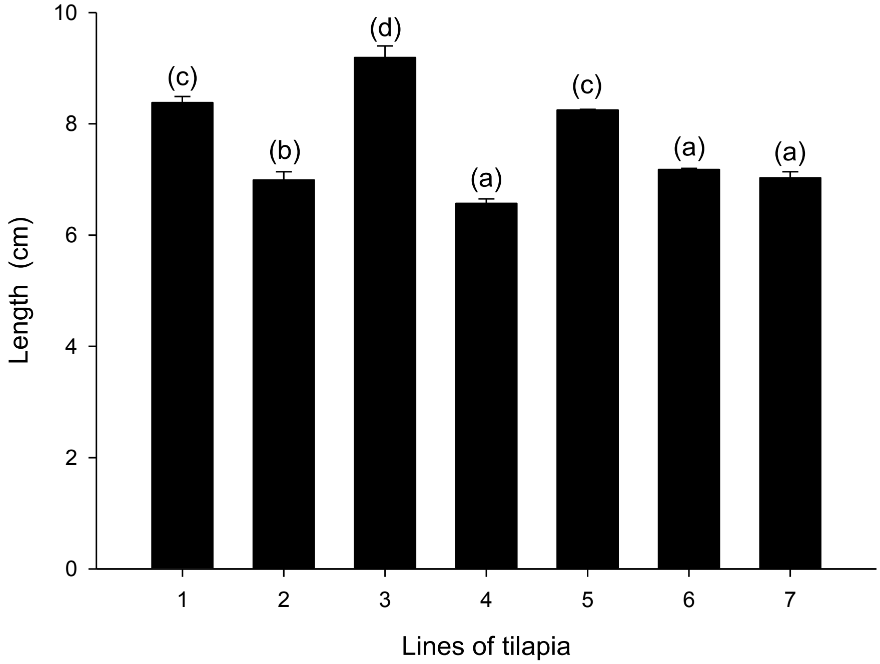

Figure 11. Growth in length of the seven Tilapia lines tested in this study during the second month of the experiment

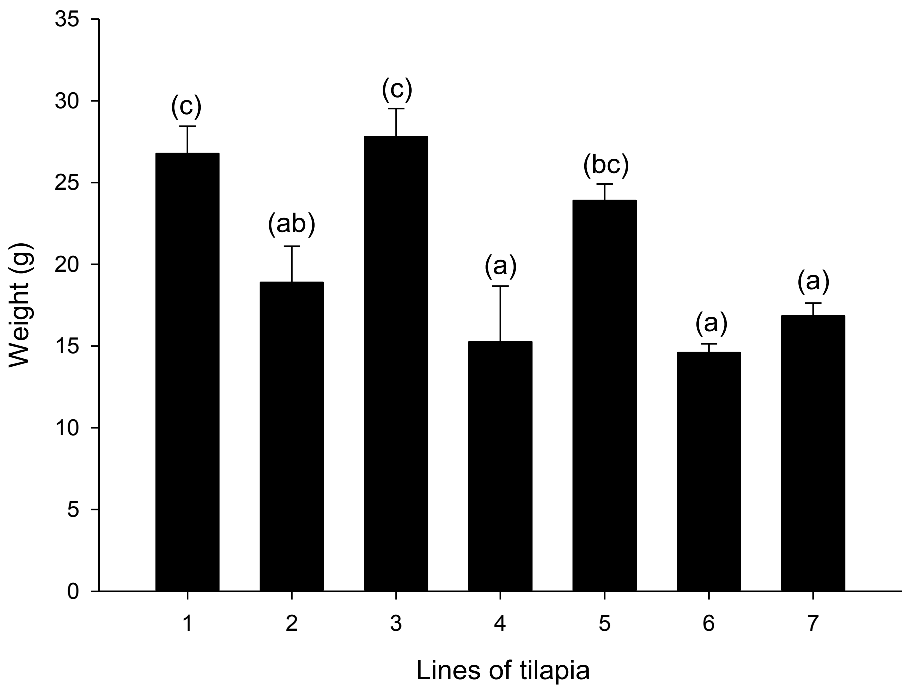

Figure 12. Growth in weight of the seven Tilapia lines tested during the second month of this experiment

