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Impact of Shrimp Farming Technology for Economic Upliftment of Rural Societies in Inland Saline areas of Punjab

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ABSTRACT

Punjab is successfully moving towards 'Blue revolution', and has recorded a commendable progress in the fish farming.The inland saline areas of Punjab, Haryana and other states (previously considered as wastelands) have recently emerged as attractive destinations for *Litopenaeus vannamei* shrimp farming due to its high export potential and low salinity tolerance. A farmer S. Harminder Singh from Village Korvala, Mansa district of Punjab was motivated by College of Fisheries, Guru Angad Dev Veterinary and Animal Sciences University (GADVASU), Ludhiana to take up shrimp farming in his salt affected land. He was trained at individual level to take up shrimp farming. A pond of 2.5 acres area was stocked at the density of 50 post larvae (PL)/m^2. Regular water quality and health monitoring was done by the scientists from GADVASU besides time to time onsite visits for technical guidance. The farmer harvested a bumper crop of 8.36 tonnes from an area of 2.5 acres (market value 23.5 lakh), against an operating cost of Rs 15.5 lakhs in a culture period of 140 days, thus resulting in a net profit of Rs 8.00 lakhs/ha. The shrimp harvested had an average weight of 25±2 grams with an FCR of 1.25. The said success is attracting many farmers of the area to undertake shrimp farming, so it is recommended to strictly follow 'Best Management Practices (BMPs), besides procuring seed from Coastal Aquaculture Authority (CAA) approved hatcheries with pathogen screening certificates. Strict adherence to BMPs and bio-security protocols is a way forward towards development of sustainable shrimp farming in Punjab.

Key Words: Punjab, Shrimp farming, *Litopenaeus vannamei*, Inland saline, Water quality, Bio-security.

INTRODUCTION

Soil salinization is a serious global threat affecting the crop outputs in more than hundred countries across the globe. This crisis has further been exacerbated by the human activities resulting in secondary soil salinization in areas with underground saline waters. In these already salt affected areas, intensive irrigation practices without proper drainage provisions have led to severe waterlogging problems. Across the globe, more than 1,300 million ha of land has been documented as salt affected, severely impacting the agricultural productivity and rural economies of many developing countries including India (Ansal and Singh, 2019). Out of total 6.74 million ha salt affected (including coastal saline soil) areas in India, around 1.20 mha is located in the non-coastal Indo-Gangetic plains of Northern India. These areas are distributed among seven states *viz.,* Punjab (1.51 lakh ha), Haryana (2.32 lakh ha), Rajasthan (3.75 lakh ha), Bihar (1.53 lakh ha), Uttar Pradesh (1.37 lakh ha), Madhya Pradesh (1.39 lakh ha), and Jammu and Kashmir (0.17 lakh ha) (Ansal and Singh, 2019).

In Punjab, six South-West districts (Fazilka, Shri Mukatsar Sahib, Mansa, Bathinda, Faridkot, and Ferozepur) are badly affected by the dual

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problems of water logging and salinity. These areas are underproductive, zero earning lands unfit for any agricultural or livestock farming activity. Due to abundance of water, these areas have recently emerged as attractive avenues for horizontal expansion of aquaculture activities without resulting in additional undesirable pressure on fresh water resources (Singh and Ansal, 2019).

Development of viable, sustainable and suitable technologies for utilization of inland saline areas has been decided as a national priority by the Government of India. In order to make these areas agriculturally suitable, it is necessary to reduce the water table to safer levels by pumping outground water. Unfortunately, this task of pumping out the ground water is a challenging job; and it is only possible through evapo-transpiration, which itself is avery costly process beyond the reach of poor farmers in these areas. However, these unproductive zero-earning lands can be converted into economically viable lands through aquaculture. The aquaculture activities not only help in evapo-transpiration of a large proportion of water but are also helpful in livelihood generation for the affected farmers (Pathak *et al,* 2013). Thus development of region specific and viable aquaculture technologies is need of the hour to overcome the dual problems of salinity and waterlogging as well as for economic upliftment of rural societies in these areas.

