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Poly^{Plus}- a cost effective feed
for brackishwater polyculture

March , 2018

भाकृअनुप - केन्द्रीय खारा जलजीव पालन अनुसधान सस्थान
ICAR - CENTRAL INSTITUTE OF BRACKISHWATER AQUACULTURE

KAKDWIP RESEARCH CENTRE
Kakdwip, South 24 Parganas, West Bengal, 743 347

Front cover : Haul of farmed multispecies fish harvest using Poly^{Plus} Feed
Back cover
Up : Commercialization of Poly^{Plus} feed through an MoU with a private entrepreneur
Middle : View of Kakdwip Research Center of ICAR-CIBA, Kakdwip, West Bengal
Down : View of Head Quarters CIBA, Chennai

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Poly^{Plus} - a cost effective feed

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Introduction

For successful culture of fish or shrimp a nutritionally balanced formulated feed is essential. Feed cost alone constitutes 50-60% of the total operational expenditure of fish or shrimp culture. Commercial shrimp feed production is expected to be 9.2 million tons by 2020 (Tacon and Metian, 2008). At present, commercially available feeds are very expensive. Shrimp feeds are sold @ ` 80-85 per kg, whereas fish feeds are sold @ ` 45-55 per kg and are not affordable by many small and marginal aquafarmers. Commercially, fish meal is the most common and expensive ingredient used for aquafeed formulation as it is having an excellent nutrient profile to fulfill the dietary requirement of cultured fish and shrimp. The cost of the feed can be reduced by partial replacement of fish meal with locally available ingredients. The cost of the feed can further be reduced if a farmer can prepare it at their own farm and can avoid the cost involved in marketing and associated tax which is about 25-50% of the market price of feed. At present farmers practise the polyfarming in tide fed ponds. They normally do not use any feed. However, few farmers use mash feed (mixture of mustard oil cake and rice bran). Availability of low cost pellet feed is a bottle neck to harness the growth potential of brackishwater polyfarming. Considering this situation, the ICAR-Central Institute of Brackishwater Aquaculture (ICAR-CIBA) -initiated development of low cost feed for multispecies culture using locally available ingredients as partial replacement of the most expensive feed ingredient, fish meal. A series of experiments were conducted for evaluating the performance of the developed feeds in indoor system as well as in farm trials.The developed feed was field tested at farmers' ponds with encouraging results and the technology of low cost feed formulation has been transferred to farmers and entrepreneurs.

Farm made feed is produced by farmers and small-scale feed manufacturers using some form of processing on farm or in a small

processing plant, resulting in moist dough or a semi-moist or dry pellet. Often feeds are provided to aquaculture systems with little regard to the economic or nutritional rationale for their use. Such practices may result in feed wastage and poor economic performance of the production systems. Factors affecting poor feed utilization and high feed conversion ratios (FCRs) include the quality of feed, feed type (pellet or dough), and the feeding strategy. Few farmers show an inclination to use extruded floating pellets, probably without attempting to use other management options to best utilize the sinking pellet or farm-made aquafeeds.

Under the project "Improvement of production and productivity of traditional brackishwater aquaculture practices in a sustainable manner and evaluation of its emerging trends with particular references to coastal areas of West Bengal" CIBA took a programme on low cost feed development and management in traditional brackishwater farming systems. Chemical analysis of locally available conventional (rice bran, mustard cake, ground nut cake, sunflower cake, wheat flour, maize flour etc.) and unconventional ingredients (mung husk, khesari husk, pea pod husk, sesame cake, deoiled karanja cake, mango seed kernel, tamarind seed powder, azolla, duck weed, mangrove leaves, *Moringa olifera* leaf, subabool leaf, acacia pod etc.) has been done and the nutritional suitability and maximum inclusion level of few potential locally available

Table 1. Inclusion level of different un-conventional feed ingredients

Ingredients	Inclusion level (%)	
	Penaeus monodon	***Mugil cephalus***
Mung husk	5	5
SFC	10	10
DOKC	2.5	7.5
MSK	7.5	7.5
TSP	2.5	2.5

ingredients for different types of feeds were ascertained, and the cost effective formulations were developed for different culture systems. These feeds were developed based on the ingredients available in West Bengal. However, these can be utilized in other regions of India with a slight modification in formulations depending on the low cost ingredients available there. ICAR-CIBA had earlier developed Farm Made Feed technology for aquaculture of Asian Seabass. Application of farm made feed decreased the cost of production and thereby increased the profit margin of aquaculture activity.