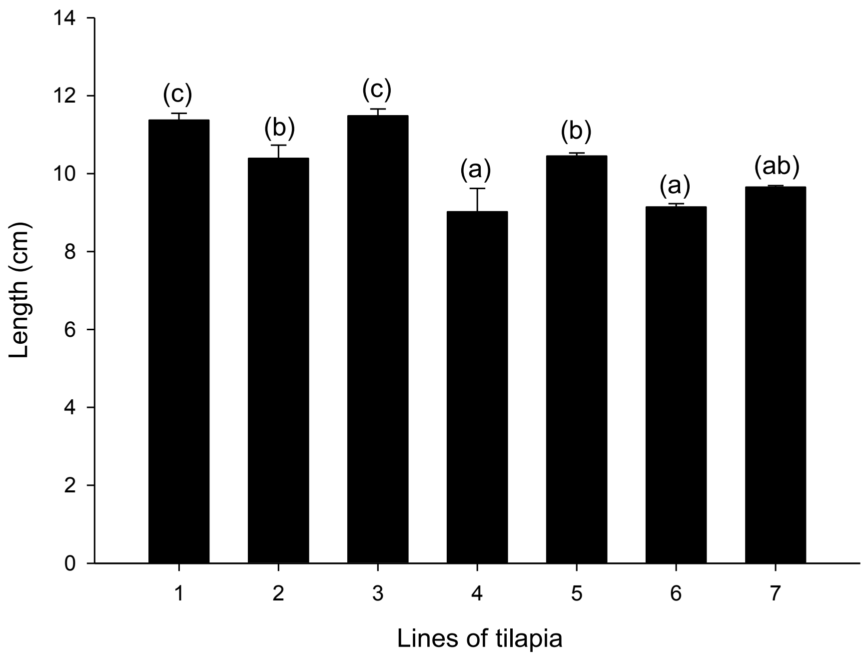

Figure 13. Growth in length of the seven Tilapia lines tested in this study during the second month of the experiment

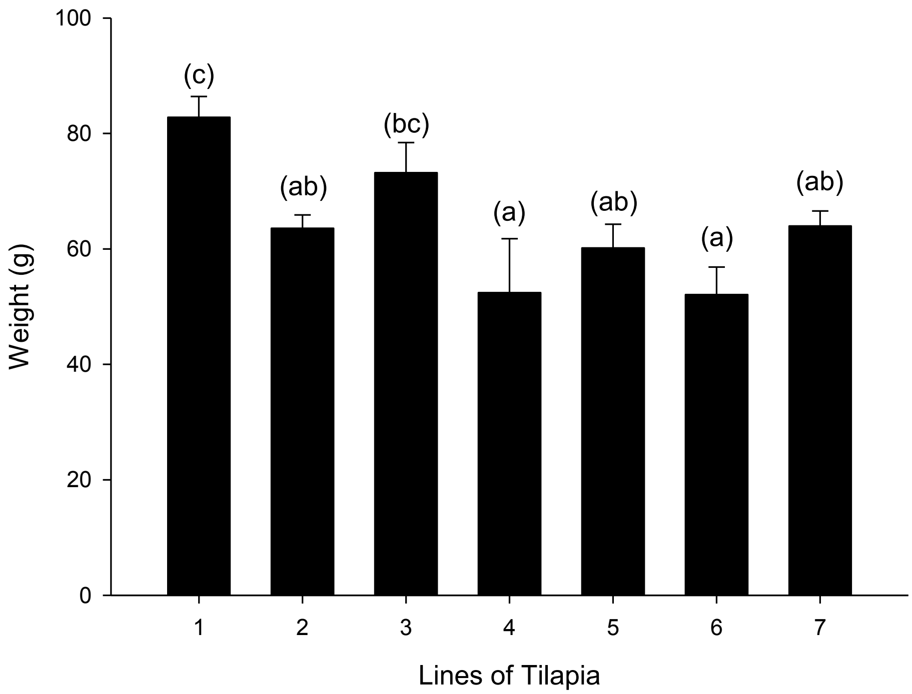

Figure 14. Growth in weight of the seven Tilapia lines tested in this study for the third month

