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Economic Impact of Periphyton-Based Stunted Fingerling Production in Arunachal Pradesh, India

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Non availability of right type quality seed at right time in required quantity is major bottleneck for the growth of aquaculture in Arunachal and major portion of seed are being import from other nearby state especially Assam in particular. To make availability of good quality seed at right time having a regional acclimation for a longer duration in far flung areas of the state, the present investigation was conducted on low cost Periphyton (grown on paddy straw) based stunted yearling production

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technology to improve the survival and health of stocked material and their economic impact on the fish farmers of district West Kameng during 2018-2021. The average values of pond water quality parameters were observed to vary between both the culture ponds with a significant seasonal differences at all the sites and there were found a greater difference in average survival rate of both the commodities *i.e.* table size fish as well as stunted yearling during whole culture period. The involved cost of cultivation was recorded higher Rs. 4,70,000 / ha in stunted yearling culture in comparison to Rs.424,940/ha in thetable size carp culture while average gross benefit was just opposite, recorded higher Rs. 6,90,000/ ha in stunted yearling culture in comparison to Rs.199,960/ ha in table size carp culture with the same trend in BCR *i.e.* 2.46 for stunted fingerling production and 1.47 in the production of table size fishes respectively.

Keywords: Bottleneck; regional acclimation; stunted yearling; economic impact and BCR.

1. INTRODUCTION

Quality and quantity of seeds are frequently a major issue and is the most important key input for the development and growth of aquaculture sector. Non availability of right type quality seed at right time in required quantity is major bottleneck for the growth of aquaculture in country as a whole and Arunachal including others hilly states of NER in particular. There are very few hatcheries in Arunachal are not in a position to meet out the required demand as a result major portion of seed are being import from other nearby state especially Assam where except few reliable suppliers most of the other sources are unknown and the seed supplied by them are far below in quality from the hatchery produced seed. Hence there are wide gap between demand and supply of quality fish seed in the Arunachal Pradesh especially in far flung areas and in this reference the present experiment had been conducted to help the needy fish farmers with a vision of aquaculture growth in the region by providing the right type, right size quality seed at right time having a regional acclimation for a longer duration through low cost stunted yearling production technology.

Stunted yearlings are the individuals which are having slow growth rate, early maturation, small size and their growth is restricted by density-dependent mechanisms and the diminished maximum size is not genetically determined. Typically these yearlings are defined as the fish fingerlings which have over wintered to add size/weight and to increase post-stocking survival in a hatchery, pond or tank. These are suitable stocking material for carp culture because of their higher survival rate (Das *et.al.,* 2016). They have shown less vulnerability to predation, disease resistant and can withstand environmental fluctuations; can reach marketable size within a less time period i.e. grow up to 700-800 gm within 2.5 to 3 months leading to higher yield & income (Radheysham and Saha, 2009). On the basis of above facts the present experiment had been conducted especially for the small & marginal farmers in the West Kameng district where quality seed availability on right time is a major issue in aquaculture. This study was designed to investigate the fish performance nursed in small aquaculture tanks in exotic carps Polyculture system for the better growth and survival and their impact on farmers economy.

2. MATERIALS AND METHODS

2.1 Study Area

The experiment was conducted from 2018-2021 in different villages *i.e.* Chug, Salari and Jigaon from 3 circles i.e. Dirang, Thembang and Rupa in West Kameng district of Arunachal Pradesh. The aim of this study is to assess the Growth & Economic parameters of stunted yearling (EMC) culture technique and their socioeconomic impact on fish farmers.

2.2 Experimental Design

The experiment had been conducted in triplicates on all the sites at more or less same topography having a control table size carp culture unit for comparison of economic parameters with yearling production units. It has also been taken care for the same size of culture units for both the commodities to avoid the dissimilarities which may creates assessment variability in water quality and growth parameters.

2.3 Farmers Training and Inputs

In the first phase before the execution of experiment the farmers from all the locations were trend in a group of 25 farmers for Proper dissemination of technology in different aspects of fish culture *i.e* .complete package and practices of all the aspects of composite fish culture technology as preparation of Pond, stocking, regular liming, manuring, feeding, health management, harvesting and marketing etc. For better motivation of the farmers to adopt this technology, critical inputs were also provided *i.e.* fish seed, feed, lime and fertilizers etc. along with the other necessary support input like, cast net, Plankton net, weighing balance and scale to the selected beneficiaries for use during the experimental period.

