

**ASSESSMENT OF GROWTH PERFORMANCE OF MONOSEX NILE TILAPIA
(*OREOCHROMIS NILOTICUS*) IN CAGES USING LOW-COST, LOCALLY PRODUCED
SUPPLEMENTAL FEEDS AND TRAINING FISH FARMERS ON BEST MANAGEMENT
PRACTICES IN KENYA**

Sustainable Feed Technology and Nutrient Input Systems/SFT/13SFT06AU

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ABSTRACT

Changing technology in aquaculture has been the major driving force for increasing aquaculture production in the phase of dwindling open water stocks. The choice of technologies and their adoption still remain a focus to increase production, productivity and farm incomes. We assessed the growth of Nile tilapia using locally available materials that included cages and low cost feeds to increased tilapia production in ponds. Various interventions were used among them experimental trials where we formulated low cost diets replacing expensive fish meal. A series of four workshops were also conducted over the course of this project period under this intervention. The first workshop on the development and use of best management practices in aquaculture was held in August 2014. This workshop targeting women in aquaculture had 18 women in attendance. There were two subsequent workshops, held in March and August 2015, and attended by fish farmers from Kirinyaga County. The fourth workshop was held for two days between 2nd and 3rd October 2015. This workshop specifically targeted the youth in aquaculture aimed at training the youth on integrated cage and pond culture focusing on development of cage culture in reservoirs located in the county of Kirinyaga that are presently underutilized by the communities.

Graduate support covered three female students who selected because of their previous linkage with AquaFish CRSP and excellent role they continue to play in development of aquaculture in this region. Among them two have submitted their theses for examination. We submitted five peer reviewed publications during this project period with two being specific on low cost feed and fish meal replacement. AquaFish provided funds for HCPIs and graduate students to attend National, Regional and WAS Meetings and Conferences as well. We note that farmers adopted feed technology very well and in their survey feed formulation and fish breeding were their priority. Under lesson learned, we noted that farmers required frequent visits, simple materials for reading and constant communication. They also require strategies on fish marketing such as use of cell phones applications and Aquashops.

INTRODUCTION

Feeding costs represents about 70% of the operation costs of fish farming. Yet, one of the foreseen constraints to intensification of fish farming is the scarcity of inexpensive and nutritive fish feeds a

major driving force for increasing aquaculture production in the phase of dwindling open water stocks (FAO 2006; Gatlin et al. 2007).

Fish meal has traditionally been used as the major protein source for formulated fish feeds because of its high protein content, balanced amino acid profile, good digestibility, high digestibility, palatability, and as a source of essential n-3 polyenoic fatty acids (Lovell 1988; Hardy and Tacon, 2002; Jackson, 2006). But the shortage in world production of fish meal (FM), which is the main conventional protein source coupled with its increased demand in feeds for livestock and poultry is likely to reduce the dependence on it as a single protein source in aquafeeds (El-Sayed, 1998; El-Saidy et al., 2003; Bendiksen et al., 2011). Therefore, the replacement of fishmeal with locally available and cheaper plant feedstuffs is proved to be very essential for the future development of aquaculture sector (Tacon and Forster, 2010). Several fish meal alternatives have been evaluated as possible fish meal substitutes. The results show great variation in the degree of success for partial or complete substitution depending on the species of fish under culture (Kaushik et al. 1995; Kissil et al. 2000; Refstie et al. 2000; Chou et al. 2004; Liti et al. 2006).

Rural pond culture in Kenya is moving from subsistence to small-scale commercial culture; a third intermediate type of aquaculture intervention that is a transition from the rural no cash enterprise to a more commercial aquaculture. Here small-scale commercial farmers endeavor to manipulate stocking densities, and nutrients levels to enhance their economic returns (Quagraine 2009). Their major production system is the small fishpond that average 400m² stocked with Nile tilapia (*Oreochromis niloticus*) and the African catfish (*Clarias gariepinus*). Since the open pond water can utilize cage wastes as fertilizers, generating natural food in the pond, the integrated system is environmentally friendly because less waste nutrients are released to the public water systems. Profitability from such venture is highly dependent on fish performance in the cage and static ponds. Resulting from success of this practice in south East Asia, Similar models based on the efficiency of cage-cum-pond systems will be introduced with a view to transferring this technology to small-scale farmers in Africa.