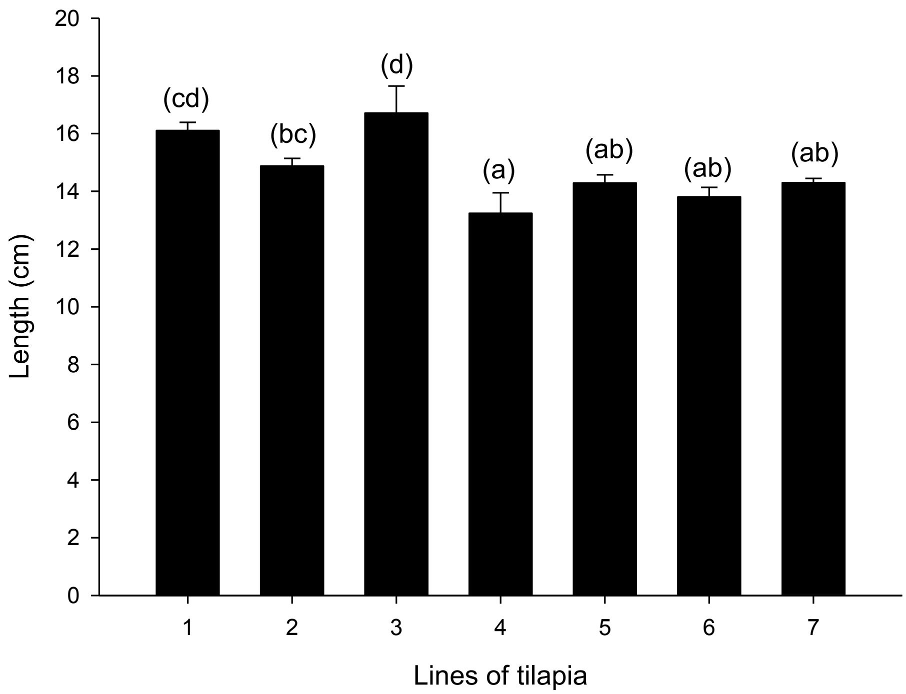

Figure 15. Growth in length of the seven Tilapia lines tested in this study for the third month

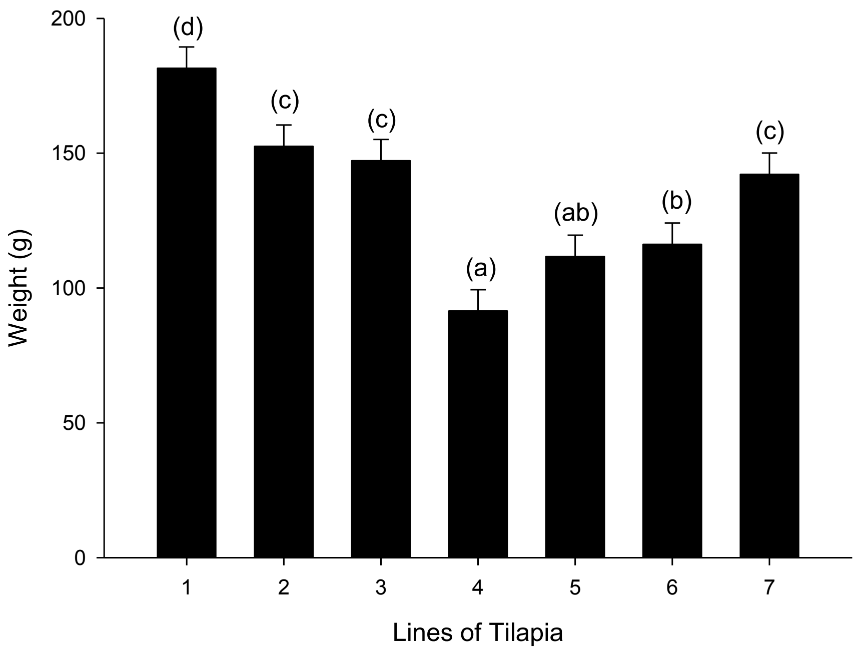

Figure 16. Growth in weight during the 120 days of the experiment for the seven Tilapia lines tested in this study.

