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Comparative evaluation of two farming practices of *Penaeus monodon* (Fabricius, 1798) in low saline waters of Andhra Pradesh, India

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Original Article

Abstract

Performance evaluation of two different culture systems of *Penaeus monodon* namely modified extensive and semi- intensive farming in low saline water (>10 ppt saline soils) has been carried out in West Godavari district of Andhra Pradesh during a winter crop season (August to November). Total production (t/ha/crop) was found to be three times higher in the semi-intensive farm (4.2 ± 0.06) than the modified extensive farm (1.38 ± 0.02). However, growth rate of individual shrimps and final average body weight were more in the modified extensive farm. The average body weights at final harvest were 35 ± 1.62 g (105 days of culture) and 28 ± 2.18 g (112 days of culture) respectively for modified extensive and semi-intensive farms. Survival and FCR were similar in both the farming practices. Water quality parameters did not vary much among the two systems and were in conducive range throughout the culture period. However, certain environmental indices such as total organic matter content and total nitrogen levels of soil were higher in semi intensive farm indicating its potential impact on environment. Ammonia-nitrogen level in water also found to be higher in the semi-intensive farm.

Keywords: *shrimp, semi-intensive, modified extensive, organic matter, low saline soils*

Introduction

Shrimp farming has shown phenomenal development in India due to its excellent commercial viability. Presently about 1,57,000 ha area is under shrimp farm in India (Abraham and Sasmal, 2009) wherein Andhra Pradesh (AP) provides more than 60% of the culture area and production. Farmers have adopted a number of innovative technologies to improve the production and to maximize the economic return per unit area. The culture practices adopted in AP can be classified into extensive, modified extensive and semi-intensive based on the management strategies adopted in terms of pond size, seed, feed and environmental control. The intensification of farming helped the farmers to get higher economic return and contributed significantly to the foreign earnings and rural development. At the same time these developments raised some serious ecological problem leading to curb on intensive farming practices in the recent past.

Saline condition of the pond influences the productivity and environmental changes in shrimp farms. Salinity is the most important ecological factor which effects the growth and survival of *P. monodon* (Chakroborti *et al.*, 1986). Several previous studies indicate that *P. monodon* can be cultured in low saline conditions (Manik *et al.*, 1978, Navas and Sebastian, 1989, Abraham and Sasmal, 2009). In the present study a comparative performance evaluation of the modified extensive and semi- intensive farming in low saline conditions in AP has been carried out in order to assess its productivity and environmental impact.

Material and methods

The study was carried out in West Godavari District of AP wherein two shrimp farms representing one each for modified extensive and semi-intensive farms were selected. The study was carried out during winter crop season (August to November). The classification of the farms was done mainly based on the stocking density and the management practices adopted. In each farm five ponds with an average area of 1.2 ± 0.2 ha were selected to study the variations in performances. The details of the farms are given in Table 1.

Table 1. Details of different farms selected for the study

	Modified extensive	Semi intensive
Location	Akiveedu, Bheemavaram	Jaipuram, Eluru
Number of ponds and area	5 (1.2 ± 0.2 ha)	5 (1.2 ± 0.2 ha)
Depth	1.5 m	1.5 m
Stocking density	5 / m^2	18 / m^2
Water Source	Canal	Canal
Soil salinity*	3 ppt	2 ppt
Soil pH*	7.6	7.8

*Soil salinity and pH were found to be constant throughout the culture period

Similar pond preparation was adopted in both the farms. Briefly, the ponds were dried for one month and the top soil was scraped and removed, ploughed and the pre-chlorinated (12 ppm available chlorine) water from a reservoir pond was filled in the pond. Bio-security measures such as bird fencing over the ponds using nylon twine and crab fencing using silpaulin sheets of 2 feet height on the pond dykes were fixed. Agriculture lime was applied @ 150 kg/ ha after drying the ponds. Slaked lime was applied @ 100 kg/ ha once in a month throughout the culture period. Fertilizers such as urea @ 45 kg /ha, Single Super phosphate @ 75 kg/ha and dolomite @ 75 kg/ ha were used immediately after filling the ponds with water.

WSSV free post larvae (PL 15) of *P. monodon* were nursery reared for 10 days and stocked @ 5 and 18 / m^2, respectively in the modified extensive and semi intensive farms respectively.

