The Pharma Innovation Journal 2023; 12(6): 535-539

www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277-7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2023; 12(6): 535-539

www.thepharmajournal.com
Received: 08-03-2023
Accepted: 11-04-2023

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A study of the growth potential and economic viability of pangasius farming in the Varanasi area of Uttar Pradesh was conducted using different stocking densities

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Abstract
The purpose of this study is to compare the pangas growth performance at different stocking density in commercial recirculating aquaculture systems (RAS) at different locations of Varanasi district of Uttar Pradesh, India. The goal of the study was to evaluate the yield or economics of pangasius as well as the stocking density for optimum growth in RAS. There were 3 separate research locations, each with 8 tanks totaling 7.65 × 7.65 x 1.0 m^3 in size. Average body weight of 5-6 gm fish were distributed at the rate of 86, 97 and 115 per m^3, with commercial feed being given at the rates of 6.5-8% body weight.
The result showed significant response in the growth performance of fish. The growth performance results were in following order:
Net Weight gain: 111.16±0.59 g (Site 1) > 71.91±0.54 g (site 2) > 57.93±0.58 g (Site 3).
Percent weight gain: 95.25 (Site 1) >90.73 (Site 2) > 82.73 (Site 3).
SGR: 4.2 (Site 1) > 4.1 (Site 2) > 3.7(site 3).
FCR: 1.35 (Site 2) > 1.55 (Site 1) > 1.74 (Site 3).
The obtained results indicated that the best growth performance of Pangas was found in Site 1 and 2 as compared to Site 3, which realized positively significant at level of 5%. The cost benefit ratio of total fish production was computed as 1.10:1.56. The results of the economic research suggested that there could be a chance for significant production cost reductions.

Keywords: RAS, growth performance, economic feasibility, pangas

Introduction
India is the second largest producer of fish in the world accounting for 7.92 percent of global production and contributing about 1.24 percent to country's GVA and over 7.28 percent to the agricultural GVA (2020). Fisheries and aquaculture are an important source of food, nutrition, income, and livelihood for approximately 20 million people. Total fish production of India increased from 0.75 MMT in 1950-51 to 14.37 MMT in 2020 with inland sector contributing 10.43 MMT (74.22%). Aquaculture in India has been able to maintain a consistent annual growth rate of ~6 percent during last three decades although, the country has remained largely carp centric (>70% contribution) in fish production. It is pertinent to mention that even though inland fisheries and aquaculture have grown in absolute terms, the development in terms of their potential is yet to be realized.
A species of catfish belonging to the family Pangasiidae in the Siluriform phylum is called *Pangasius pangasius*. One of the most significant and significant interior fisheries in the world, the Mekong River fishery, includes it as one of its key fish species. Its prolific spawning behavior, which results in relatively large numbers of larvae that are easily harvested from flowing rivers, is probably where the traditional development of capture-based aquaculture for this species began, particularly in Vietnam and to a lesser extent in Thailand and Cambodia.
The aquaculture production in India has grown significantly in recent years. The quick growing Mekong Silurid Pangasius, *Pangasianodon hypothalamus* introduced in West Bengal in 1994 as pond grown food fish expanded rapidly owing to fast- growth, easy farm operation and affordable price. The higher productivity and economic returns attracted and encouraged many farmers to adopt the species on large- scale culture for production. Today, this introduced fish species is flourishing across length.

Recirculatory Aquaculture Systems (RASs) are land-based aquatic systems that partially or entirely reuse water following mechanical and biological treatment to decrease water use, energy use, and nutrient release into the environment, preventing eutrophication. When water is scarce, RAS systems are a method for intensive fish production. Using a variety of components, the RAS system enables recycling of 90 to 99 percent of the water. RASs enable the best circumstances for fish production by giving the operator better control over environmental and water quality factors. (Heinen *et al*., 1996) [15].

The term "stocking density" (Ellis, 2001) [6] refers to the weight of fish per unit volume or the quantity of fish supplied at the start of an experiment (Ruane *et al*., 2002) [39]. Fish that are stocked in large numbers frequently display aggressive behavior, especially when food is scarce. This situation frequently causes fish stress, which might have an impact on the health of the fish. Therefore, when considering fish density, food availability is crucial (Holm *et al*., 1990) [17].

The RAS may be used as hatcheries to generate spawn, fry, and fingerling fish for stocking as well as decorative fish for home aquariums or as grow-out systems to create food fish (Helfrich & Libey, 1991) [16]. RAS provides more independence from the outside environment (i.e., higher degrees of control) in comparison to conventional aquaculture approaches, providing a foundation for improved risk management (Rawlinson, 2002) [36].

