Farmers as Scientists

This is a series anchored by M.C. Nandeesha. It describes farmer-driven innovations and experiences.

Substrate based aquaculture systems

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Farmer innovation withstands scientific scrutiny and proves robust

Use of substrates to aggregate fish in the natural environment has been in practice for several centuries in different parts of the world. Scientific evidence to the existence of this type of system has begun to emerge from Africa and Asia. The application of this technology evolved by farmers have resulted in the generation of new technologies that are likely to benefit the poor who always have difficulty in obtaining pond input resources. Welcomme (1972) made the pioneering efforts to record the Acdja-based fisheries prevalent in West Africa. In the Acdja system, dense clusters of branches are placed in lagoons to attract fish. The tree branches are known to promote the growth of periphyton, which is an excellent food for many different species of fish. In addition, tree branches also provide shelter for the fish by creating a protective environment. After nearly two decades of the pioneering work by Dr. Welcomme, which showed that farmers could get a high production (ranging from 4-20 tones /ha), scientists from France explored the possibility of applying the basic principles of Acdja system to aquaculture in West Africa. The results with tilapia culture, showed the possibility of increasing production of tilapia up to 8 tones /ha by addition of bamboo as a substrate. This created a lot of interest to test this technique to enhance the productivity of different aquaculture systems.

Asian fishers experience

In Cambodia, brush parks, commonly known as "Samarahs" are used as fish aggregating devices in many river stretches. The tree branches are submersed in rivers and the surface is covered with floating aquatic vegetation. Fish begin to inhabit these structures after about two months. Fishers encircle the area with a net, the branches are removed and the fish are harvested. Brush park fisheries similar to those in Cambodia are also seen in several other Southeast Asian countries.

Adequate number bamboo poles fixed in the pond would provide good amount surface area for the growth of periphyton

In Sri Lanka brush park fisheries are also prevalent in the shallow coastal waters with more than 3000 brush parks established during the season to attract fish and shrimp. In other South Asian Countries such as Sri Lanka, different forms of fish aggregating devices are used. In Bangladesh, "Katha fisheries", which employ the same principle have been prevalent for centuries. Farmers submerge different types of woody branches in the river stretches and after two-three months, the area is encircled with the net and the aggregated fishes are collected.

In the state of Manipur on the Northeastern part of India, substrate-based aquaculture systems are widely prevalent in the Lok Tak Lake. This lake, which is the lifeline of Manipur supplies a large part of the fish needs of the state. Floating islands formed through the dense growth of aquatic weeds and grasses are spread throughout the lake and are used as the natural fish aggregating devices. These floating islands, which are constructed by trimming the fronds of weed mats to a width of 1-2 meters and these trimmed fronds are bent in a circular format to give a diameter of 10 to 30 meters. The two ends are held together with bamboo and ropes. Once the circular ring is formed, they are moved to the desired place in the lake and they are anchored using the bamboo. The inside of the weed ring is filled with other aquatic vegetation. The dense network

Jute sticks, which also has been found to be as a good substrate, though commonly available, has not gained popularity with farmers

Bamboo branches, which are commonly used in ponds to prevent poaching are also found to be effective as substrates in promoting fish growth.

Tilapia has shown excellent growth in the presence of substrates in fish ponds

of the weeds act as floating platforms and as centers for the trapping of nutrients and their subsequent release in to the environment through death and decay. These circular weed mats are locally called "Phums". Fishers even build houses on the weed masses and there are about 500 families living on such masses on the lake. The phums are harvested at an interval of one to two months. Several strategies are adopted by farmers to increase productivity from the phum like fixing feedbags in the area to attract fish in the early stages of phum establishment and increasing productivity by regulating weed density inside the weed ring. Production obtained from these phum areas are reported to be very good (estimates indicate 300 to 1000 kg / phum). Some fishers own 3-4 phums and the income earned through fishing them is reported to be good. As the number of phums are increasing in the lake and affecting the ecology of water body, Government is exploring various ways to regulate the number of phums inside the lake to safeguard the ecology and fisheries of the lake as there are many who are dependent on it to meet their livelihood necessities.

More scientific research results support the novel invention of farmers

A recently concluded research project with the funding support of the European Union and through the twin partnership work between the Asian and the European scientists added very valuable scientific information to support the benefits of these traditional systems evolved by the farmers. The two institutions from Asia (the Fisheries Faculty, Bangladesh Agricultural University, Mymensingh the College of Fisheries, Mangalore in India and) and the two institutions in Europe (the Institute of Aquaculture, University of Stirling, UK and the Fisheries Faculty, Wageneningen Agricultural university, Netherlands) worked over a period of three years. Some of the interesting results obtained are highlighted here to encourage others to explore this simple and efficient technology to increase productivity from aquaculture systems. E-mail contact addresses are also provided to enable those interested to

contact the person with expertise to get more information.

Mangalore findings

Research in Mangalore focused more on the use of degradable substrates and their benefits in promoting fish growth. This followed the earlier work of Dr. Shankar (kalkulishankar@rediffmail.com) and his group that biologically degradable substrates, rich in C:N ratio will result in higher periphyton production and the growth of fish. Further detailed studies by Dr. Keshavanath (perarkeshavanath@yahoo.co.in) and his group have shown the benefit of easily degradable biological substances like water hyacinth, bagasse and paddy straw in enhancing fish productivity. Growth comparison of fishes on these substrates with bamboo, which has longer shelf life and is known to provide good surface area for the growth of periphytic organisms was impressive. The results obtained at Mangalore under the field conditions also demonstrate clearly that it is possible to obtain 46% higher profit just by the addition of bagasse as substrate, as compared with the control treatment.

