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Rejuvenation of the Traditional Pokkali Farming System through Integrated Paddy- Shrimp Fin Fish Farming

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Introduction

Pokkali farming is a typical farming system in which paddy and shrimp cultures are alternatively done in the same field (S. M. Plllai 1999). The biomass residues of paddy crop forms feed for shrimps and residues of shrimp farming forms fertilizer for the paddy. There are no external inputs used in this farming as both the cultures are mutually compensating and the soil is nutrient rich as it is carried by river flows and deposited in the Pokkali fields which are located in the coastal areas (George 1968). Pokkali farms are spread mainly in the coastal areas of Ernakulam and in some parts of Thrissur and Alappuzha districts of Kerala (Panikkar, N. K 1937).

Pokkali farming is purely organic as the farmers do not use any chemicals because they have to start shrimp farming in the next season. Pokkali paddy and prawn possess a characteristic taste since no chemical inputs are usedas well as the rich peaty soil in pokkali fields also imparts good taste to the pokkali rice and shrimp (Purushan, K. S. 1996). Since rice is the most important food crop of the world (Cantrell and Reeves 2002) conservation of naturally organic varieties needs special attention. Pokkali paddy received geographical Indication (GI) and a logo during 2007 and plant genome community saviour award during 2011 from Govt. of India.

Lee et al. 2003 reported that very few Rice varieties possess ability to resist salinity during its growth phase. Pokkali paddy requires less than 1 ppt salinity for its germination. However once germinated and grown, it can sustain salinities upto 5 ppt. Hence the planting season coincides with onset of monsoon in June first week during which the salinity of the soil gets washed off in runoff water. The growth period is 120 days and during this

phase, the salinity increases up to 4 ppt. The pokkali paddy grains are resistant to decay in submerged conditions.
The field preparations starts after April 14thand paddy seeding would be done after 3 or 4 monsoon showers in the first week of June. The harvesting is done in the first week of October. Shrimp farming in pokkali fields require license. The license period is for 5 months starting from November middle to April middle. It's a tradition in pokkali farming tracts that fishermen (landless) can catch fish from pokkali fields except during this license period irrespective of the ownership of the field. This tradition is a classic example of how our ancestors were concerned about the livelihood of all the classes in the society.

This paddy variety is promising in the context of climate change where the sea water level is raising leading to intrusion of salinity in fresh water systems and paddy fields. Un-predictable rain and associated flood is also yet another consequence of climate change. Pokkali paddy can very well sustain flood as well by growing above flood waters up to a height of 1.5 metres whereas the ordinary paddy can grow only up to 0.9±0.2 m. Pokkali can sustain in this situation also as it has flood resistant properties as mentioned. Hence the pokkali germplasm needs conservation as a promising crop for saline areas in the future years.

There were more than 25,000 ha under Pokkali cultivation in Kerala 10-15 years back, which has come down to 5,000 ha currently and the cultivation is being done only in an area of less than 610 ha (Table 1).

Table.1 Status of pokkali paddy fields and production in Kerala

District	Available Area (ha)	Presently Cultivating area (ha)	Production (ha)
Ernakulam	4000	610	929.64 ton
		-	-
Alappuzha	3000	-	-
Thrissur	2000		

Issues identified in the Pokkali farming system

- Lack of machinery for land preparation as the Pokkali fields are marshy to cause sinking of the land preparation machinery like tractors and power tillers. Even now Pokkali lands are prepared by

manual labour using long handled spades. Labour in Kerala is costly and scarce which contributes to increased production costs.

- Lack of machinery for harvesting the paddy which is in a state of *floating* in water at the time of harvesting. Manual harvesting involves drudgery as the labourers need to work in standing water.
- Low productivity of Pokkali paddy in the range of 1.5 MT/ha for local varieties and only 2.5 MT/ha for improved varieties in comparison to the productivity of 5.2 MT/ha for hybrid paddy varieties commonly cultivated elsewhere.
- Set back to the shrimp farming due to WSS (White spot syndrome) virus disease, which is a global issue. Most of the loss in paddy crop in the previous season were compensated by the remunerative shrimp farming in the subsequent season till the WSSV incidence.
- Pollution from the industries located upstream of pokkali fields.
- Though quality and taste of the pokkali paddy are its attractions, there is no premium market for the paddy and shrimp grown in pokkali fields.
- This farming system is largely depending on climate, *i.e* onset of monsoon and tidal fluctuations.