With a production rate of 35 tons per hectare, the average cost of producing pangasius in Andhra Pradesh is INR 65–70 per kilogram. Since the start of the culture in 2004, the cost of producing pangasius has climbed by 190% in India. Except for the great irregularity in delivering remunerative pricing, farm-gate prices climbed by 180% by 2020. Profits in Pangasius culture have decreased concurrently from 54% in 2004 to 18% in 2019. 9% of farmers have lost money because to the COVID pandemic, which is exceptional.

To ensure near accurate assessment of the RAS system to prepare a realistic approach for development. The available sites for regularly visited and stake holders were interviewed to share their experience. Issues outline were also discussed with the fishery department officials to know the technoeconomic feasibility of such projects in the light of short comings at the end of farmers.

Recirculating aquaculture systems (RAS) have been introduced to reduce waste discharge and to improve water quality in fish ponds as a response to environmental regulations (Martins *et al*., 2005; van Rijn, 2013) [32, 42].

Economic feasibility analyses have been carried out for some fish species, such as asp (*Aspius Aspius*) and ide (*Leuciscus idus*) in Poland, and tilapia in Egypt and Norway. Some studies conclude that RAS is an economically viable option, but others argue that RAS is only feasible for large-scale production facilities. Past economic studies on RAS have not addressed pangasius, nor assessed the risks of RAS arising from uncertainties about different factors, such as future prices, yields, and operating expenses. (Ngoc *et al* 2016) [34]

By using precise stocking density, improved development and survival, and the usual physicochemical properties of water, this research may enable fish farmers to boost fish productivity. The degree of sustainability of agricultural systems in the future with the following research goals will be crucial for maintaining the world population's growth and development within the safe bounds of the planetary boundaries.

Material and Methods

Experimental Site area

In the eastern part of the state of Uttar Pradesh, at an elevation of 80.71 meters, in the heart of the Ganges valley in North India, Varanasi is located along the left crescent-shaped bank of the Ganges (Fig 1). Varanasi district lies in Between 25° 14' and 25° 23.5'N and 82° 56' and 83° 03'E is where the urban agglomeration is situated. The soil is incredibly fertile in North India's Indo-Gangetic Plains because to low-level Ganges floods. Varanasi's proximity to the Tropic of Cancer causes summertime temperatures to occasionally soar to 45 °C while also being humid. For about two months, the monsoon season, which normally begins in late June or early July, is characterized by heavy rain and high humidity. April marks the beginning of the dry summer, which lasts through June. The monsoon season follows from July to October. The summertime temperature is between 22 and 46 °C.

Experimental set up

The study was carried out at the different sites of commercial RAS situated in Varanasi district (Fig 2). There was total 8 cemented tanks in each site, size of each tank was 7.65 x 7.65 x 1.5 m. The unit comprises of the filtration tank as well. The name of the villages where sites were situated are-Site 1-Village Majhwa, Site 2- Village chuppepur and Site 3-Village Khanuuan. The study duration was of 60 days. Commercial diets were fed @ 6.5 -8% body weight twice daily given in morning and evening. The diet was divided equally between the two feeding.

After acclimatization fishes were transferred at the rate of Site 1-86/m^3, Site 2- 97/m^3 and Site 3- 115/ m^3 per tank. Observations were taken for their periodic weight at fortnight interval. At the end of the experiments the samples were analyzed for growth performance and survival rate were calculated. The results were statistically tested for significant difference SPSS 16.0.

Results and Discussion

Growth performance and Economic analysis of culture period in different units was studied and summarized in Table 1 and Table 2. Following observations were made-

During the period of study, the total net weight gain in Site 1-111.16±0.59 gm, Site 2-71.91±0.14 gm and Site 3-57.93±0.55 gm. The total net weight gain of all sites was significantly different (CD=0.45) during research duration. The percentage weight gain of all three units was different. Weight gain (%) is shown in decreasing order in the following manner: 95.25 (Site 1) > 90.73 (Site 2) > 82.73 (Site 3). The Percent weight gain of all Study units was significantly different (CD=4.76) during experimental duration. RAS provides optimum environmental conditions all year long, raising FCR and improving fish welfare, claim Losordo, 1998 [31]; and Roque d'Orbcastel *et al*. (2008) [38].

Along with others, Roque d'Orcastel (2008) [38] in order to allow the fish to develop as long as possible, Pangasius feed is divided into two stages, the first of which is rich in protein and other minerals. In the second stage, the concentration of carbohydrates is frequently increased to fatten the fish, make them heavier, and so boost output. The result revealed that the best FCR was recorded in Site 2 (1.3) fishes followed by Site 1 (1.5) and Site 3 (1.7). FCR was also found significantly different (CD=0.14) among all Study sites. The lowest FCR was found in the fishes of Site 3 which was significantly different from Site 1 and 2.