Evaluation of potential locally available feed ingredients for inclusion in feed

For formulation of low cost feed for polyculture, experiments were conducted to determine the inclusion level of mung husk (MH), sunflower cake (SFC), deoiled karanja cake (DOKC), mango seed kernel (MSK) and tamarind seed powder (TSP) in diets of Penaeus monodon and Mugil cephalus. It was found that MH and SFC can be incorporated up to 5 % and 10 % level, respectively, in diet of both the species. DOKC can be incorporated at 2.5 % and 7.5 % level in diet of P. monodon and M. cephalus, respectively, without affecting survival, growth and digestibility. MSK and TSP can be included at 7.5 % and 2.5 % level in diet of both the species, respectively.

Nutrients in fish feed

Fish need energy and essential nutrients for maintenance, movement, normal metabolic functions and growth. Fish can obtain their energy and nutrients from natural food in ponds, from feed supplied or from a combination of both sources. The major components of feeds are water, protein, lipid, carbohydrate, minerals and vitamins. Fish obtain the energy they need by eating protein, lipid and carbohydrate (these nutrients are called the macronutrients). Small (or trace) amounts of minerals and vitamins are also essential. These are called micronutrients.

Protein is composed of amino acids. There are 10 different amino acids that cannot be synthesized in fish at rates sufficient for maximum growth and development and need to be supplied through diet. These are the "essential amino acids". There are many others that can be synthesized from the essential amino acids by fish. The exact requirements for essential amino acids vary between species and life stages.

Lipids are composed of fatty acids and glycerol. Lipids are important in the diet as a source of energy, essential fatty acids, sterol, phospholipids and carrier of fat soluble vitamins. Fish oil and soya oil are generally used as lipid sources during feed formulation.

Carbohydrates include fibre, starches and sugars, and are not usually considered essential. Carbohydrates are usually the cheapest sources of energy, although different species of fish differ in their ability to use carbohydrates. Carbohydrates can also act as binders in feed formulation.

Minerals are important for normal skeletal development of fish but some also play vital role in the functioning of enzymes and other metabolic functions. Vitamins are complex organic compounds required in small amounts for normal growth, reproduction, health and general metabolism. Diets lacking adequate levels of vitamins and minerals can result in growth and development disorders and death in severe cases of deficiency. Many vitamins and especially, vitamin C (ascorbic acid) are easily damaged by heat, light and humidity, and this reduces their usefulness to fish.

Fish eat primarily to satisfy energy requirements. If there is too much energy compared with protein, animals will stop eating before they consume enough protein for maximum growth. Too

much energy from dietary fat or carbohydrate can also lead to high body fat, low dress out yield and poor shelf life in market size animals. If there is too little energy compared with protein, part of the dietary protein will be used for energy. It is, therefore, important to determine the optimum ratio of energy to protein for different species of fish. This ratio can also be affected by the size of the animal. Generally, the ratio of energy to protein increases as the animal gets bigger.

Feed formulation and ingredients used

Efforts have been put to develop the polyculture feed using locally available ingredients after studying their inclusion level by partially replacing the costliest ingredient, fish meal. It was found that feed containing different unconventional ingredients (sunflower cake, mung husk) with 10% fish meal performed at par with the feed containing 22 % fish meal in respect to growth and FCR. Based on these observations, a low cost feed formulation was developed using rice bran, mustard cake, sunflower cake, pulse husk, low value wheat flour, low value fish meal and mineral-vitamin-amino acid mixture. Production cost of this feed is ` 25.32/ kg considering the retail price of the ingredients in the local market of West Bengal. This feed should not be stored for more than 2 months.