Many farmers are traditionally continuing pokkali farming despite all these constraints due to cultural and emotional attachments to the farming and to continue the tradition.

Challenges

The indigenous fishermen of this region have the traditional right to enter these farmers' fields and catch wild fish and shrimp as livelihood means prior to and during the paddy cultivation period. Land holding farmers get exclusive ownership and license to their field solely for five months during shrimp farming. At the end of each year's license period the farmers open up the fields again for the local fisherfolk for their livelihood. Due to this special agreement between farmers and fisherfolk any intervention in this farming system is challenging. But at the same time a strong intervention is required since widespread attack of viral disease on shrimp, labour shortage, lack of machinery, water pollution, low market price, erratic monsoon, saline intrusion, unpredicted floods etc. is compelling the farmers to discontinue this farming system.

The main objective of the present work is to develop and introduce a new package of practice to augment income from unit area of Pokkali field by

integrating high density cage culture of high value candidate fin fishes such as pearl spot Asian sea bass and mullet along with shrimp in the pokkali farming system without disturbing the traditional farming system.

Area description, materials, methods and techniques employed

Integrated cage culture of finfish

A detailed survey was conducted and selected pokkali fields located at Kadamakkudy, Ezhikkara, Pizhala andNayarambalam for the present study measuring in size varying from 4.5 acres to 50 acres respectively (Table 2).

Table 2. Details of farmers with farming area and species of finfishes cultured in Pokkali farming systems

	Pokkali farmers	Area (Acre)	Species Stocked
1.	Pushpangathan K.A Karammal H Kadamakkudy, Pizhala	6.0	Mullet, Pearl spot Asian Seabass
2.	Murali P.R Putheth H KadamakkudyPizhala	6.75	Mullet, Pearl spot
3.	Vincent V.A Valiyaparambil H KadamakkudyPizhala PO	16.0	Mullet, Pearl spot Asian Seabass
4.	Vinod Kumar D.V Devaswamparambil H Kadamakkudy, Pizhala	7.0	Mullet, Pearl spot Asian Seabass
5.	A.R. Saigal, Anjil H Ezhikkara, Vypeen	3.5	Mullet, Pearl spot Asian Seabass
6.	Shyam Sunder P.R. Pallathupady H Nayarambalam, Vypeen	50.0	Mullet, Pearl spot Asian Seabass
7.	K.K. RamakrishnanKallarakkal H Pizhala	4.5	Mullet, Pearl spot, Asian Seabass

In order to initiate integrated farming of fin fishes cage fish culture method was adopted. The vacant sluice pits and channels in the pokkali fields area was selected for the integrated cage fish culture along with paddy.The sluice pits and channels in their Pokkali fields were de-silted and cleaned to ensure minimum 2m water depth in the sites wherever required. Mullet (*Mugil cephalus*), Asian Sea bass (*Lates calcarifer*) and Pearl spot *(Etroplus suratensis)* were selected as the candidate species for the integrated farming. Due to the erratic rains received during June of 2014, many of the pokkali seeds sown were washed away by runoff water and in 2014 less than 200 ha were under active farming.

Nursery rearing of mullet *(Mugil cephalus)*

Mullet seeds are generally caught from the sea shore during the onset of monson by traditional fisherman using cast net. The length range of wild caught mullet was 1- 2 cm and weight range was 150-400 mg. Frys of these size are not ideal to stock in cages directly and therefor nursery rearing is essential to rear the fish in to fingerling size (above 8cm) which is ideal for stocking in cages for integrated farming. Mullet fry's (3000) acclimatized and stocked in the netlonhappas (1.2m x 1.2mx1.2m size) fixed using bamboo poles in the main channel of the Pokkali field. The fishes were fed using floating (500 micron, 700 micron) and slow sinking commercial feeds (1mm) with high protein (>40%) and fat content (>8%) for 30 days.

Grow out culture in cages

Grow out culture was done in rectangular floating cage units. The cages were fabricated using HDPE nets and PVC pipes. HDPE nets of 12mm mesh (0.5mm thickness) and 16mm (1mm thickness) were selected for cage fabrication. The cage floating unit was fabricated using 90 mm PVC pipes. Cage sinkers were fabricated using 32mm PVC pipes filled with sand. Fingerling size mullet, pearl spot and Asian seabass was stocked separately in each cage. Stocking density was 30/m^3, 40/m^3 and 30 m^3 respectively.