Integrated cage-cum-ponds culture is a system in which fish are fed with artificial diets in cages suspended in ponds, while same species or others low value fish are stocked in open pond water to utilize natural foods derived from cage wastes. The technique uses the niche optimization concept for feeding; the fish in cages are fed while those in open waters are either fed at lower rates or not fed at all. Pond fish, therefore, derive their nutrients from uneaten foods from the cages or from autotrophic and heterotrophic food chains (Yi et al., 1996).

The aim is to rear fish in a cage while the pond fish utilize the uneaten cage feeds and the plankton generated in the pond to satisfy the bio-energetic needs. In some farmed fish species, early maturation and breeding before attaining market size is a significant constraint on production. Energy is used for egg production at the expense of growth and, in some cases, such as with tilapia; ponds can become filled with undersized fish. This is a notable problem in Africa with the Nile tilapia. In such cases, stocking with monosex tilapia or sex reversed fish would be useful.

To limit competition for food, raise pond carrying capacity, and increase pond fish production, a higher supply of artificial feed is required. This systems, provides small-scale farmers an opportunity to use their limited resources to increase fish yield, generate more income and improve their livelihood. This training, therefore, provided the selected farmers with improved skills in seed production and feed formulation skills that would raise their level of fish production within the same area that they have used in the past.

Increased understanding of the basic premises of production of quality seed and feed aquaculture technologies will aid in raising production levels and better managed aquaculture systems. Providing

series of workshops to fish farmers was seen as an important contribution towards AquaFish Innovation Labs' overall mission of supporting sustainable aquaculture in this region of sub-Saharan Africa. The aim of these series of workshops was therefore to sensitize fish farmers on factors that increase fish production in ponds by demonstrating use of sex reversal techniques, low cost feeds, introducing methods of suspending cages in ponds and providing farmers an opportunity to commercialize aquaculture in Kenya.

OBJECTIVES

1. Develop low-cost, improved quality feeds utilizing rice bran and freshwater shrimps (*Caridina niloticus*) as fish meal replacement. One Publication.
2. Assess the costs and benefits of three different feeding regimes in cages. Graduate student.
3. Transfer technologies on management of monosex tilapia in cages through training farmers and extension officers. Workshop
4. Training on Best Management Practices for Fish farmers and extension officers.
5. Compare work conducted in this investigation on the use of low-cost supplemental feeds with the accomplishments of 20 years of CRSP-related work in the area.

METHODS AND MATERIALS

In this investigation, we planned on an experiment and a study. The project supported three graduate students instead of two and held three farmers workshops. Additional activity included a fish farmers field day leveraged by FAO regional office and the county government of Kirinyaga. We completed a fish farmer's survey and published two peer-reviewed papers in addition to three that we had submitted earlier. We carried out two experiments on feed trails

Experiment 1. Growth, yields and economic benefit of Nile tilapia (*Oreochromis niloticus*) fed diets formulated from local ingredients in cages: shrimp and bran.

In our endeavour to develop low cost feed for small-scale farmers, we did feed trials in cages. Development of low cost fish feeds through replacement of fish meal as protein source in the diet of Nile tilapia (*Oreochromis niloticus*). This study evaluated the suitability of replacing fishmeal with formulated freshwater shrimp and rice bran diet (Formulated Diet) as the main protein source on growth performance, nutrient utilization, carcass proximate composition and economic benefits in the diet of Nile tilapia (*Oreochromis niloticus*).

Fishmeal was replaced with low value *Caridina niloticus* (Freshwater shrimp) mixed with rice bran at a ratio of 25%, 50%, 75% and 100% and the dietary treatments tested in triplicate for six months. The fish were fed three times a day at 4% body weight. Growth and survival of fish were then recorded and analyses done on the economic benefits of producing Nile tilapia in small cages.

Experiment 2. Growth, yields and economic benefit of Nile tilapia (*Oreochromis niloticus*) fed diets formulated from local ingredients in cages: amaranth.

In our second trails, we used Amaranth leaf as fish meal replacement. The amaranth leaf has been drawing increasing attention for its nutritional content. In addition to growing quickly and being inexpensive to produce, it is also resistant to conditions such as heat and drought. The leaves are documented to contain 17.5-30.3% protein dry matter of which 5% is lysine, while significant levels of Vitamins A and C are also present.

Other major elements in the leaves include sodium (to maintain extracellular fluid balance), potassium (for haemoglobin functioning and maintaining electrolyte balance and normal cellular function), magnesium (for enzyme action, muscular contraction, nerve transmission and bone health) and phosphorus (to regulate acid-base balance and form bone and cells). Amaranth trials are being conducted in various continents and does form part of cutting edge research in fish meal replacement.