Low value Fishmeal

Mustard cake

Sunflower cake

Pulse Husk

Rice bran

Wheat flour

Table 2. Nutritional composition of low cost polyculture feed

DM%	96.02±0.11
CP%	29.77±0.06
EE%	5.00±0.03
CF%	8.72±0.04
OM%	88.70±0.03
AIASH%	3.72±0.05
NFE%	45.21±0.01
Calcium (%)	2.23
Phosphorous (%)	2.04
Vit A (µg/100 g)	300.03
Vit C (mg/100 g)	4.28

AIASH: Acid insoluble ash; NFE: Nitrogen free extract

Farm made pellet feed preparation

For preparation of farm made feed, farmers or co-operative should have minimum machineries for grinding (flour mill/ pulverizer), steaming (idly cooker or big container with facility of giving moist heat) and pelletizing (pelletizer/ meat mincer).-Preparation of farm made feed involves the following steps -

STEP 1 Grinding of ingredients to uniform particle size. Prior to grinding, a sieve can also be used to remove large particles or foreign materials like stones, pieces of metal etc. that can damage machinery.

STEP 2 Weighing of the feed ingredients as per the formula. Care to be taken for weighing micro-nutrients (vitamin and mineral premixes) as these expensive ingredients are used in very small quantities.

STEP 3 Mixing of all the ground ingredients (except vitamin and mineral mixture) thoroughly by hand. If large batches are to be prepared, the dry ingredients can be mixed in a horizontal mixer/dough mixer or even in a cement mixer for 10-15 minutes.

STEP 4 Mixing of oil: If oil is added mixing has to be continued for at least an additional five minutes. To ensure oil is well mixed throughout the ingredients, it is useful to make an emulsion with warm water. Mix the emulsion with dry ingredients gradually.

STEP 5 Addition of water: Add water and mix well to form a mash with a cake-like consistency. Water should be added slowly. Small test batches of the mixture are extruded through the pellet machine (mincer) to examine how easily the mixture passes through the die and how the pellets hold together. As a general rule, the total moisture content of the mash should be in the range

of 45 to 55% to produce good pellets. If moist ingredients are used, less water will be needed. Adjustments must also be made depending on the type of binders.

STEP 6 Steam cooking: Cook the mixture in an idly cooker or in a big container at 100 °C temperature for 5-10 minutes. Take out and cool the feed mixture. Steam cooking will gelatinize the starch and also sterilize the feed mixture.

STEP 7 Incorporation of vitamin-mineral mixture

Mix vitamins and minerals with small amount (e.g. 10% of total batch) first and then blend into larger mixture (to ensure the vitamins and minerals are evenly distributed within the mixture). Vitamin and mineral mixture may also be added to dry ground ingredients before steam cooking, but, in that case heat labile vitamin will be denatured on cooking.

STEP 8 Pelletisation: Pass the feed mash mixture through a pellet machine (mincer) with a 1, 2, or 3 mm die depending on the size of the fish that is being fed. Cut the pellet (which look like noodles) into required length. Pellets can be cut off with a knife during extrusion or broken into smaller lengths after drying.

STEP 9 Drying: The moist pellets should be dried to a moisture content of ≤12%. Ideally, feed should be dried in drier or oven at low temperature (less than 60 °C) and with a good airflow. Alternatively feed can be sundried to reduce cost.

It is most important to prevent any fungal contamination and avoid an excessive loss of critical nutrients while drying the pellets. Fungus can be toxic to fish and to the human who handle the feed.

Step 10 Storage: When pellets are dry and cooled they should be stored in bags or containers that can be protected from insects, rats or other pests and to keep out moisture. Avoid using plastic bags because feeds can sweat and this encourages growth of mould (Fungi). Farm made feed should not be stored for long time. Freshly prepared farm made feed should be used for culture.