According to research by Enache *et al*. (2011) [7], the SGR varied between 1.28% and 1.49% in several treatment groups during the production of carp in RAS. The highest SGR was in site 1-4.2 and lowest was in site 3-3.7. In this investigation, SGR's conclusions are less important than those of Enache *et al.* (2011) [7]. The SGR's lower value in the production of Pangas may be due to the decreased water temperature, which directly influences growth. The specific growth rate indicates the effective role of feed in the growth performance. Results were found significantly different (CD=0.19). The result revealed that the best SGR was recorded in Site 1 (4.2%), followed by Site 2 (4.1%) and Site 3 (3.7%) after 60 days which was statistically non-significant to each other at 5% level of significance. There was different survival rate of different study unit site 1- 93.75%, Site 2-94.33% and site 3-88.18% was observed during the study period.

The experiment was carried out by Caffey and Kazmierczak (1996a) [24] in order to develop a thorough aquaculture production model that considers restrictions unique to closed system culture and to undertake a rigorous economic study of closed system operation. The expenditure in variable cost includes fish seed, fish feed and miscellaneous expenditure (water charges, electricity, filter bed pump, etc.) The miscellaneous expenditure varied in all the three units was included. The total variable cost based on cubic meter area in different RAS in units was site 1-57740, site 2-33201 and site 3-43526 rupees (₹) respectively. The production in different RAS units was site 1-548.66, site 2-415.99 and site 3-386.08 kg/m^3 respectively. The net profit obtained different RAS units was site 1-10847, site 2-18797 and site 3-5034 rupee (₹) respectively. A better percent return to variable cost and percent return to turn over was found in site 2 of RAS. Benefit cost ratio different RAS units was site 1-1.18, site 2-1.56 and site 3-1.10 respectively.