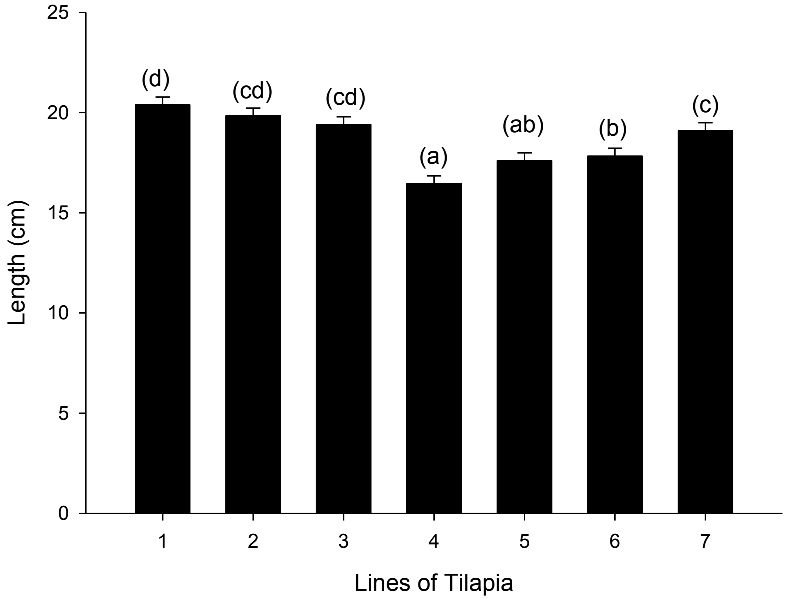

Figure 17. Growth in length during the 120 days of the experiment for the seven Tilapia lines tested in this study.

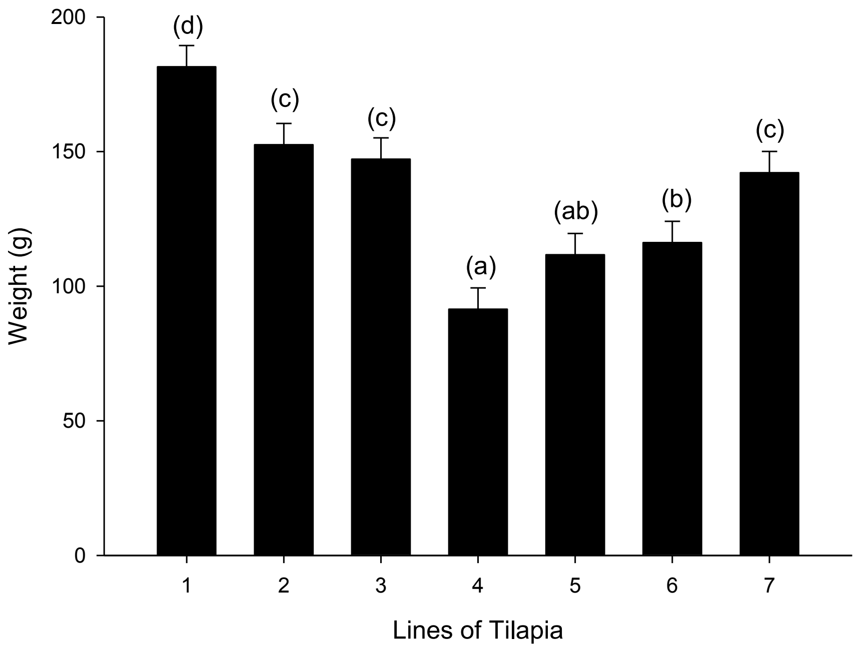

Figure 18. Average growth value in weight of the seven lines of Tilapia during the 150 days of the experiment

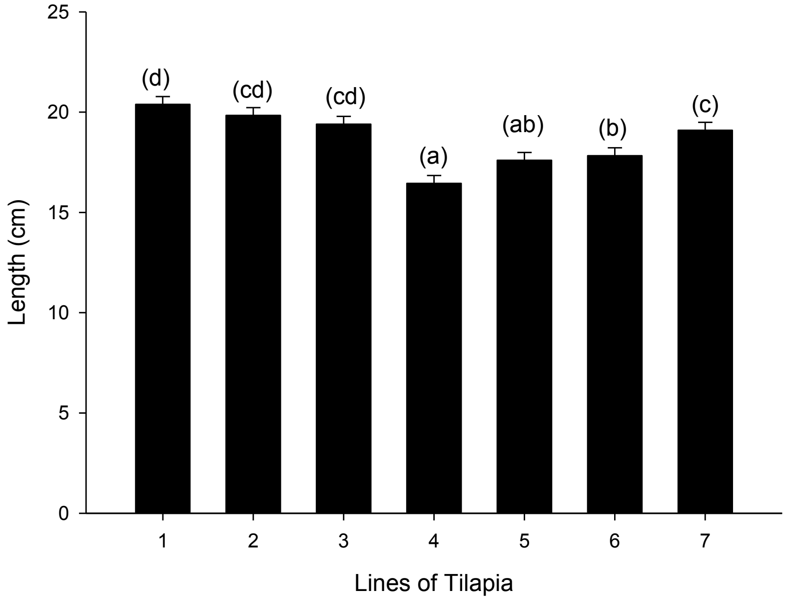

Figure 19. Average growth value in length of the seven lines of Tilapia during the 150 days of the experiment