Field testing of low cost polyculture feed

A series of experiments were conducted for evaluating the performance of developed feeds in indoor system and in farm trials with different species combinations and also with different stocking densities. Considering the inclusion level of different low cost ingredients three types of feed with 22 %, 10 % and 7% fishmeal were formulated and tested in indoor trials. It was found that feed

containing different locally available ingredients (rice bran, mustard cake, sunflower cake, mung husk etc.) with 10% fish meal performed at par with that of feed containing 22 % fish meal in respect to growth and FCR. On-farm trials of polyculture with different species combinations using low cost pelleted feed resulted a production of 687.44 ± 27.64 to 717.08 ± 43.75 kg/ha with FCR of 1.74 to 1.99 after 170 days of culture. On farm experiment of polyculture with *Mugil cephalus*, *Liza tade, Etroplus suratensis* and *Penaeus monodon* at different stocking densities (Table 3) using low cost formulated feed yielded a production of 1170.8 ±31.5 to 1557.3 ±10.5 kg/ha with FCR of 1.87 to 2.47 after 300 days. Further, the feed produced by ICAR-CIBA was field tested at farmers' pond in polyculture system. Six selected species of brackishwater fishes and shrimp were stocked at varying stocking densities in farmers ponds. The fishes *Liza parsia* (5000/ha, average body weight, ABW: 0.5 to1.7 g), *Liza tade* (5000/ha, ABW: 0.5 to1.8 g), *Mugil cephalus* (2500/ha, ABW: 11.0 to 50.0 g), *Scatophagus argus* (2500/ha, ABW: 0.34 to10.0 g), *Mystus gulio* (30000/ha, ABW: 0.53 g to 5.0 g) and the shrimp *Penaeus monodon* (2500/ha, ABW: 0.02 to 0.45 g) were used. Fishes were fed @ 2 to 10% of feed of total biomass. Water quality parameters were monitored periodically every month. Lime was applied in the pond @ 140 kg / ha monthly. After 325 days of culture, the crop was harvested and *Liza parsia, L. tade, M. cephalus, S. argus* and *M.gulio* attained ABW of 57.35-75.87 g, 110.09-222.18 g, 300.15-390.56 g, 180.44-196.23 g and 80.23-86.65 g, respectively in different trials. Partial harvesting of *P. monodon* was done five months onward from the start of culture and shrimp attained a body weight of 32.21 to 55.0 g. Survival of *L. parsia, L. tade, M. cephalus, S. argus, M. gulio* and *P. monodon* were in the range of 72-75%, 75-79%, 70-82%, 76-90%, 65-86% and 56-65%, respectively in different trials (Fig.1). The total productivity of 3141 to 4764 kg/ha with low cost farm made feed were recorded in different trials against the productivity of 1597 kg/ha in polyculture with conventional rice bran and mustard cake mash (Table 4). FCR of polyculture feed ranged from 0.88 to 1.36.

Table 3. Performance of low cost feed in on-farm trials

	1st trial		2nd trial	
Duration of culture	**300 days**	**300 days**	**170 days**	**170 days**
Species cultured	*M. cephalus, Liza tade, Etroplus suratensis P. monodon*	*M. cephalus, L. tade, E. suratensis P. monodon*	*M. cephalus, L. tade, L. parsia, P. monodon*	*Chanos chanos, P. monodon*
Stocking density (nos./ha)	21250	42500	28000	28000
Total production (kg/ha)	1170.8 ±31.5	1557.3 ±10.5	687.4 ± 27.6	717.1 ± 43.8
FCR	1.87 ± 0.24	2.47 ± 0.03	1.74 ± 0.02	1.99 ± 0.25

Table 4. Production performance of polyfarming under different trials at farmers' ponds