For over a decade, the consistent initiatives and efforts of Guru Angad Dev Veterinary and Animal Sciences University (GADVASU) have led to the tremendous development of inland saline aquaculture in South-West district of Punjab. Under various project activities, GADVASU initiated carp culture in inland saline waters of salinity ≤5 ppt in Shajrana village of district Fazilka; and subsequently the area under aquaculture in the village increased from 1 ha in 2014 to more than 30 ha in 2018 with average annual earnings of 1,50,000 per ha (Ansal and Singh, 2019)**.**Encouraged by these developments, the scientists of GADVASU started looking for more finfish/shellfish species, which could specifically be adapted in these low salinity areas with potential to yield higher economic returns. Globally, White leg shrimp *Litopenaeus vannamei* is considered as an important aquaculture species with high export potential and profit margins. Being a euryhaline species with salinity tolerance range of 1 to 50 ppt, inland waters with salinity as low as 5 ppt have emerged as attractive destinations for vannamei shrimp farming. Accordingly, the scientists of GADVASU conducted the first commercial vannamei farming trial at Painchanwali village in district Fazilka in one acre farm area (Singh *et al,* 2016). The successful outcome of this trial attracted the attention of Government of Punjab leading to the execution of another *Litopeneaus vannamei* demonstration project at village Rattakhera of district Sri Muktsar Sahib by State Government under technical guidance of GADVASU and Regional Research Centre of ICAR-CIFE, Rohtak. Success of these projects and start-up financial grants by State Government motivated the farmers to adopt the shrimp farming in state resulting in rapid increase in culture area from 37.5 acres (in 2017) to 230 acres (approx.) (in 2018), and 350 acres (approx.) in 2019. A farmer (S. Harminder Singh) from district Mansa, Punjab was motivated to take up shrimp farming in his salt affected land at village Korwala. His success has led the many famers from Mansa district to adopt shrimp farming, and the area under vannamei farming has increased from 21 acre in 2018 to 42 acres in 2019.

MATERIALS AND METHODS

The farm was located at village Korwala in Jhunir Tehsil in district Mansa of Punjab state. It is located 19 km towards South from district headquarters Mansa and 199 km from State capital Chandigarh. Korwala is surrounded by Mansa Tehsil towards North, Sardulgarh Tehsil towards South, Budhlada Tehsil towards East and Talwandi Sabo Tehsil towards West.The pond (area 2.5 acre) was prepared followingthedetailed protocol (Table 1).

Ingredients

Mixing the ingredients

Pouring in Stirring facility

Continuous stirring of Mixture

Fig 1.Preparation of prebiotic media (Representational picture; Source: Mayank Aquaculture Private Limited)

Preparation of prebiotic media

Prebiotic media for planktonic growth was prepared by mixing 20 kg rice bran, 20 kg jaggery, 200 g baker's yeast and 250 g good quality water probiotic in 200 l of water (Fig. 1). The ingredients were stirred at regular intervals for next 48 hr for proper fermentation. The fermented prebiotic mixture was applied uniformly on the pond surface near the aerators to facilitate consistent spreading in the pond.

Biosecurity arrangements

In order to prevent cross-contamination and aquatic bird predation, nylon twines were tied on the pond. The pond was fenced with net to avoid entry of animals to prevent disease outbreaks. Besides, the provision of foot and hand cleaning was kept at the farm. The inlet of the water was covered with 40 mm mesh size net to prevent entry of any unwanted organism in the pond.

Potassium level monitoring

Throughout the culture period, potassium levels in the pond water were regularly monitored. To maintain the potassium content of pond water at 50% equivalent of the seawater, the pond water was fortified with potassium chloride (fertilizer grade Muriate of Potash) @ 2 mg/l prior to stocking and during the culture period to avoid any osmoregulatory stress to the shrimps.

Table 1. Time and activity schedule of pond preparation for vannamei shrimp farming.