Tilapia larvae (mean weight 24.0 ± 2.0 g, 24 day old, mixed sexes) were obtained from Mwea Fish Farm Ltd hatchery. Each of the 15 static earthen ponds with an average surface area of 200 m² and an average depth of 1.2 m were stocked with 600 fingerlings. The feeding trials were conducted concurrently in the same set of pond.

Water quality parameters; dissolved oxygen, temperature and pH were determined in all the ponds on daily basis at 0800 and 1800 h. Dissolved oxygen (DO), temperature and pH were measured in situ at each sampling sites, using a calibrated JENWAY 3405 electrochemical analyser (Barloworld Scientific Ltd, Essex, UK), with independent probes for each variable. Portions of the water samples were used to determine: (i) nitrite nitrogen (NO₂-N) by the sulphanilamide diazotizing method; (iii) Total ammonia nitrogen (TAN) by the indophenol blue method; (iv) soluble reactive phosphorus (SRP) by the standard ascorbic acid method, after filtration of the sample through a 45- μ m pore membrane; and (v) total alkalinity (TA) by the acidimetric method, using sulphuric acid as the titrant. Total hardness was also done using EDTA titration. Total phosphorus and total nitrogen were determined following standard digestion procedures.

The strain of *A. cruentus* used for this study was obtained from Mwea Market, Kenya. Four isonitrogenous (38.1% CP) and isocaloric (23.6 kJ kg⁻¹) diets were formulated to contain four inclusion levels (25%, 50%, 60% and 80%) of *A. cruentus* using locally available feeds ingredients. The diets were compared to control feed containing fish meal alone. One-half litre of warm water in which the binder was dissolved was added to each diet thus formulated and mixed. The prepared feed were preserved in a refrigerator (-4°C) until used for feeding fish.

Fish were fed with the standard diet for the first 30 days in the hatchery. They were then transferred to the 15 ponds and stocked at a density of 3 fish m⁻². From the day of stocking, which was taken as the 1st day of the feeding experiment, the fish were provided with five experimental diets (D0, D25, D50, D75 and D100) in triplicates per treatment. The fish were hand fed four times a day for the entire experimental period at the recommended body weight of 2.5%. Daily feed ration was determined and adjusted every week based on fish body weights.

Ingredients, experimental diets and fish samples were analysed at the beginning and end of the experiment for crude protein (N₂×6.25), crude lipid content, moisture, and ash content using standard methods detailed in AOAC (1995). Gross energy was calculated using conversion factors for protein, lipids and carbohydrates provided in Tacon (1990). Amino acid compositions of the feed ingredients were determined by ion exchange chromatography. Sulphur-containing amino acid were oxidised using performic acid before acid hydrolysis. All analyses were performed, in duplicate, on the sub samples from each pond.

Growth in weight of the fish was expressed as the specific growth rate (SGR, % day⁻¹) using the formula:

$SGR (\% \text{ day}^{-1}) = 100 (\ln W_2 - \ln W_1) / \Delta t$ where: W₁ and W₂ = initial and final body weights (g) and Δt = time intervals in days.

Survival were determined at the end of the experiment by completely draining the pond and counting the remaining fish in the pond (taking into consideration any fish that died during weighing exercise) and percent survival calculated based on the number of fish remaining in the ponds as a percentage of the stocked fish.

$\% \text{ Survival} = \text{number of fish in the tank} / \text{Initial stocking rate}$

Nutrient utilization was determined using two parameters: protein efficiency ratio (PER) and protein productive value (PPV, %).

$PER = (FB - IB) / W_{\text{protf-1}}$; $PPV = 100 (W_{\text{prot2}} - W_{\text{prot1}}) / W_{\text{protf-1}}$

Where: FB and IB = final and initial fish biomass (g);
Wprot1 and Wprot2 are initial and final protein weight in larvae respectively (g); Wprotf = weight of dietary protein supply per larvae.

RESULTS

Under our experiment trials based on Development of low cost fish feeds through replacement of fish meal with maize gluten meal as protein source in the diet of Nile tilapia (*Oreochromis niloticus*), the best growth performance and feed conversion ratio (FCR) occurred in fish fed fishmeal followed by those fed a combination of rice bran and *C. nilotica*, while rice bran alone resulted in lowest fish growth performance. The best economic benefit was obtained from fish fed a combination of rice bran and *C. nilotica*. We therefore demonstrate that it is possible to replace expensive fishmeal in the diet of *O. niloticus* using combination of cheaper rice bran and *C. nilotica* without compromising economic benefits for the small-scale aquaculturists.