	Polyfarming with rice bran & mustard cake mash feed	Polyfarming with farm made pellet feed		
		1st trial	2nd trial	3rd trial
Pond area (ha)	0.47	0.47	0.04	0.03
Culture duration (days)	300	325	325	325
Production (kg)	745	1465.79	168.40	154.51
Productivity (kg/ha)	1597	3141.43	3855.09	4764.11
FCR	3.45	0.88	1.36	1.32
Survival (%)	ND	75.60	70.53	75.61

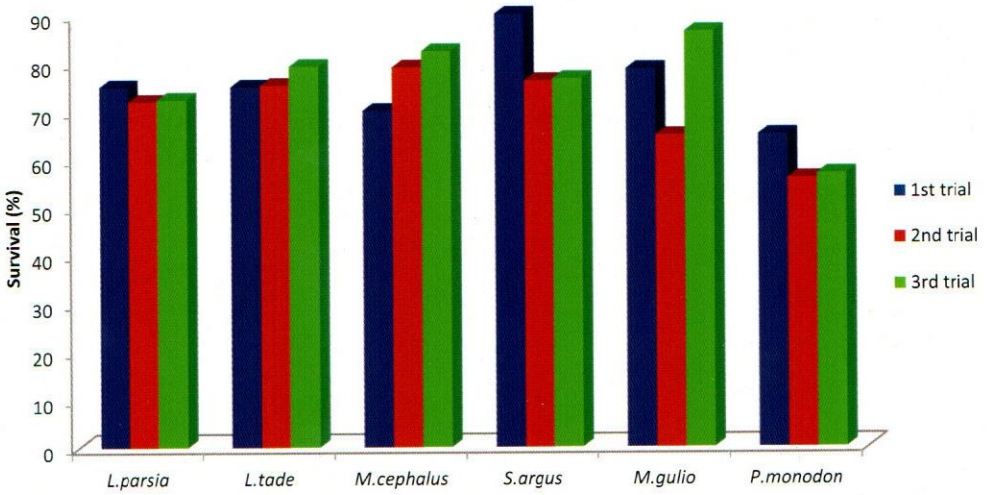


Figure 1: Survival of different candidate species under polyfarming in different trials

Contribution of different species towards total production and income

Total contribution of individual species (based on three trials at farmers ponds) towards total biomass is presented in Fig. 2. Results of three trials showed that *M. gulio* contributed 40 % and mullets (*L. parsia, L. tade and M. cephalus*) contributed 47 % to total biomass production. Results also demonstrated that *M. gulio* contributed 37% to the total income of the farmer (Fig.3)

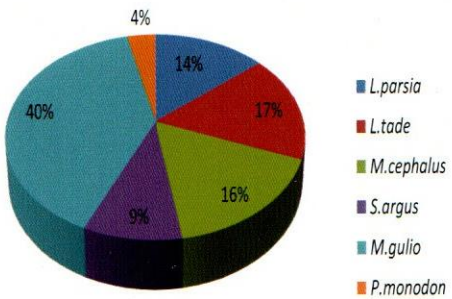


Figure 2: Contribution of individual species towards total production

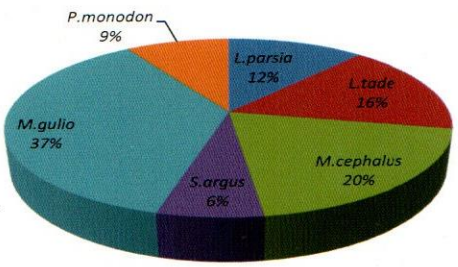


Figure 3: Contribution of individual species towards total income

Table 5. Farm gate selling price of different cultured fishes and shrimp

Species	Pricce (₹)
Liza parsia (50-75 g)	95-125
L. tade (100-200 g)	85-150
Mugil cephalus (300-400 g)	110-175
Scatophagus argus (180-200 g)	80-95
Mystus gulio (80-90 g)	115-150
Penaeus monodon (40-60 g)	327-350