Mymensingh findings

The work carried out in Bangladesh by Dr. Wahab (wahabma@bdonline.com) and his group at the Bangladesh Agricultural University has revealed good lot of information on the use of substrates that are not easily degradable. Bamboo poles, bamboo branches, bamboo mats, jute sticks, etc, have been evaluated for their benefits as substrates in fish ponds. In addition, the growth performance of different species of carp has also been evaluated. Rohu and calbasu have shown to grow rapidly in presence of the above substrates. The growth of these species has been found to be several folds higher (60-80%) as compared to control treatment. These results are very important in view of the benefits one would derive in terms of growth with species like rohu, which has very high market demand.

The European Institutions with Dr. Malcolm Beveridge (m.beveridge@marlab.ac.uk) from

A farmer with the harvested from a family fish pond provided with substrates

Phums (weed aggregated areas) have demonstrated to be excellent areas to promote the growth of fish and also serve as good spots to aggregate the fishes

Among carps, rohu is known to grow rapidly in the presence of substrates and this species also has the highest market demand

Stirling and Marc Verdegeham (marc.verdegem@wur.nl) from Wageningen have played major in planning the experiments and data processing including human resource training at various levels. Dr.M.E. Azim from Bangladesh completed Ph.D. program from the Wageningen University. The thesis produced by him is considered as one of the best thesis, with many publications emerging from the study appearing in widely read journals like "Aquaculture" and "Aquaculture Research " (azim@post.saitama-u.ac.jp).

From lab to land

Inspired by the good results that were obtained in the research station, some field trials were carried out by the farmers in a CARE supported project in Bangladesh. I had the opportunity to be associated with this work along with my other colleagues like Mr. Manjurul Karim (manjurul@stir.ac.uk) who led the field investigation. Early trials carried out with jute sticks as a substitute to Bamboo, although demonstrated benefits, small size of the sticks and the amount of labor involved in fixing these sticks in water did not encourage farmers to explore large scale adoption of the technology, though the jute stick is commonly available in many parts of the country. Discussion with farmers revealed that they would use different types of substrates that are commonly used by the fishers in rivers along with whatever amount of bamboo that they can obtain. A field trial conducted with a group of 31 Farmers over a period of one culture cycle revealed that all the farmers used bamboo as a substrate and this supplemented with two other tree branches namely, saora (*Streblus asper*) and Mango (*Magnifera indica*) tree branches. The results indicated that even the sparse addition of these substrates resulted in the significant increase in production. While quantitative analysis of the data showed a significant increase in production from 1411 kg/ha to 1876 kg/ha, qualitative analysis indicated that 79% farmers were happy with the production, while rest of the farmers were moderately happy as compared to the baseline year when 56% were unhappy, 36% were moderately happy and remaining 8% were very happy with the production obtained.

Growth performance of high value species

Preliminary studies conducted in Bangladesh and detailed investigations carried by Tidwell and his group in USA have also demonstrated the benefits of substrates in enhancing the growth and yield of freshwater prawn *Macrobrachium rosenbergii*. These results are significant in view of the commercial value of the species and easy possibility of introducing substrates in to promote the growth of these high value species.

Availability of commercial mats

Different types of mats have begun to appear in the market, which employ the same principle of augmenting the availability of periphyton in the water. It is reported that usage of mats in some experimental areas has resulted in a reduction in feed usage of almost 50% without any effect on production. In Ghana, a new project using the principle of "substrate based growth promotion" has been initiated between Ghana Artisinal Fisheries Development and exporters Organisation (GAFDEO) and Fair Trade Seafoods (UK). Acdjamat, which has been developed using polymer composite materials and registerd in UK will be used with fishers to promote the growth of tilapia in cages. The fish cultured will be processed and exported.

Opportunities for further experimentation

In several places, bamboo poles and tree branches are placed in ponds as a device to prevent poaching. It would be useful, if the farmers could increase the amount of substrate to a level taking in to consideration of the surface area that would be available and ensure that the substrate added would contribute to additional increase in surface area almost to the same level. It bamboo poles could be fixed at 8-10 / m^2, it appears that, it will provide good surface area for the production of periphyton. So far, efforts have not been made to combine rapidly degradable substances like sugarcane bagasse, paddy straw and water hyacinth along with bamboo poles or tree branches, which have longer shelf life in water. Water productivity is an important criterion in determining the abundance of plankton, including periphyton. Hence, addition of biologically degradable substrates with slowly degrading materials like bamboo and woody branches might result in the best growth of fish. Filling of bamboo poles with manure and provision of holes for the slow release of nutrients through these holes also likely to promote the good growth of periphyton.

It appears that not all species may perform well with the addition of substrates. Tilapia, rohu and calbasu have shown very good growth in the presence of substrates, particularly bamboo. Rohu has the highest market demand in the whole of South Asia. Farmers in Andhra Pradesh have proved that it is possible to obtain more than 10 ton/ha /year with rohu comprising more than 90% of the stock. It may be possible to further step up the production of rohu by employing the substrate-based system.

In eastern and Northeastern part of India, rice and fish are the staple food items of the population. While bamboo is grown widely in the region, paddy is the common agricultural crop cultivated. Usage of bamboo along with biologically degradable substances like paddy straw or water hyacinth might help in increasing productivity from carp culture ponds. Field trials are necessary to evolve technologies that are appropriate to the farming practices noticed. Partnership with farmers in carrying out field trials under the actual farming conditions would result in generating more useful information.