2.4 Pond Preparation and Management

Pre-stocking pond preparation methods are followed i.e. removal of predatory and weed fishes by bleaching powder (10 mg/l chlorine) and then basal fertilization (3tonn cow dung and 30 kg single super phosphate / ha) were carried out before stocking of fingerlings (Jena *et al.,* 2005). Regular fertilization schedules were followed as recommended practices to increase the natural fish food organism. There was no any external feeding provision during the trial period to minimize the input cost and only culture had been practiced with help of natural fish food organism. The plankton growth have been increased by the technique of pond fertilization as said above and for the development of Periphyton the bunches of paddy straw had been put half submerged by hanging with the help of plastic ropes in the pond water. After decaying the older one new bunches were used for the said purpose.

2.5 Stocking and Growth Monitoring

The cultured fry were selected from exotic categories i.e. Silver carp, grass carp and Amur carp as they are most demanding because of their good growth and survival in hilly conditions of Arunachal Pradesh. The initial size of advance fry was ranging from 25-30 mm having weight ranging from 1.0 to 1.2 gm/piece. The ready ponds at all the locations were stocked in the month of April having stocking density @ 2, 00,000 advance fry/ha. The study was conducted as all the locations as said above in 3 replicates.

2.6 Water Quality Analysis

Water quality parameters in the culture ponds for both the commodities were analyzed at monthly interval on regular basis before all netting for thinning of stocked material to maintain the proper aquatic environment and also for future study APHA (1981). The water quality parameters assed and data were recorded for Temperature, pH, Do and conductivity etc. through use of suitable tools and techniques.

2.7 Data Collection and Analysis

The thinning of the stock was also done at 45 days interval to maintain the suitable pond environment and to minimize the mortality due to overstock. At the all thinning days the data were recorded to measure the length and weight of stocked material for assessment of growth performance. To check the health and growth of fish, 50 nos. of stocked fish from each experimental pond were sampled using a cast net at monthly intervals. The, survival rate %, weight gain %, SGR and Net yield (kg/ha) were measured at the end of the experimental period, following the equation (Hossain et. al., 2022).

Survival (%) =Total number of fish present /Total number of fish stocked ×100

Weight gain % = [Final Weight – Initial Weight / Initial Weight] x 100

SGR = [Final weight – Initial Weight / Experimental Period in days] x 100

Net yield (kg/ha) = Fish biomass at harvest – Initial biomass during stocking

The data regarding survival rate average cost of production and gross return after sale of carried over stunted yearling were also recorded. The recorded data were analyzed by suitable statistical tools for the study of economic impact on farmer’s economy.

3. RESULTS AND DISCUSSION

3.1 Water Quality Parameters of Yearling Culture Ponds

The findings of present study on the various aspects of the production from all the sites for both farming practices *i.e*. table size carp culture and stunted yearling production are summarized in Figs. 1 & 2 and Tables 1-3. The Table 1 depict about the physiochemical parameter in the water of yearling culture ponds *i.e.* Temperature, pH, Dissolved oxygen and Conductivity. The average pond water temperature for all the trial locations were in the range of 13.6 to 23.4 during the experimental years. It was recorded lowest 13.4

^{0}c in the month of December and 23.4 during the month of June. There were continuous increase in temperature since April to Aug except the month of July and after that a continuous decreasing trend was observed from September to December while the again temperature rise had been noticed from January to March at all the locations. The fluctuation in the water temperature might be because of seasonal variation in environmental temperature except sudden change (fall) in temperature in month of July which may be because of continuous heavy rain having high speed cold air. The average pH has been observed in the range of 6.9 to 7.8 for all the treatments at all the locations during the whole culture period. It was recorded highest 7.8 in the month of Feb and lowest 6.9 in the month of May. There were some fluctuations have been observed as per seasonal changes which might be due to the change in water temperature. Results are in accordance with the findings of Dey et.al., (2021) on the study of Seasonal variation in water quality parameters of Gudlavalleru Engineering College pond.