Feeding

Commercially available formulated floating pellet feed of 2mm size containing 32 % protein and 4 % fat was used for feeding mullet whereas, Institute developed feed "Pearl plus" was used for pearl spot culture. This feed contains 47% protein, 6% fat and also other essential nutrients such as vitamins, minerals, etc., Proximate composition of Pearl plus larval and grow out feed are given in Table 3.

Table 3. Proximate composition of "Pearl plus" larval and grow out feed

Sample name	% dry matter	% moisture	% crude protein	% crude fat	%crude ash	% crude fibre	% acid insoluble ash	% nitrogen free extract
Pearl plus grow out feed	93.63	6.37	38.36	4.33	11.46	3.45	4.61	36.04
Pearl plus	93.71	6.29	44.71	6.90	14.54	4.09	5.37	23.47

nursery
feed

Pearl spot fingerlings were fed Pearl plus PS3 (1000 μm), PS 4 (1.4 mm)and juveniles fed PS5 (2 mm). Asian Seabass were fed with 1.2 mm floating pellet feed and 2 mm floating pellet during dawn and dusk.

Grow out culture in open fields

Mullet seeds were reared in cages during the paddy farming season and released in to the Pokkali fields after the license period (November 15). Formulated floating feed (2mm) were fed twice a day at fixed points in the four corners of the field.

Water quality testing and Analysis

Water samples were collected fortnightly from the pokkali field and nearby creek and water during the farming period. 15 Hydrographical parameters varying from atmospheric temperature to ammonia content in the pond water were analyzed using water samples collected from the different aqua farms in Kadamakkudy, Pizhala, Ezhikkara and the creek situated in Kadamakkudi. An average fourteen day sampling interval protocol were followed for the collection of water samples. The samples were usually collected during the morning hours. Physical parameters such as temperature and salinity were recorded on the sampling site itself using digital analytical instruments. Fixation of dissolved oxygen was also carried out on site. Water samples were collected from both the inlet sluice entrance area and other different area of the farm as well. The collected water samples were stored in one L high density plastic dark bottles in duplicate. The samples were transported to the laboratory in ice box and stored in freezing temperature in the lab to maintain United States Environmental Protection Agency (1976) guidelines. Before the laboratory analysis the samples were thawed overnight. The physico-chemical and biological analysis were carried out following the APHA 1981 protocol in room temperature.

Results and discussion

Significant variations in all the water quality indicators were obvious in the Pokkali farming system. Since the water in Pokkali fields are replaced daily with the creek water according to the tide, control over the water quality regulation was negligible in this farming system. Rain fall, tidal strength, river run off volume, etc., are the major critical factors which influenced the water quality in the system.

Among the various water quality indicators, pH of the Pokkali field ranged from 6.54 (June during monsoon) to 8.00 (February during summer). pH is always interdependent with other water quality parameters, such as carbon dioxide, alkalinity, and hardness. It can be toxic in itself at a certain level, and also known to influence the toxicity as well of hydrogen sulfide, cyanides, heavy metals, and ammonia (Klontz, 1993). According to Boyd, 1998 fresh water fish can tolerate wide variation in pH (6.5 - 9.0) whereas the tolerable pH range for euryhaline fish is usually lies between pH 7.5 and 8.5. Normally fish growth will be cease or it will die when pH rises above 11 or decrease below 4.0 (Lawson, 1995). Pearson correlation revealed (2-tailed) significant positive correlation ($P<0.05$ level) between the pH and salinity of the Pokkali fields (Table 1).

Table 1. Pearson Correlation of salinity and pH of the Pokkali fields

		pH	Salinity
pH	Pearson Correlation	1	.467*
	Sig. (2-tailed)		.025
	N	23	23
Salinity	Pearson Correlation	.467*	1
	Sig. (2-tailed)	.025	
	N	23	23

*. Correlation is significant at the 0.05 level (2-tailed)

Salinity

Salinity is the crucial water quality parameter in the Pokkali farming system wherein the species diversity and abundance was directly influenced. Salinity in the Pokkali fields varied significantly throughout the year (Table 2 & Fig 1). Average salinity in the Pokkali fields varied from 0.51 ppt (during July month) to 23.96 ppt (during May month). Reduction in salinity was observed during the onset of south west monsoon. Reduction is significant during these periods in all the fields (23.96 ppt to 3.29 ppt. This is essentially required to backwash the saline contents from Pokkali soil which is required to start the paddy cultivation. Sudden changes in water quality contents significantly affect the micro and macro flora exists in the system. This may reduce the bacterial and other parasites load in the system naturally.