In our study on use of Amaranth leaf as fish meal replacement, we found that although the fishmeal-based diets had a higher profile of various essential amino acids, phenylalanine and tryptophan levels were lower compared to the amaranth leaf. Growth performance was generally unaffected by amaranth leaf replacements, with no significant differences in terms of SGR, mean weight gain and weight gain between diets of 100% fishmeal and those containing 75%, 50%, 40% and 20% of fishmeal respectively. However, the diet containing 100% amaranth leaf protein concentrates produced a lower final weight, weight gain and FCR, and the highest survival rate was observed in fingerlings given 100% fishmeal. Daily feed intake rose with increasing fishmeal substitution, and there were also significant differences in nutrient utilization parameters.

The study concluded that up to 80% of fishmeal could be replaced with amaranth leaf protein concentrates without compromising growth performance and nutrient utilization, but differences between the two were observed. For example, the essential amino acid composition of both was similar except for histidine, leucine, lysine and methionine levels, which were lower in the amaranth leaf. This was presumed to be more limiting for fish growth performance, especially low lysine levels. Anti-nutritional factors such as phytates and oxalates were also observed in the amaranth leaf, with some remaining bound to certain proteins in the diets, rendering them inaccessible to digestive enzymes and thus reducing protein digestibility. This may also have impaired the absorption of some essential amino acids in the amaranth leaf diets, depressing fish growth as a result. Phytate may also have been responsible for reduced growth in fingerlings that were given higher levels of amaranth leaf.

We have gone further to test nutritional composition of locally available ingredients including insects as formulation of possible low cost feeds for small scale farmers. This is being done under a collaborative project with Sterling and Machakos Universities.

Outreach activities- Activity 1:

Based upon the current county and national interest and continuing CRSP efforts on development of aquaculture in Kenya, we organize the BMP women in Aquaculture workshop in August 2014. This workshop, attended by 18 women drawn from Kirinyaga County, was very stimulating and an eye opener for the women involved in aquaculture in this region.

Preparation of the workshop included identifying BMP materials and data generated during the previous BMP project funded under AquaFish CRSP. Government officers, extension workers, and University resource persons were sourced to conduct this workshop. We discussed Best Management Practices in Aquaculture, Gender participation in Aquaculture; the role of women in development of

Aquaculture, record keeping, seed and feed production, and value addition in Aquaculture. Farmers participated in feed formulation, catfish propagation, and gutting and grading fish for local markets.

Activity 2:

Two trainings under this activity were held in March and August 2015. These workshop laid emphasis on techniques on production of monosex Nile tilapia in ponds and formulation of on-farm low cost feed by farmers. The workshops consisted of lecture sessions, demonstration, and on hand spawning/ hatching work. Attendees of the March 2015 workshop totaled 81 and were selected from those farmers that had either been trained by previous CRSP efforts or had benefited from the Government Funded Economic Stimulus Program. The August 2015 workshop had 37 participants drawn from a pool of farmers that had been trained earlier on best management practices.

During the August 2015 workshop, we invited guests from Aller-Aqua Denmark to give a talk on floating and extruded feed and their advantages in fish production as well as advice farmers on how to formulate feeds at a lower cost. Professor Honno from Aller-Aqua gave a stimulating presentation on production of quality fish feed in Denmark. Simple on-farm technologies for propagation of both Monosex tilapia and catfish were demonstrated under the guidance of experienced resource persons from both Kenyatta and Karatina Universities. Farmers were able to evaluate and compare alternative technologies in fish breeding, stocking cages and formulating their own feed at the farm site.

Activity 3:

A youth workshop was held for two days running from 2nd to 3rd October 2015. Attendees were youth from Kirinyaga country drawn from five clusters, extension officer that would later work with the youth, and nine undergraduate students from Karatina University. There five clusters of youth selected based on reservoirs that were identified in the county. Each cluster was responsible for developing and managing cages in their respective reservoir. The County Director of Fisheries selected the youth with assistance of the respective sub county extension officers. They were chosen according to their willingness and ability to participate, and because of suitability of their reservoir as a resource to the community where they were drawn from. A rapid needs assessment was done on the capabilities of cluster farmers, basic requirements such as minimum number of participants, ability to stay as a cohesive cluster, maintain the reservoir, and keep records. For the two days they learned group dynamics and cluster mobilization, cage site selection, production of Nile tilapia in cages suspended in reservoirs or ponds, monosex tilapia production, cage carrying capacity, designing, materials and construction of cages, fish nutrition and feeding fish in cages, sequencing production, and management of cages in reservoirs. At the end of this training, each cluster successfully constructed one cage that they took away with as their first cage.