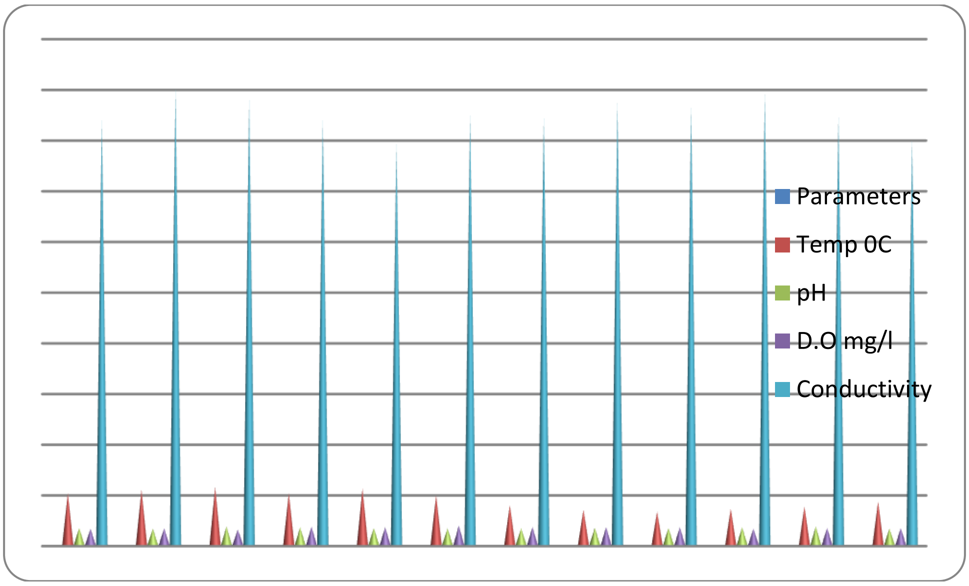

Fig. 1. Physico-chemical analysis of yearling cultured pond water
(Note: Values or mean of all trial years from all locations)

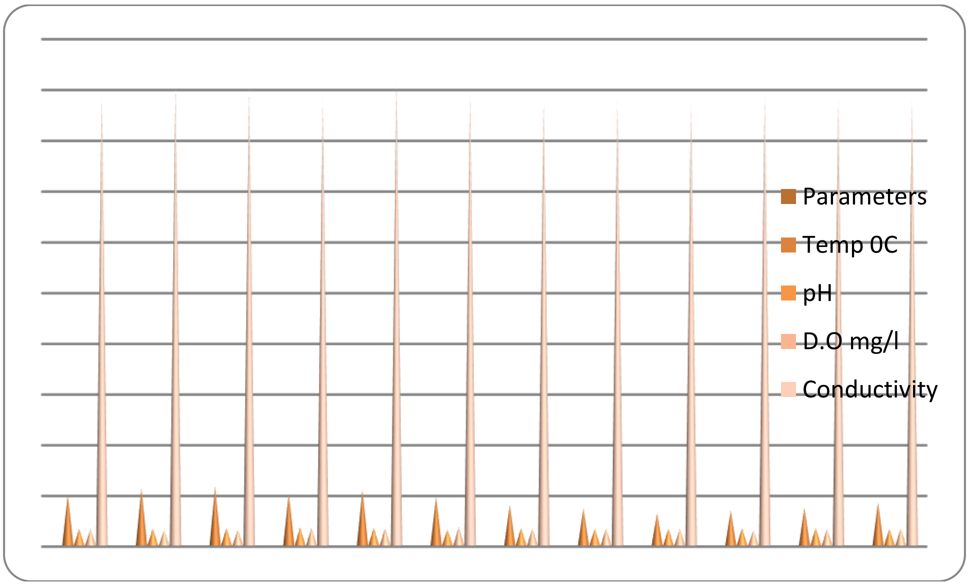

Fig. 2. Physico-chemical analysis of table size fish culture pond water
Note: (Values are mean average of all the experimental sites for whole experimental period

The dissolved oxygen in the pond water was found in the range of 6.55 to 8.20 mg/l, it was recorded lowest 6.55 mg/l in the month of June and highest 8.20 in the month of Sep. The change in oxygen concentration could be due to the change in the environmental conditions and feeding demand of fishes according to seasonal changes. During winters the occasional sudden decrease in oxygen concentration may be because of lower feed acceptability by the fishes because of their lower BMR linked with lower water temperature and deposition of leftover excess feed material in pond bottom which got decompose in pond and also consume the dissolved oxygen and reflects the decrease in oxygen concentration in culture ponds. In spite of change in feed consumption pattern and decomposition of leftover feed, the lower photosynthetic activity because of cloudy weather during most of winter may also be a big reason for sudden decrease in oxygen concentration. The same line of results also been reported by Martin et.al., (2019) in the findings of their research on Diurnal stratification of oxygen in shallow aquaculture ponds in central Europe and recommendations for optimal aeration.