Table 2. Salinity of Pokkali fields

Sampling Time	Salinity (ppt)	Std. Deviation	Std. Error
June 1	3.29	0.39	0.22
June 15	1.37	0.15	0.09
July 1	0.51	0.44	0.26
July 15	0.28	0.24	0.14
August 1	0.76	0.69	0.40
August 15	0.55	0.47	0.27
September 1	0.95	0.38	0.22
September 15	1.18	0.28	0.16
October 1	4.35	0.45	0.26
November 1	6.04	0.05	0.03
November 15	7.05	0.05	0.03
December 1	7.33	0.31	0.18
December 15	11.85	0.55	0.31
January 1	13.89	0.40	0.23
January 15	17.50	0.10	0.06
February 1	19.08	0.13	0.08
February 15	15.60	0.10	0.06
March 1	16.23	0.46	0.27
March 15	15.95	0.22	0.13
April 1	18.33	0.38	0.22
April 15	20.98	0.43	0.25
May 1	22.51	0.42	0.24
May 15	23.96	0.34	0.20

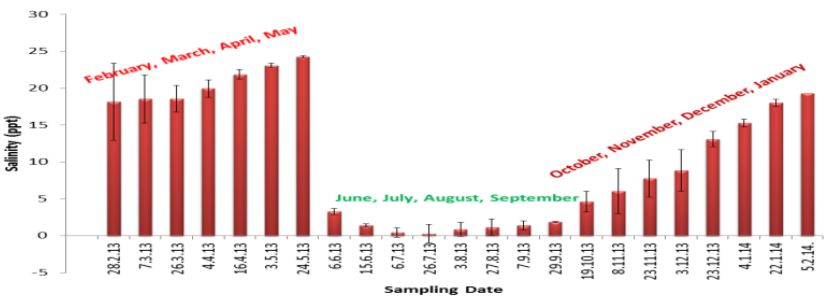

Figure 1.Seasonal salinity (ppt) level in the Pokkali field

Turbidity (NTU) level also varied significantly throughout the year (January to December). Lowest turbidity level was observed during summer (May 6.12 NTU) and maximum observed during monsoon period (June 41.50 NTU). Similarly total suspended soluble (TSS) also showed significant variation pattern throughout the year. Pearson correlation revealed (2-tailed) significant positive correlation (P<0.05 level) between the turbidity (NTU) and TSS of the Pokkali fields (Table 3).

Table 3. Results of environmental parameters in the Pokkali fields

Parameter	Number of observation	Mean	SD	Median	Mean absolute deviation	Min. Value	Max. Value	Range	Skewness	Kurtosis	Standard error
Air temp	92	31.05	2.32	31.60	2.67	25.00	35.40	10.40	-0.39	-0.69	0.24
Water temp	92	29.33	2.12	29.40	2.08	24.10	33.70	9.60	-0.11	-0.54	0.22
pH	92	7.40	0.46	7.41	0.59	6.54	8.41	1.87	-0.04	-0.82	0.05
Salinity	92	40.66	24.68	40.50	31.88	1.00	84.00	83.00	0.08	-1.27	2.57
Turbidity	92	19.18	11.93	17.57	9.50	1.87	58.23	56.36	1.16	1.20	1.24

Fish growth rate in Pokkali farming system

Mullet migrate to Sea during January to March periods for spawing and the fry swim towards coast during the onset of monsoon (Quignard and Fartugio, in Oven, 1981). These Mullets fry's (collected from the wild 3.49±0.25 cm and weight 481.66±57.49 mg) were nursery reared in happas and reached fingerling size (6.35±0.23 cm and 3.54±0.16 g) within 28 days of rearing. Mullet fingerlings reached harvestable stage (330.43±2.21 g) within 270 days of post stocking in HDPE cages (Table 4).