Timeline	Activity
Day-1	Pond was filled with underground saline water up to 1.2 m water depth, and left undisturbed for 2 d for settlement of suspended solids
Day-4	Chlorination was done @100kg/acre with bleaching powder followed by dechlorination for 4 d
Day-8	Application of first dose of fermented prebiotic media (Jaggery 20 kg+ Rice bran 20 kg + Yeast 200 g+ Water Probiotic 250 g)/acre, and leaving the pond undisturbed for 1 day
Day-9	Application of soil probiotics, and leaving the pond undisturbed for 2 d
Day-11	Application of water probiotics, and leaving the pond undisturbed for 1 d
Day-12	Application of minerals and Muriate of Potash after Potassium estimation in the water, and leaving the pond undisturbed for 1 d
Day-13	Application of second dose of fermented prebiotic media (Jaggery 20 kg+ Rice bran 20 kg + Yeast 200 g+ Water Probiotic-250 g)/acre, and leaving the pond undisturbed for 2d. Water quality was checked again prior to seed stocking. Muriate of potash was also applied to balance potassium content based on water quality report.
DAY-15	Pond was stocked with good quality tested SPF Post Larvae (PL9)

Aeration of the pond

Six numbers of two horsepower each paddle wheel aerators per acre placed at 3-5 m away from the dykes were installed in the pond. While installing the aerators, a proper layout scheme was followed in order to achieve maximum flow of pond water and to prevent damage to the pond dykes,which can increase the sedimentation process and decrease the life span of ponds. The aerators were installed as per the following layout:

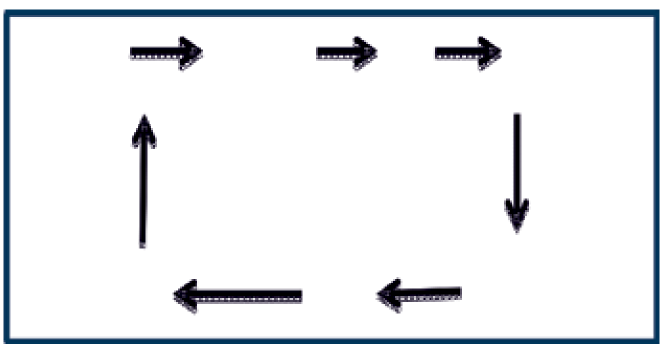

Fig 2: Schematic Layout of aerators in the pond

Procurement of shrimp seed

Specific pathogen free (SPF) post larvae 9 (PL9) were procured from Coastal Aquaculture Authority approved Sri Venkateswara shrimp hatcheries, Kakinada and KPR, hatcheries East Godavari, Andhra Pradesh. The larvae were screened using PCR testing at hatchery testing facility for pathogens like WSSV, IHHNV, MBV, AHPND and IMNV before packaging. Besides this for cross checking, the farmer got seed tested at individual level for the above dreaded pathogens. The seed was airlifted from Rajahmundry airport to Delhi airport from where it was transferred to Mansa through private transport.

Survival test

Two numbers of 2.0 x 1.0 x 1.0 m hapa made of 40 mesh nylon cloth were fixed in the pond and stocked with one hundred numbers of PL-9. The hapas were left undisturbed and seed survival percentage was checked after 96 hr.

Stocking density

The pond was stocked with PL9 at the rate of 50/m^2 (2.0 lakh/ acre), and pond water depth was maintained at 1.5 m. The seed bags were first emptied in a big tank which was immediately supplied with aeration followed by feeding with a small quantity of pre-starter feed. The seed after acclimatisation for about one hour were transferred in the pond. This led to increased seed survival.

The seed was stocked in the second week of April, 2018 and harvesting was done in the last week of August, 2018 (140 days culture).

Feed management

During the first month of the culture, blind feeding of the shrimp was adopted. The shrimps were fed at the rate of 2 kg feed/acre/lakh larvae for the first month with an increment of 0.5 kg up to 11th day, 0.6 kg up to 16th day, 0.7 kg up to 22nd day, 0.8 kg up to 27th day and 0.9 kg up to 30th day. The feed was given in split doses (3-4 times a day) by broadcasting it around the pond. Four check trays were kept in the pond for checking the feed consumption on daily basis. From 2nd month onwards, the feeding was done as per body weight. The feeding schedule was adopted throughout rest of the culture period as per Table 2.