Conductivity is a good rough guide to the condition of ponds. It measures how much 'stuff' there is dissolved in the water and ponds which are polluted usually have more 'stuff' dissolved in them than those that are clean. Significant changes (usually increases) in conductivity may indicate that a discharge or some other source of disturbance has decreased the relative condition/health of water body and its biota. The average values for conductivity of pond water at all the sites were found in the range of 160.2 to 180.2 having its lowest value recorded in the month of March and maximum in the month of May. The fluctuation recorded might be due to seasonal change in environmental conditions and entered runoff loaded with dry/dead organic debris in pond water during rain. The findings are almost synonyms of the findings of Ilknur and Cuneyt (2021) for the study of Change Trend of Electrical Conductivity (EC) Values of Water Resources in Trout culture Farms in Turkey.

3.2 Water Quality Parameters of Table Size Fish Culture Ponds

The data presented in Table 2 are the details of physiochemical parameters of water in the table size fish culture ponds *i.e.* Temperature, pH, Dissolved oxygen and Conductivity. The data revealed that the average value of recorded temperature was found in the range of 13.2 ^{0}C to 23.8^{0}C. The Lowest value was observed in the month of December and lowest in the month of June. The same trend as in yearling culture pond was also observed in fish culture pond with continuous increase in temperature since April to Aug except the month of July and after that a continuous decreasing trend was observed from September to December while the again temperature rise had been noticed from January to March at all the locations. The change in the pond water temperature seems might be due to climatic variability linked with seasonal changes as in case of yearling raising pond water. The same line of findings have also been recorded by Dinesh Kumar et.al., (2017) on the Study of seasonal water quality assessment and fish pond conservation in Thanjavur, Tamil Nadu, India.

The recorded average value of pH was found in the range of 6.7 to 7.7 at all the 3 locations. It was recorded highest 7.7 in the month of July and lowest 6.7 in the month of Sep. The fluctuating value of pH from neutral to slight alkaline have been observed during whole experimental period which might be due to seasonal changes as well as lower density of stocked fishes in fish culture pond in comparison to yearling culture pond having higher stocking density.

Dissolved oxygen (D.O) in water is one of the most significant characteristics in aquaculture, along with temperature and pH. Since oxygen (O2) has a direct impact on feed intake, disease resistance, and metabolism, maintaining adequate D.O levels in the water is crucial for optimal production of fish. The dissolved oxygen in the pond water was found in the range of 6.50 to 7.90 mg/l, lowest in the month of January and highest in the month of Sep. It shows initially the decreasing trend with rise in temperature up to June after that intermittent ups and downs in the value of oxygen had been observed from July to November which could be due to climate variability but after that again decrease in oxygen level was found in December and January which might be because of lower feeding demand of fishes due to wintery months and became consumed in the degradation of unconsumed leftover feed material in the pond bottom. Again slight increase in oxygen concentration have been found in the month of February and March as weather got slight hot with increased photosynthetic activity along with feed consumption by the stocked fishes. The data are in accordance with the findings of Hemlata

(2013). The data clearly indicates that the change in oxygen concentration is because of the change in the environmental conditions and feeding demand of fishes according to seasonal changes.

3.3 Growth Performance of Yearlings

The significant increases in final length & weight of advanced fry were recorded and are depicted in the Tables 1a & b.