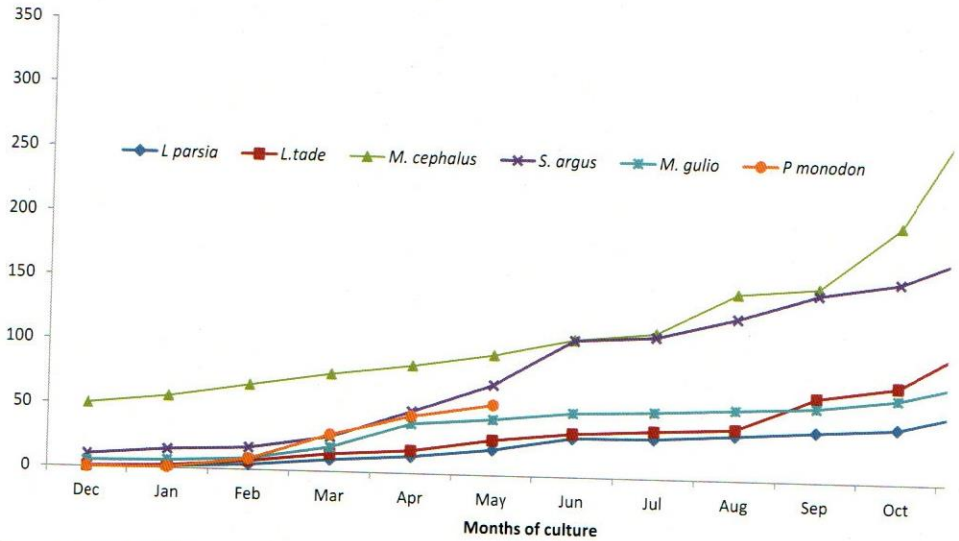


Figure 4: Growth patterns of fish and shrimp under polyculture

Standardization of feeding frequency and mode of feed application

Based on the feeding experiments, it is suggested that low cost pellet feed should be offered as supplementary feed at 2–10% body weight per day depending on the weight of fish. Daily ration has to be distributed at three equal quantities in the morning (09:00 hours), afternoon (13:00 hours) and evening (17:00 hours) in trays. Total feed has to be offered in feeding tray and quantity has to be given in two split doses at 1 h intervals (09:00, 10:00 hours), (13:00, 14:00 hours) and (17:00, 18:00 hours) to meet the requirements of fish with various size-groups.

Economics

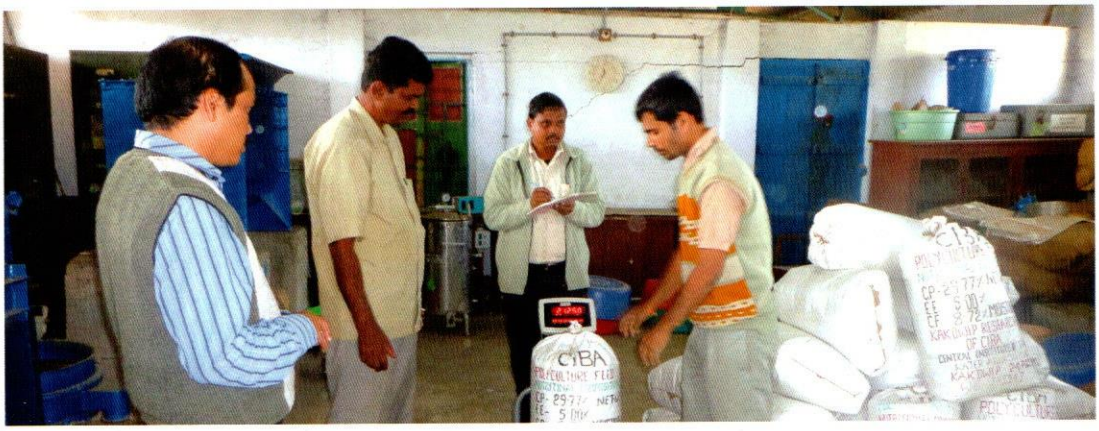
Polyfarming with low cost farm made feed for 325 days resulted a production of 3.14 to 4.76 tonnes/ha with net profit of ₹ 1.94 to 2.94 lakhs/ha (Table 6).