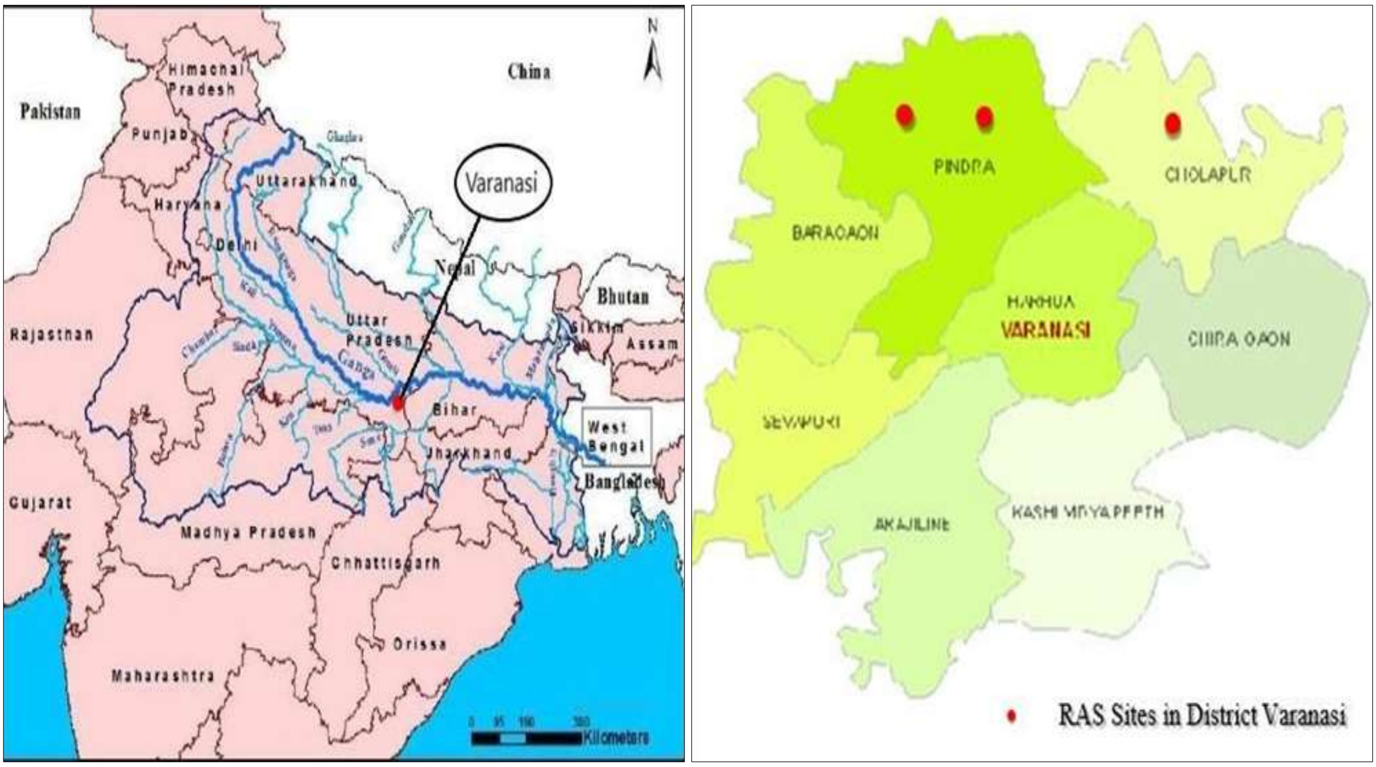

Fig 1: Map showing Varanasi district and study sites

Table 1: Results of current investigation

S. No.	Sites	Parameters			
		Net weight gain (g)	**Per cent weight gain**	**SGR**	**FCR**
1.	Site 1	111.16±0.025	95.25±0.028	4.2±0.225	1.5±0.057
2.	Site 2	71.91±0.011	90.73±0.034	4.1±0.005	1.3±0.057
3.	Site 3	57.93±0.024	82.73±0.022	3.7±0.075	1.7±0.058
	SEm±	0.15	1.58	0.07	0.05
	CD at 0.05	0.45	4.76	0.19	0.14

Table 2: Economic analysis of *Production* at different sites-

Sr. No	Parameters	Study Sites		
		Site 1	Site 2	Site 3
1	Area of cement cistern (m^3)	7.65 x 7.65 x 1.5 m		
2	Water depth (m^3)	1.0 m	1.0 m	1.0 m
3	Stocking density/m^3	86/ m^3	97/m^3	115/ m^3
	Variable cost			
1	Total feed intake(kg)	877.85	499.18	656.33
2	Total Seed cost@5rs(no.)	430	485	575
3	Total Feed cost (65/kg)	57060	32446	42661
4	Miscellaneous	250	270	290
5	Total variable cost	57740	33201	43526
Return				
1	Total production(kg)	548.66	415.99	386.08
2	Total fish production(125₹kg)	68582	51998	48260
3	Net profit/loss	10842	18797	5034
4	Percent return to variable cost	18.77	56.61	11.56
5	Percent profit to turn over	15.80	36.14	10.43
6	Benefit cost ratio	1.18	1.56	1.10

Conclusion

The present study indicates that feed utilization and growth performance are better in Site 2 as compared to other. Water recirculation two times in day favorable for the growth of the experimental fish. Low growth rate was found because during the experimental period winter season more. Survival was more in Site 2 as compare to other. Total output and yield per unit area was higher in site 2 than other. The study concludes that the re-circulatory aquaculture system may be economically viable for intensive farming of pangasius where water and land are constraints.

It also suggests that perhaps component performance should be combined with the cost of ownership of these components (which ultimately make up the total cost of the system) into a "performance/cost" factor. Engineering performance and economic performance must be balanced to provide an optimum production system for the specific site, species, and operating personnel requirements. Thus, COVID-19 pandemic has had a profound impact on fisheries and aquaculture globally, driven by changes in consumer demand, market disruption and the logistical difficulties of ensuring stringent containment measures that prevented or hampered fishing and aquaculture activities, including lockdowns, curfews, physical distancing in operations and onboard vessels, and port restrictions.

Mortality in Cement Tanks: Mortality of juveniles in initial stage has been reported in new cemented tanks, even though acclimatized. This problem gets slowed down with passing time. Release of chemicals into water from mortar may be one of the reasons. No scientific study has been done so far to resolve this issue. It is highly suggested to standardize mortar and other building material suitable for fish culture by civil engineering experts.

Feed Quality: Feed constitutes highest (more than 70%) among various segments of Operational Expenditure. Production, supply, and availability of quality fish feed at genuine price is important to get higher FCR that improves the economic profitability of the venture. In fact, feed manufactures and suppliers earn more than farmers in entire venture that is too at minimal risk.

Overall, COVID-19 brought a new set of challenges to national statistics systems and operations. These challenges were not homogeneous among countries or even within the same country, as some had better institutional, financial, technological, and digital capacities to develop solutions.

The challenges for recirculating systems designers and engineers are many. Recirculating systems and system components must be designed to be manufactured at a lower cost or to utilize components that are currently available to other industries at lower prices. Where possible the carrying capacity of a system must be increased without increasing cost or sacrificing system reliability.

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