Activity 4:

An important element of this investigation was a survey to evaluate the alternate technologies we presented to farmers during the workshops. In particular, we sought through a questionnaire detailed feedback from fish farmers who attended the March and August 2015 workshops on their view with regard to the technologies introduced to them and how best they would adapt them. Feedback was also obtained through personal interviews and panel discussions both during and after the workshops. Feedback questions were compiled in electronic form (MS Excel) and analyzed (Tables 1 and 2). We also discussed possibilities of farmers raising fish to 100g then selling to selected farmers who would in turn fatten the fish until market size then send to the local markets. Farmers were enthusiastic with this arrangement and over 15 fish farmers were ready to join in this program.

Additional activities (leverage)

We held a fish farmers' field day organized by the county director of Fisheries, Kirinyaga and attended by the county governor and representative of five fish farmers clusters. There were over 200

attendees present during this event whose climax was learning how to eat fish. Under this investigation we held a side activity that trained 28 young persons for three days on pond construction. We plan on forming a pond construction crew in the county and this team was trained with a view to forming such a crew to be contracted by fish farmers to construct ponds for them whenever such request arises.

Food and Agriculture Organization (FAO) Kenya regional office organized a six days training at Mwea Aquafish Farm attended by 30 Fish farmers. This training is on enhancing commercial hatchery and nursery development under an FAO Kenya/Uganda ASFT (GCP/SFE/001/MUL) project. It is funded for five years and will cover three counties in Central Kenya. Hatchery managers were therefore selected from Kirinyaga, Embu, and Tharaka Nithi Counties. Attendees learned how to select and maintain brood stock, catfish and monosex propagation, biosafety and biosecurity in the hatchery, record keeping, and nursing fry and fingerlings, among other Hatchery management protocols.

Technology transfer and adoption levels

From the survey that we carried out through the questionnaire administered to the attendees, we found out that in most training sessions, the representation of women was 47.8%, compared to that of men who were 52.2% (Table 1). The increased number of female representation is an indication that young women are now equally participating in fish farming. Farmers reported having learnt new fish farming practices from the activity. Ranking high on the list of new ideas learned was monosex seed production, feed formulation, pond management, record keeping, as well as on-farm propagation, and production of catfish fingerlings. Most farmers intend to engage in fry production.

Farmers were keen to learn quality seed production, indicating that farmers recognize there is a shortage of quality fingerlings and would prefer to produce for sale. A large proportion of farmers (80%) realized that aquaculture is a viable enterprise and that they can engage themselves and grow fish at a profit. When asked how much they harvested last season, they reported a range of 10-500 kg per annum. Most farmers, however, promised to increase production after adopting technologies that they learned during the workshops.

As shown in Figure 1, the youngest attendee was 20 years old and the oldest 89 years, with over 80% of the farmers aged between 40 and 60 years; only one farmer was above 80 years old. Farmers interviewed had their education levels ranging from primary to tertiary (Table 2). Twenty-one of these farmers read up to primary level (23.30%), while 34 up to high school and 35 (38.9%) beyond high school, and either acquired a diploma or a degree. Therefore, a majority spoke English fluently, although about 10% indicated that they preferred Kiswahili or English.

Majority of farmers owned more than one pond measuring 300 m², and have been in fish farming for more than 3 years. Pond sizes ranged from 200m² to over 1000m². Most of the new farmers had one pond whose size was 300m² because these were the fishponds constructed by the government under the Aquaculture Economic Stimulus Program. They raised Nile tilapia in polyculture with catfish, as Monosex, or kept only catfish as shown in Table 3, and presented better in Figure 2. This implied that although they were being introduced to monosex fish culture, a percentage already are practicing it on their farm.

When asked whether they kept records of their farm activities, only 25% farmers reported that they kept records on stocking and harvesting, but majority acknowledged the need to keep records. Over 60% (25) of the farmers had now joined or formed an association and only 10 indicated that they were willing to be members of Kirinyaga County Fish farmers Association. Most farmers were close to a market, except for 12 farmers who had to travel over 20 kms to get to the markets. On average,

most farmers spent not more than Kshs 300 as bus fare to get to the market. Seventy-four percent of these farmers stated that their roads were accessible throughout the year and only 5 said that their roads were impassable, especially during the rainy season.