Table 2. Feeding rate for shrimp based on body weight from 30th day onwards.

Days	Mean body weight (g)	Feeding rate at percentage of body weight
30	3.5	8.0
40	5.8	6.0
50	8.5	4.5
60	11.5	4.0
70	14.5	3.5
80	16.5	3.0
90	18.5	2.8
100	20.5	2.6
110	22.5	2.2
120	25	2

Note: To check daily feed consumption, feed in each check tray was put as upto 70 days of culture period: 0.5% of the total feed provided.From 70-120 days of culture period: 0.7% of the total feed provided.

Water quality management

Regular monitoring of the water quality parameters like salinity, pH, dissolved oxygen, alkalinity, hardness, calcium, magnesium, sodium, potassium, ammonia, nitrite and nitrate was done. In order to maintain soil and water quality parameters of pond, water and soil probiotics were used at regular intervals throughout the culture period. The water samples were regularly brought to the water quality lab of the College of Fisheries, GADVASU, Ludhiana for analysis.

Health management

Throughout the culture period, the shrimp samples were regularly monitored for any health related issues, abnormalities and mortalities.To maintain the optimum health status of shrimps under stressful inland low salinity conditions, regularly fed with gut probiotics, organic acids and immuno-stimulants etc. as per recommended dosages. Besides, the pond water was regularly fortified with water and soil probiotics at recommended doses and intervals to keep optimum water quality throughout the culture period.

RESULTS AND DISCUSSION

Water quality parameters

The results revealed that water quality parameters were within the optimum range required for brackish water shrimp species *Litopenaeus vannamei*, except for ammonia which was slightly higher than normal range (Table 3). The salinity during the culture period ranged from 10-11 ppt which was within the range as prescribed for shrimp culture practices. Salinity is an important parameter for normal growth and moulting of *L. vannamei,* and large fluctuations may lead to variable survival and growth. Venkateswarlu *et al* (2019) reported that salinities may show fluctuations during the extreme summer conditions due to evaporation, and have a pronounced effect on the survival and growth of shrimp. In our study in inland saline farm, the salinity did not show very high fluctuations.

The alkalinity values ranged from 210 mg/l to 260 mg/l during the culture period. Alkalinity range of 150-250 mg/l is considered as optimum for growth and survival of shrimp (Boyd *et al,*1992).

Table 3. Average water quality parameters during the culture period.

pH	Alkalinity (ppm)	Hardness (ppm)	Salinity (ppt)	Ca (ppm)	Mg (ppm)	K^+ (ppm)	Na (ppm)	Ammonia (ppm)	Nitrite (ppm)	Nitrate (ppm)
8.1-8.5	210-260	2420-2940	10-11	277.5-365.0	480-491	84-88	1800-2210	0.01-0.02	Nil	1.5-2.0

Alkalinity plays an important role in moulting process of shrimp and low alkalinity cannot buffer the pH leading to wider pH fluctuations causing a stress on growth and survival of shrimp (Venkateswarlu *et al*, 2019), and sometimes even causing heavy mortalities. Higher alkalinity may affect moulting process due to excessive salt loss (Venkateswarlu *et al*, 2019).

Hardness in the present study ranged between 2420-2940 mg/l. Kumari *et al* (2019) in their studies on fish farms of salt affected Fazilka district have reported similar results for total hardness. They observed that the electrical conductivity and total hardness of water increased in accordance with the salinity, and also varied significantly at same salinity levels. These variations can be attributed to differences with respect to ionic composition and their respective ability to conduct electric current.