During the start of experiment the initial weight was recorded 1.0, 1.3 & 1.2 gms with reference to Silver carp, Grass carp and Amur carp respectively while the recorded length was 2.6, 3.1 & 2.3 cm for Silver carp, Grass carp and Amur carp. The data also revealed that the highest length increment in silver carps advanced fry was found 2.6 cm in the month of February and lowest 0.3 cm in month of November, in case of Grass carp advanced fry the length increment was highest 2.8 cm in February and lowest 0.1 cm in month of January while it was highest 2.0 cm in month of March and lowest 0.2 cm in month of January in the Amur carps advanced fry. The recorded weight increment in silver carp was highest 5.9gms in month of February and lowest in 0.4 in month of November, and 5.68 highest in July and 0.1 gm almost nil in January in case of Grass carp while it was observed highest in Amur carp *i.e* 6.8 gms. in month of February and lowest 0.4 gms. in the month of January. The variation in the length and weight gain of stocked material might be due to their adoptability variation for local microclimate linked with favorable feed material availability in the culture pond which varies from difference in pond location. The almost same line of findings were also recorded by Ujjania et.al., (2022) for length weight relationship and condition factor study in village pond reared exotic fish Cyprinus carpio Valsad Gujrat and Mehta et.al., (2015) in the study of Comparative growth performance of exotic carps seed in cemented and poly tanks in mid hills of Uttarakhand.

3.4 Growth Performance of Table Size Fish

The growth performance of species cultured for table size was different from species to species and it was highest for grass carp followed by Silver and common carp. The details about related data are given in Table 2. The data showed that the initial weight of fingerlings was 4.1 +- 0.2 gms. for Silver Carp, 3.7+-0.3 for Grass Carp and 4.3+-0.4 for the fingerlings of Common Carp during stocking, it has been observed that it was highest 4.3 gms for the common carp fingerlings and lowest 3.7+-0.3gms for the fingerlings of grass carp. During harvesting the mean average weight was recorded highest 470 +- 21 gms. in grass carp followed by 330 +- 25 gms. in Silver Carp and 280 +- 28 gms. in Common Carp having same trend in Weight gain %, SGR% and Net Yield with highest value for grass carp followed by silver carp and Common carp respectively.

Although the weight gain by the cultured table size fishes was less than expected potential but rather than that the higher weight gain in Grass carp was comparatively better than others, may be because of availability of plenty of soft grasses during rain and other seasons too except winter and in Silver Carp higher than common carp because of their higher position in aquatic food chain being surface feeding habit and get more available energy in form of phytoplankton in comparison to common carp. The findings are in accordance with Mehta et.al., (2016) during the study in Development of carp fish culture practice under different stocking densities in mid hills of Uttarakhand, India.

3.5 Comparative Economic Analysis on Cost and Revenue from Intervention

Economic analysis showed that advanced fry nursed in small aquaculture pond is more profitable than table size fish culture for small and marginal farmers in the district. The detail about economics along with related data has been depicted in the Table 3. The data revealed that average survival rates varies between these two commodities and it was recorded highest 73% for table size carp culture and 58% for culture of yearling. The variation was also observed in total cost of cultivation including cost of stocking material having higher cost 470000/- in stunted yearling production in comparison to 424,940/-in table size carp culture. The larger variation was also recorded in sale value for both commodities and it was highest 1160,000/ in stunted yearling culture rather than having lower survival rate in comparison to lower sale value 624,900/- with high survival rate in table size carp culture.

Table 1a. Month wise increment in length and weight of fishes

Months/	April		May		June		July		Aug.		Sep.		Oct.		Nov.		Dec.		Jan.		Feb.		March	
Species	L	W	L	W	L	W	L	W	L	W	L	W	L	W	L	W	L	W	L	W	L	W	L	W
Silver carp	2.6	1.0	3.80	3.2	5.20	7.10	6.7	11.1	7.1	15.1	7.5	17.5	8.2	20.0	8.5	20.4	9.1	22.5	9.5	23.3	12.1	29.2	14.2	32.5
Grass carp	3.1	1.3	4.10	3.4	5.20	6.42	7.1	12.1	7.5	16.3	8.5	18.5	9.2	24.0	9.5	25.4	9.8	25.7	9.9	25.8	12.7	31.3	15.1	35.3
Amur carp	2.3	1.2	3.50	4.1	5.00	6.8	6.1	10.1	7.2	13.3	8.2	16.8	9.0	23.0	9.4	24.5	9.8	25.3	10.0	25.7	11.5	32.5	13.5	36.8

L= length in (cm) and W= Weight in (gm), (Values are mean of 50 specimen per sampling for each species)