When asked about information and sources, farmers' replies were interesting, as well as diverse. Most farmers have received information free, and only 4 have paid for information in the past. However, 95% of these farmers were willing to pay for information. They preferred booklets and manuals to posters and fact sheets. Indeed, fact sheets were ranked lowest in order of their preference. Mostly ranked government extension officers as main source of information and universities as the least source of contact. Only one farmer did not have a radio or TV, while majority had both radio and TV. Seventy-six percent of the farmers had a radio each and did value TV programs as main source of information. Interestingly, local NGOs and newspapers did not appear as major source of information.

Farmers prioritized fish and feeding fish, pond management, and pond construction as areas in which they needed information. Other areas included seed production, fish marketing, and equipment, as well as diseases and predator control. They are now using their phones to text messages, while about 18% have access to internet. Their main challenges as stated are lack of information, lack of follow up after training, lack of feed and seed, as well as fish marketing information.

As a way of improving on past fish farming practices, they wished there were more training, workshops, seminars, information dissemination, field visits by extension workers, and aquaculture materials. Certainly, for these farmers and others to adopt aquaculture technologies and have good practices, information sources are needed. Information should be in the form they indicated but not just information, but correct information on aquaculture practices that would contribute greatly to improved pond fish production. They highly valued practical training and information sharing as a way of motivating them and resolving most of challenges they experience in the field.

Feed Technology transfer included Training activities on Best Management Practices Liming fishpond to ameliorate soil acidity, formulating feeds in the back yard, building own cages using locally available materials. During these trainings we laid emphasis on training women and youth in aquaculture practices.

Compare work conducted in this investigation on the use of low-cost supplemental feeds with the accomplishments of 20 years of CRSP-related work in the area

At the onset of the CRSP program, it was evident that fish farmers in Kenya fed their tilapia using expensive poultry diets and dairy meal or bran that were low in protein and contained high fiber content and that there were no commercial fish feed manufacturer in the country. The disadvantages being that commercial poultry rations are not nutritionally balanced for fish, containing more digestible energy per unit of protein than recommended for fish, and brans alone are nutritionally deficient and often unconsumed by the fish due to small particle size. These feeds were fed as powder leading to high losses in the ponds. Pelletizing feeds reduces feed losses, especially when multiple ingredients are included in the formulation.

Work on sustainable feed technology research in Kenya supported by Pond Dynamic Aquaculture CRSP began in 2002 at the Sagana Fish Farm then under the Ministry of Agriculture, livestock and Fisheries, State Department of Fisheries. We planned on generating low cost feed technologies that would help inform future aquaculture feeds research and technology developers beyond the life of the AquaFish program. The purpose of developing low cost feed and teaching farmers to formulate their own feeds using locally available ingredient was aimed and lowering cost of fish production and raising farmers income.

Under work plan nine and ten, experiments done at Sagana prioritized feed formulation using locally available agricultural by-productions. Trials were done using pig finisher, rice, maize or wheat brans in combination with fishmeal to lower the feed cost and provide complete diet. Lower quality pelleted feeds formulated specifically for tilapia, were combined with fertilization regimes to increase the availability of natural food organisms, and found to be economically appropriate approach for intensification of tilapia culture. In an attempt to seek ways of increasing fish yields, a study was conducted at Sagana fish farm to compare locally available rice bran with two compounded feeds, a domestic animal feed (pig finisher pellet) and a laboratory formulated diet. The objective of this study was to assess economic benefits of a tilapia and catfish polyculture under three different nutrient regimes, namely Rice Bran (RB), Pig Finisher Pellet (PFP) and a Formulated Diet Pellet (FDP), with the goal of establishing recommendations for the most suitable diet for tilapia and catfish fish farmers. The results demonstrated that the two compounded diets had similar nutritional value and promoted better fish growth than rice bran. The fish in this study performed better with formulated diets as compared to single ingredients. Also an economic comparison performed in this study favored the utilization of formulated diets.

The second study was by Dr. David Liti, Karen Veverica and Sagana team on growth and economic performance of Nile tilapia fed on two formulated diets and two locally available feeds in fertilized ponds. Two isonitrogenous (24%) diets were formulated from shrimp meal (*Caridinia nilotica*), cottonseed meal (CSM) and Wheat Bran. One of the formulated diets was supplemented with a locally manufactured commercial vitamin and mineral premix at 0.5% inclusion level. Wheat bran in this diet was included at 63.5% to allow for the premix. Commercial feeds were purchased from a local feed manufacturer while WB was purchased from a wheat-processing factory. Feeding *O. niloticus* on the formulated diets in fertilized ponds resulted in significantly higher mean weight than that of fish fed on commercial diet or Wheat Bran. However, fish that fed on diets formulated with or without vitamins and minerals premix had similar mean weights. Since then, additional trials have been done to replace fishmeal with locally available ingredients and using rice bran as the primary source so as to lower the cost of feed. Results from these trials have been published in various articles listed in the reference section of this report.