Table 6. Economics (per ha) of polyfarming with farm made feed (Based on three trials)

Parameters	Quantity	Rate (₹)	Amount (₹)
Bleaching powder	300 kg	25/ kg	7500
Lime	710.2 kg	10/ kg	7102
Pumping for water intake	127.41 hours	100/hour	12741
Seed			74984
Feed	4660 kg	25.32/ kg	117991
Labour	179 man-days	260/ man-day	46540
Harvesting (netting and dewatering)			24500
Marketing (transport)			16597
Sub total			307955
Interest on operational cost	11% for 11 months	12% annually	33875
Total operational cost			341830
Economic return from fish sale			633090
Net profit			291260
Benefit- cost ratio			1.85

Low cost polyculture feed sold to Farmer

Realizing the performance of polyculture feed developed by ICAR-CIBA many farmers approached us for getting the feed on payment basis.



Impact/ adoption of the technology

Aquafarmers of coastal rural area have been educated through various extension activities like field day, farmers meet on the technology and its results. They have shown interest and started preparing the farm made feed using locally available ingredients. A farmer from Madanganj, South 24 Parganas, West Bengal conducted polyfarming of brackishwater fish and shrimp using the farm made feed. He prepared feed himself with a hand pelletizer following the CIBA farm made feed technology. Use of the farm made feed in brackishwater polyfarming resulted in a net profit of ` 1,43,611 per hectare within a seven-month period with an impressive benefit-cost ratio of 1.81. Brackishwater polyfarming using the CIBA developed farm made feed has become popular and currently several progressive farmers of West Bengal are undertaking polyfarming using this feed. During the course of preparation of farm made feed farmers faced some problems of pulverizing the ingredients. The owners of flourmill available in villages do not always allow grinding the feed ingredients. To cater the need for farm made feed, the farmers of Madanganj formed a cooperative society (Madanganj Matysachasi Samabay Samity Ltd.) andpurchased a pulverizer with the financial help of the State Govt.

Commercialization of Technology

Polyculture feed processing and production technology has been transferred to NRG Feeds, Hooghly, West Bengal, who signed MOU with ICAR-CIBA for up scaling and commercial production of PolyPlus on a non-exclusive basis. The company envisaged to produce Poly Plus feed with the CIBA technical collaboration. This low-cost feed is expected to cater the needs of the farmers who are doing polyculture and will have an impact on the farming community around West Bengal and adjoining states.

Future strategy

Cost of commercially available feed has shown an increasing trend, mainly due to the uncontrolled increase of fish meal price in last 10-15 years. As a result, the cost of production is increasing to uneconomical levels for the aquaculture farmers who rely on commercial feed. Thus, the time has come to put stress on proper utilization of locally available resources to produce cost effective feed for brackishwater aquaculture systems. As commercial brackishwater aquaculture is mostly oriented towards shrimp farming that depends on nutritionally balanced commercial feeds, the low cost farm made feed may cater the need of small and marginal farmers who mainly involve in polyculture of fish and shrimp. Moreover, for this new initiative towards sustainable farming a farmer-researcher interaction is necessary to get proper feedback and further improvement. Many more locally available cost effective ingredients can be used after proper evaluation for further reduction of feed cost. Aquafarmers may form co-operative or self-help groups to establish small scale and low investment feed mills, and make the feed available to them at the local level itself. Farmers may be trained about the feed preparation methods, storage of the feed, selection of the species for polyculture and management practices for brackishwater polyculture, so that they can utilize aquafeed in the most judicious way and make the farming practice more profitable and sustainable.

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CIBA
SIGNING OF MEMORANDUM OF UNDERSTANDING FOR
TECHNOLOGY TRANSFER ON
PROCESSING AND PRODUCTION
WITH
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K.R.C. OF C.I.B.A.
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