The ionic profile of the water i.e., calcium, magnesium, potassium and sodium ranged from 277.53-365 mg/l, 480-491 mg/l, 84-88 mg/l, and1800-2210 mg/l, respectively. Calcium is considered one of the important ion for shell formation in crustaceans. Low concentrations of calcium may lead to the loose and soft shell formation in the crustaceans. Similarly, magnesium plays an important role in stable plankton bloom and mineral balance of the animal body. Potassium plays an important role in the normal physiological functions of the *Litopenaeus vannamei*.The deficiency of potassium in the inland saline waters can lead to decreased growth rate as a result of physiological stress on shrimps (Roy *et al*,2007). Potassium is the primary intracellular cation necessary for the activation of the Na^+K^+ -ATPase (Mantel and Farmer, 1983), which is a key component of extracellular ionic regulation. During the present study, the pond water was regularly fortified with sodium and potassium (muriate of potash) to avoid any osmoregulatory stress on the shrimp growth and survival. Besides, the diet was fortified with lab grade potassiumchloride at the rate of 5 g/kg as suggested by Jahan *et al* (2018).

The ammonia concentration of the water during the culture period fluctuated between 0.01-0.02 mg/l. Although it was slightly higher than the optimum range, it couldn't effect the growth and survival of shrimp as it was regularly monitored and controlled during the culture period. The ammonia built up in the pond is mainly due to excretory products of the organisms besides the feed wastage. Ammonia usually limits the oxygen transport capacity of the blood across the tissues. Different strategies like water exchange, sludge removal and ammonia controlling aqua medicines were utilized to control the ammonia concentration. Unionised ammonia is found to be usually toxic at extremely high and low pH ranges (Venkateswarlu *et al*, 2019). As the pH concentration of water was within the optimum range throughout the culture period, the ammonia built up couldn't effect shrimp growth and survival.

Health management during the culture period

The health status of shrimps was regularly monitored throughout the culture period by on-field observations and laboratory analysis. No sudden mass mortality or disease symptoms in shrimps were observed during the culture period.

Fig 3. Scientists at farmers field

Fig 4. Awareness' camp and farmer's pond

Production and economics

The farmer successfully harvested around 8.36t of shrimp with an average body weight of 25 ± 2.0 g (Table 3) in 140 days culture period. The farmer could make a net profit of Rs. 8.0 lakh/ha (Table 4) which was exceptionally higher than income generated from his traditional rice-wheat rotational farming practices. The feed conversion ratio was also exceptionally good at the value of 1.25.

CONCLUSION

The present study and the successful shrimp farming by S. Harminder Singh has motivated the several farmers of the Mansa area and the shrimp farming area has increased to around 42 acre in 2019, directly benefitting around 10-12 families. Although shrimp farming is developing very fast in salt affected areas of inland states like Punjab, Haryana and Rajasthan, but its sustainable development in these areas is a collective responsibility of the farming community and R & D agencies/institutes. The farmers need to follow stringent bio-security protocols; stock SPF or Specific Pathogen Resistant (SPR) seed from CAA approved hatcheries only. In addition to obtaining the certificate of screening from hatcheries, the farmers are also advised to get the seed tested at their own level for diseases/pathogens. The stocking density should not be higher than 60 post larvae (PL)/m^2. Adherence to best management practices (water quality management, feeding and health

Table 4.Economics of vannamei shrimp *Litopenaeus vannamei* culture in 1 ha inland saline water pond.

Sr.No.	Parameter	Cost (Rs.)
1.	Seed Cost	2,10,000
2.	Feed Cost	8,25,000
3.	Labour Cost	80,000
4.	Electricity Cost	1,54,000
5.	Medicine Cost (Soil & water probiotics, Sanitizers, Disinfectants, Zeolites etc.)	65,000
6.	Fertilizers	1,52,500
7.	Miscellaneous(Diesel, skilled labour, etc)	64,500
8.	Gross Expenditure	15,51,000
9.	Total Production 8,366 kg (Sold in batches with varying prices)	23,51,860
10.	Net Profit	8,00,860

management), effluent/sludge disposal protocols, and guidelines regarding use of drugs/chemicals is necessary to get higher productions while ensuring the food safety standards. The farmers of the area are strictly advised to undertake shrimp farming in their salt affected land only and not to convert good agricultural land into shrimp farms. Besides, the farmers should register their farms with State Fisheries Department, Govt. of Punjab

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