QUANTIFIABLE BENEFITS

- Feeding ration estimated to improve farmers' feed efficiency and reduced costs for grow-out of tilapia by as much as 35%, without compromising yield.
- An additional 200 farmers, extension agents, and stakeholders received training through workshops and farm visits.
- Peer-reviewed publications and presentations and regional and international conferences increase AquaFish visibility and shared technologies
- Three graduate students received research training and education on sustainable aquaculture technologies and have since then submitted their theses for examination except one who suspended here studies due to family issues.
- Linkages increased numbers of farmers trained and technology transfer
- Annual meetings increased level of interaction and possibilities of furthering collaboration among host country PIs various international organizations

LESSONS LEARNED

During this investigation, and as has been the case in the past, the project team enjoyed a successful four-way partnership between the Government Ministry responsible for Fisheries and Aquaculture the County government in the Host country, the University hosting this project, and The US Host University. This partnership has worked well to get work done and seems to have had the beneficial

effect of bringing the partners into a good working relationship, wherein they work together towards common goals in aquaculture development and in training of extension personnel and farmers. We need to recall that in the recent past (2010) Kenya adopted a new constitution that devolved all agricultural function to County governments. Consequently, most of collaboration is now at the County level and this has brought new challenges in the way we communicate and engage government extension officers.

In Kirinyaga County, we began engaging the County Governor, and later the County Chief officers, into our programme. This has made our work much easier, and whenever we wish to invite farmers we do so through the County government and have not experienced any major challenge. Indeed, we began by inviting the governor and his executives to our meeting so as to solicit support and leverage funding. The governor spent a whole day with fish farmers, ate fish with us, and donated five freezers to cluster farmers. This was very encouraging and did give us an easy take off as well as open channels of communication with County government.

CONCLUSION

We have been training farmers on various aspects of fish farming. However, in the recent workshop we challenged farmers to give thought to the level of investment we have put in these trainings and that in future we shall require some accountability; mainly though reporting on how much production they have achieved and proof that our investment in training is changing their incomes to what extent. One way will be by evaluating their management performance and increased fish yield. We will then be able to assess ourselves and determine what we have achieved and to what extent. We therefore laid more emphasis on record keeping and looking at aquaculture as a business.

Through linkages, we received leverage funding from FAO to run training for six days for Hatchery managers and one day workshop organized by Ana Athifah and Nathaniel Hishamunda. FAO has a five-year project in this region and is indeed riding on the CRSP success as well as the government Economic Stimulus programme. Both have had links with AquaFish Innovation Lab and so were willing to partner with us. Though the 5 publications and numerous fact sheets generated from this project since 2013 we are reaching out more investors and fish farmers in the region. Farmers in this region (Kenya, Uganda and Tanzania) have now in place National Aquaculture Associations that have regular annual meetings. These associations are ready to engage government and policy makers in discussions that will provide legislation and budget for aquaculture legal framework and financial support.

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TABLES AND FIGURES

Table 1. Summary of responses to the question on gender

| Response | Number | Percent |
|----------|--------|---------|
| Female | 43 | 47.8 |
| Male | 47 | 52.2 |
| Total | 90 | 100.0 |

Table 2. Summary of responses to the question: “what is your level of education?”

| Response | Number | Percent |
|-----------|--------|---------|
| Primary | 21 | 23.3 |
| Secondary | 34 | 37.8 |
| Tertiary | 35 | 38.9 |
| Total | 90 | 100.0 |

Table 3. Summary of responses to the question “What is your method of fish culture?”

| Response | Number | Percent |
|----------------------|--------|---------|
| Tilapia Monosex | 28 | 31.1 |
| Tilapia with Catfish | 22 | 24.4 |
| Catfish | 5 | 5.6 |
| Tilapia Mixed sex | 30 | 38.9 |
| Total | 90 | 100.0 |