Table 1b. Month wise incremental differences in length and weight of fishes

Months/	April		May		June		July		Aug.		Sep.		Oct.		Nov.		Dec.		Jan.		Feb.		March	
Species	L	W	L	W	L	W	L	W	L	W	L	W	L	W	L	W	L	W	L	W	L	W	L	W
Silver carp	0	0	1.2	2..2	1.4	3.90	1.5	4.00	0.4	4.0	0..4	2.4	0.7	2.5	0.3	0.4	0.6	2.1	0.4	0.8	2.6	5.9	2.1	3.3
Grass carp	0	0	1.0	2.1	1.1	3.02	1.9	5.68	0.4	4.2	1.0	2.2	0.7	5.5	0.3	1.4	0.3	0.3	0.1	0.1	2.8	5.5	2.4	4.0
Amur carp	0	0	1.2	2.9	1.5	2.7	1.1	3.30	1.1	3.2	1.0	3.5	0.8	6.2	0.4	1.5	0.4	0.8	0.2	0.4	1.5	6.8	2.0	4.3

L= length in (cm) and W= Weight in (gm), (Values are difference in length and weight gain for each month)

Table 2. Growth Performance of fingerlings up to table size after stocking

S. No	Species	Initial weight during stocking (In gm)	Weight of fishes during harvest (In gm)	Weight gain (%)	SGR (%)	Net Yield (Kg/ha)
1	Silver Carp	4.1+- 0.2	330 +- 25	5,775.60	207605.47	761.30
2	Grass Carp	3.7+-0.3	470 +- 21	9172.97	223167.12	816.96
3	Common Carp	4.3+-0.4	280 +- 28	4653.49	131572.60	483.03

(The values related to weight are mean average of 50 specimens during stocking and harvest in all trial years for each species)

Table 3. Comparative economic analysis for culture of Advance fry and table size carp culture

S. No.	Species	Stocking Density		Survival rate		Average Cost involved (Price of advance fry and fingerlings + Culture cost)		Sale value		Gross Profit		BCR	
		Advanced fry rearing	Table size Carp culture	Advanced fry rearing @58%	Table size Carp culture@73%	Advanced fry rearing	Table size Carp culture	Advanced fry rearing	Table size Carp culture	Advanced fry rearing	Table size Carp culture	Advanced fry rearing	Table size Carp culture
1	Silver carp	80,000	3200	46,400	2336	1)Cost of 200,000 advance fry@Rs1.5/pc =300,000/- 2)Culture cost including Miscellaneous expenses =90,000/- 3)Packing Charges for 116,000 advanced Yearlings=80,000	1)Cost of 8,000 fingerlings@Rs5/pc =40,000/- 2)Culture cost =3,74,940/- 3)Miscellaneous expenses including periodical netting 50,000	Rs 1,160,000/- For sale of 116,000 advanced yearling @Rs 10/pc	Rs 624,900/- for 2083kg fish @ Rs300/kg	1,160,000- 4,70,000 = 6,90,000/-	624,900/- 424,940= 199,960/-	2.46	1.47
2	Grass carp	60000	2400	34,800	1752								
3	Amur carp	60000	2400	34,800	1752								
Total		200,000	8,000	116,000	5840	4,70,000/-	424,940/-	1,160,000/-	624,900/-	6,90,000/-	199,960/-		

The data also showed that the gross profit was higher 6,90,000/- in stunted yearling culture rather than 1,99,960/-in table size carp culture with same trend of BCR 2.46 and 1.47 in stunted yearling culture and table size carp culture respectively. The economic variability in the sale value of both the commodities seems because of the variation in their price and demand in the local market. The high demand of well adopted yearlings for culture in local climate makes them more valuable in comparison to table size fishes during the season of stocking. The results obtained from the study regarding economics of yearling raisings are almost synonyms of the findings obtained by Saikia et.al., (2020) for the study on Production for Fish Fingerling, Advanced Fish Fingerling and Yearlings in Kamrup District of Assam.

4. CONCLUSION

The present study clearly indicates that stunted yearling culture technology is more profitable than table size carp culture rather than higher cost of production than table size carp farming. The presented data showed that it is a good income generational technology for small and marginal farmers who have small land holdings and also helpful in providing the availability of well acclimated quality fish seed at right time to the farmers living in far flung areas that are unable to procure the seed input from distant places in nearby states.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of this manuscript.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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