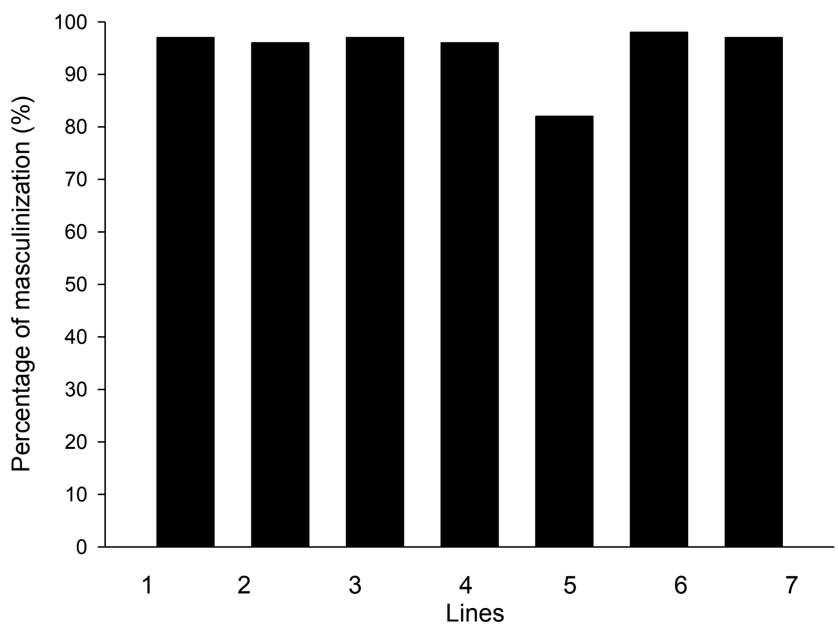

Figure 20. Percentage of masculinization of the seven Tilapia lines tested in this study (n=100 for each Tilapia line)

APPENDIX 1

Universidad Juárez Autónoma de Tabasco
División Académica de Ciencias Biológicas
Laboratorio de Acuicultura Tropical
Workshop on Integrated Aquaculture Agriculture Systems

Agenda

Registration 9-10 AM

AUGUST 12, 2010		
Time	**Topic**	**Instructor**
10:00-12:30	Introduction Concepts of Integrated Aquaculture Agriculture Systems (IASS) Practical activity	PhD. Candidate Rafael Martínez García
12:30-13:00	**Break**	
13:00-14:00	Historical perspective IAA projects on development	
AUGUST 13		
9:00- 12:00	Principal objectives of the IAAS Function and development of IAAS Implementation of IAAS	Dr. Dennis McIntosh/ Dr. Kevin Fitzsimmons
12:00-13:00	**Break**	
13:00-15:00	Actual status of IAAS projects around the World * Special participation Dr. Kevin	
August 14		
9:00- 14:00	field trip	
August 16		
9:00-11:00	Organic cycles involved in IAAS	Dr. Dennis McIntosh
11:00-12:00	IAAS Project engineering	
12:00-13:00	**Break**	
13:00-14:00	Presentation of practical activity	
August 17		
9:00-12:00	Development process of IAAS	Dr. Dennis McIntosh
12:00-13:00	**Break**	
13:00-14:00	Future perspectives of IAAS	
14:00	Closing	

Diario Avance Tabasco 10 January 2012 By: Luis Garcia de la Cruz

LA UJAT POR UNA COMBINACIÓN DE ACUACULTURA Y AGRICULTURA
Explica Kevin Fitzsimmons, investigador de la Universidad de Arizona los proyectos que existen con la División de Biología.

Kevin Fitzsimmons, investigador de la Universidad de Arizona.

FOTO: Avance

LUIS GARCÍA
SEGUNDA Y ÚLTIMA PARTE

Luego de reconocer que México tiene mucho interés en la exportación de productos del mar a través de la acuacultura, prevalece siempre la necesidad de soportar el consumo local, externó el investigador de la Universidad de Arizona, Kevin Fitzsimmons quien destaca el trabajo que mantiene la Universidad Juárez Autónoma de Tabasco en ese sentido.