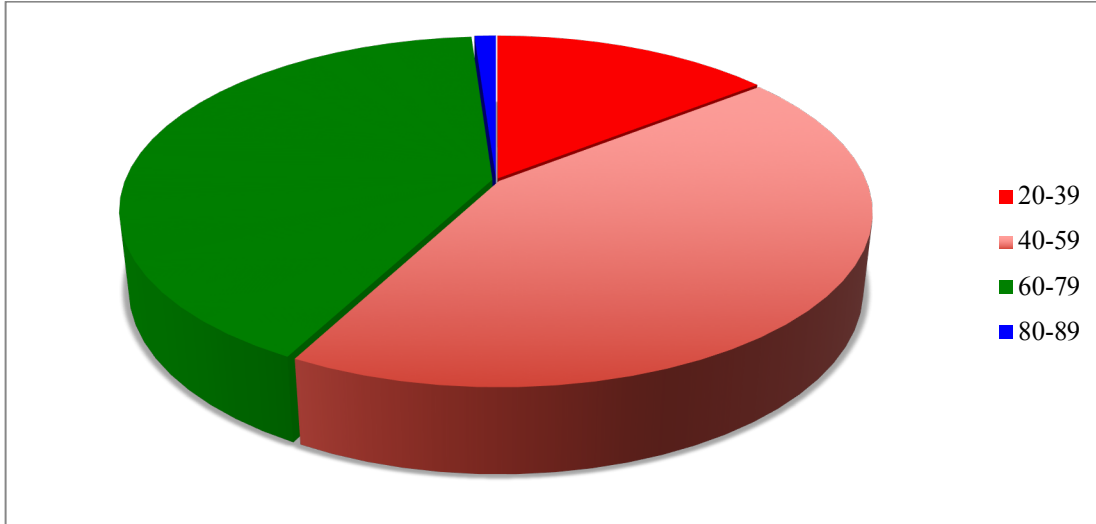


Figure 1. Summary of age groups of fish farmers that attended the workshops

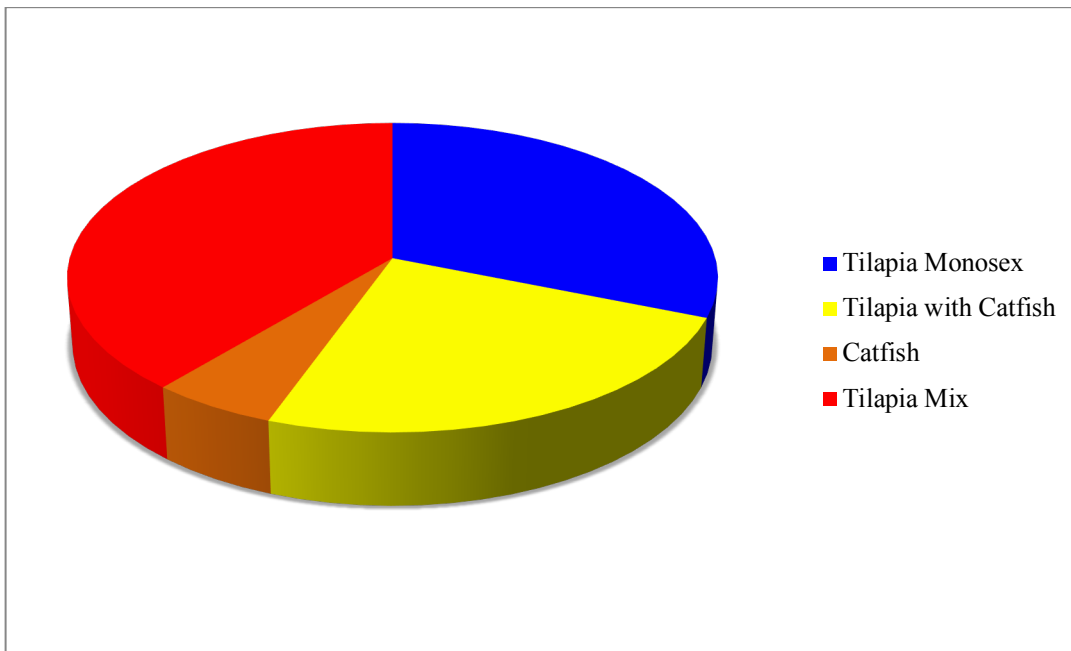


Figure 2. Summary of fish farmer aquaculture practices



Fish farmers Hatcheries in Kenya are using tilapia egg incubation technology to raise fry in the hatchery using locally available materials.



Joe Molnar and Ram Bhujel listen to a presentation during the AquaFish session in Cape Town South Africa.



The AquaFish team Visited fish farmers that were trained on feed formulation to check on how they were formulating and feeding their tilapia.



The AquaFish team in a technical session in Kampala regional meeting, Uganda;



Ann Athifah and Nathaniel Hishamunda both from FAO and the AquaFish team conducted a Business Training for fish farmers at Mwea Aquafish farm.