Table 4. Length and weight increment data of mullet during nursery rearing

Day of rearing	Length (cm)	Weight
1	3.49±0.25	481.66±57.49 mg
10	4.99±0.23	1.92±0.22 g
16	6.25±0.38	3.16±0.35 g
28	6.35±0.23	3.54±0.16 g
62	11.85±0.91	20.92±2.97 g
89	13.2±0.28	25.6±2.12 g
100	14.76±0.25	46.83±1.44 g
120	18.20±1.07	67.43±2.21 g

200	26.12±2.12	250.43±2.21 g
270	29.52±3.34	350.56±10.76 g

Growth data of Pearl spot is furnished in Table 5. Pearl spot fingerlings (4.0 g weight with 6cm length) reached average size of 127.64 g weight and 16.36 cm within 23 weeks of farming in cage system in pokkali fields. Growth data of the pearl spot, *Etroplus suratensis* in small floating cages for eight month is given in Table 5.

Table 5.Six- month growth data of the pearl spot, *Etroplus surratensis* in small floating cages

Duration	Length (cm)	Weight (g)
Stocking time	6.0	4.0
10 weeks	12.9	52.6
14 weeks	13.5	58.6
18 weeks	14.4	69.9
21 weeks	14.5	97.6
23 weeks	16.36	127.64

Water quality of the field was maintained by exchanging fresh water from the creek by regulating the sluice gates.

Harvesting

Mullets reached 350±50 g size after nine months of culture with a survival rate of 70%and harvested using gill nets and cast nets from the pokkali fields during the first week of April Asian Sea bass reached average weight of 800 g in cages with survival rate of 80% whereas pearl spots reached 127.64 ±20 g size in cages with survival rate of 90% and harvested using scoop net as and when required (Table 6).

Table 6. Fin fish species, initial and harvest size and survival percentage in Pokkali fields

Sl No	Species	Average length at time of stocking	Average weight at time of stocking	Average weight at harvest	Culture period	Percentage survival
1.	Mullet	2.4 cm	0.20 gm	350 gm	9 months	70
2.	Asian Seabass	8.0 cm	7.02 gm	800 gm	9 months	80
3.	Pearl spot	4.5 cm	2.7 gm	127 gm	8 months	90

Farm gate markets

Freshly caught live pearl spot and mullet marketed through the newly established "farm gate markets" with premium price (Rs. 500/kg). This new

market received wide acceptance among fish lovers of the state due to the superior quality and taste of the live fish harvested from pokkali fields. Presently, this superior quality fish from pokkali fields are currently being mixed up in the market with low quality fish from elsewhere. This new venture has the potential to ensure safe-to eat product for the consumers at a reasonable price in chorus enhancing the income from pokkali farming towards its sustainability.

Cost-benefit ratio

The fixed cost for cage culture in a 1 ha pokkali field would be Rs. 88,000/-. Since the assets can be used for 5 years, the fixed cost per year would be Rs.17,600/-. The operational cost per year comes to Rs. 90,000/-. The gross income per year would be Rs.1,90,000/- and the profit per year is Rs 83,000/-. Pokkali farmers are getting a profit of only Rs. 15,000 from paddy crop alone and Rs 50,000 only from combined paddy and shrimp cultivation from a 1 ha field. The new system of paddy-shrimp-fin fish culture ensures Rs1.3 lakhs per ha (Table 7).

Table 7. Cost economics of Integrated cage fish culture

Item	Unit cost	Total No	Total no
Cage unit*	6,000	10	60, 000
One Year cage Cost			**12,000**
Seed cost Asian Seabass	30	500	15,000
Seed cost Mullet	5	1,000	5,000
Seed cost Pearl spot	10	1,000	1,000
Feed cost	75	1,200	90,000
Labour charges	600	100	60,000
Other Charges			5,000
Total Cost			**1,88,000**

*The cage can be used for minimum five crops

In order to sustain the developed technologies an urgent intervention in seed production of candidate fish such as Mullet are needed, new candidate species suitable for brackish water resources has to be identified and field tested along with the present species. An intervention in development of location specific custom made machineries for land preparation and harvesting are also can contribute for the sustainable rejuvenation of this farming system.

Conclusion

Pokkali is a naturally organic farming system in the coastal areas of Ernakulam district. Conventional Pokkali farming involves alternate growing of Paddy and

Shrimp in the same field. In order to reap more profit, KVK introduced a third component-fish farming anddemonstrated this profitable venture in selected Pokkali fields. In this unique method, fish alone can contribute profit of INR80,000- per ha whereas paddy-shrimp farming gives only INR50,000- per ha. Subsequent to the success of this integrated farming, Fish FarmersDevelopment Agency (FFDA), Government of Kerala has initiated a scheme - *Integrated fin fish farming in Pokkali fields.*

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