Cuestionado sobre el papel que juega la máxima casa de estudios el investigador en acuacultura, indicó que el trabajo que se realiza con la Universidad Juárez y en especial con la División de Biología, donde existen proyectos en coordinación con el doctor Wilfrido Contreras, son de suma importancia por todo lo avanzado, porque se desarrolla de manera rápida, la domesticación de peces, camarones, ostiones, almejas y las algas.

"Algo que la UJAT y el doctor Wilfrido (Contreras), han estado trabajando en acuacultura y agricultura. La acuacultura tiene similares problemas a la agricultura, pues también causa contaminación, necesitamos encontrar alimentos para los peces, para ir eliminando las harinas de pescado por ser muy caras y no es suficiente para atender la alimentación de las especies domesticadas".

Por ello, agregó, decidimos poner la acuacultura y la agricultura juntos, es mejor para la "Revolución azul", que es la conjugación de la acuacultura y la agricultura, explica ante la presencia de sus colegas tabasqueños que escucharon atentos la explicación del especialista de la Universidad de Arizona.

Y refrenda que es usar el agua que no sirve para los peces, utilizarla para irrigar las plantas, pues los desechos de los peces son muy orgánicos, pues tienen potasio, que las plantas necesitan y el productor puede ahorrar dinero, no se contamina el ambiente, porque son desechos de peces y no se usan fertilizantes. Un sistema similar que se usa con camarones y con algas marinas.

Sostiene que es un sistema nuevo en América, tiene su prototipo en China, Japón, que han tenido por largos años la siembra de arroz y pescado, "ellos tienen el uso de plantas y peces juntos".

Indica que los investigadores norteamericanos y mexicanos explican a los granjeros como atender la tierra, pero en China, la gente no entiende los ciclos de los nutrientes, nosotros hemos trabajado con las comunidades, nuestros estudiantes se involucran con las comunidades para mostrar nuestros sistemas, dan asesorías, demostraciones, talleres en el campus.

Precisa que en Tabasco se trabaja en Tacotalpa, en la comunidad de Caridad Guerrero; en Nacajuca en Oxiacaque, y un sistema en el campus universitario. Mientras que en otros estados, se trabaja con Chiapas, Oaxaca, Tamaulipas, Veracruz. Se trabaja con tilapias aunque el concepto es para todas las especies, también en Jalapita, Centla, se investiga con algas, camarón, manglar, ostión.

Refirió que en el proyecto participan todos los profesores, todos los alumnos, todos los administrativos de acuacultura, es algo único en México. Porque está enfocado hacia la triple hélice, empresa, gobierno y universidad. Es importante el proyecto porque se logró traer a otros investigadores e instituciones. "Unas de las cosas por las que me gusta trabajar con los colegas de México, de aquí de la Universidad, es porque México le ha apostado más fuerte a la acuacultura que el mismo Estados Unidos, la industria de la tilapia ha crecido muy rápido, camarón, bagre en el norte, un programa muy fuerte para trabajar con las especies nativas como robalo, tenguayaca, casta rica, paleta y el pejelagarto, por supuesto".

Cuestionado sobre las perspectivas de desarrollo en materia de educación de la acuacultura y sobre todo de México, dijo que a través de programas como los que se están tratando de reproducir aquí en Ciencias Biológicas y explica que en Estados Unidos, se han comenzado a trabajar con las preparatorias, colocando estanques, peceras para que los muchachos aprendan a cuidar a los peces, principalmente en Arizona, porque la mayor parte de las secundarias y prepas están en áreas rurales. Antes, estudiaban vacas, cerdos, pollos, pero las ciudades han crecido y ahora las escuelas ya están dentro del perímetro de la ciudad en zonas urbanas. Con la acuacultura se pueden enseñar la crianza, mantenimiento y gestión de granjas y se pueden usar en sus clases de cocina. Pero lo más importante es que las personas dedicadas a la protección de animales, no se quejan porque son criaderos.

Explicó que uno de los egresados del programa está trabajando en una escuela y ha comenzado a desarrollar esa misión. "Bueno, realmente no es una acción integrada, pero espera que con esa visión que tiene del programa más adelante se pueda reproducir esa forma de trabajo. Es el comienzo. Una de las cosas que admira de la UJAT es que todos los participantes, lo tienen muy claro, que tienen que tener una solida formación", concluye Kevin Fitzsimmons.