Six long arm aerators (motor 5 H.P.) having 16 paddle wheels on each side was provided in all the ponds of both the farms. A good quality (32% protein) commercial feed (CP Aquaculture India) was given 4 times (6 am, 11 am, 5 pm, 10 pm) by broad casting from a boat as per the feeding schedule of the manufacture (Table 2). Check trays were used to monitor feed consumption after two hours of feed application. Vitamin C was given daily @ 1 g/kg feed and a commercial feed probiotic (Super biotic) @ 20 g /kg feed was provided every fortnight through feed by mixing with binders (banana juice).

Table 2. Feeding programme followed in modified extensive and semi intensive farm

Age (day)	Feed increase/ day (g)	Feed/day for 1 lakh PL (kg)	Size of feed (mm)
1	-	2	0.42
2-10	400	2.4-5.6	0.89
11-30	600	6.2-17.6	0.89 -1.41
31-50	500	18.1 -27.6	1.41-3.5
50-120	500	27.6	3.5

Bioremediators such as Nitrobactor suspension @ 250 ml/ha were used weekly. Zeolite was applied @ 40 kg/ha whenever the ammonia levels were high. Zero percentage water exchange was adopted in the farms except a fourty percent water exchange was done after 90 days of culture using pre-chlorinated water from the reservoir pond in order to avoid excessive algal growth.

The physico-chemical parameters such as transparency (cm), temperature (^{0}C), pH, dissolved oxygen (ppm), salinity (ppt) and total alkalinity of grow out ponds were analysed at weekly interval following standard methods (APHA, 1998). Ammonia nitrogen levels were analysed at 10 days intervals spectrophotometrically (Thermo Spectra, USA) following standard procedures (APHA, 1998). Soil quality parameters such as organic matter (Walkley and Black, 1934) pH (pH meter - ELICO, PE 131, India) and total nitrogen (FAO, 1970) were analysed once in a month.

To evaluate the growth, 40 individual prawns were sampled weekly from 40th day of culture using a cast net. Weight of the shrimps was measured using a top loading balance with an accuracy of 0.1 g. The specific growth rate of the shrimps were calculated according to standard formula (De Silva and Anderson, 1995).

After 103 days of culture, harvesting initiated in modified extensive farm and in semi-intensive farms, harvesting started after 110 days by completely draining the ponds. Total production and survival in each pond were also assessed at the time of harvest. Total feed consumed and the FCR of each pond were calculated according to the feeding rates. Statistical analysis was carried out using MS Excel.

Results

The results of physico-chemical parameters of water are given in Table 3. Salinity range of the modified extensive farm was 2 to 7 ppt and that of semi-intensive farm 2 to 3 ppt. Temperature (20-26^{0}C) was lower in both the farms.

Table 3. Water quality parameters of the culture systems*

	ME	SE	ME	SE	ME	SE	ME	SE	ME	SE	ME	SE
Month	Transparency (cm)		Temperature (0C)		pH		Dissolved oxygen (ppm)		Salinity (ppt)		Total alkalinity	
1st	26 ± 2	25 ± 2	23 ± 3	23 ± 3	8.1	8.2	8.2 ± 2	7.6±1	6±1	2±0.8	124±11	118±20
2nd	22 ± 2	23 ± 3	22± 2	22 ± 3	8.5	8.1	8 ±1	8.1±1	5± 1	2±0.6	102±18	126±18
3rd	21± 2	22 ± 2	23 ± 2	23 ± 2	8.2	8.2	8.1±1	8.9±1	4± 2	2±0.8	116±14	108±12
4th	22± 2	22 ± 2	23 ± 2	23 ± 2	8.1	8.2	8.3±1	8.6±1	4± 2	2±0.6	104±10	112±16

* Average for every month is provided along with standard error between ponds (ME- Modified extensive; SE- Semi-intensive)

Transparency, dissolved oxygen, pH and total alkalinity were in the optimum range.

Variation in the level of ammonia - nitrogen in each farm is depicted in Fig. 1. Ammonia level was found to increase as the culture progressed. Ammonia level was always higher in the semi-intensive farm compared to the modified extensive farm. Organic load accumulation (Fig. 2) indicates that the organic matter content in soil increased at the pond bottom as the culture progressed. It differs significantly during the last month ($p<0.05$). Total soil nitrogen content also exhibited similar trend (Fig. 3).

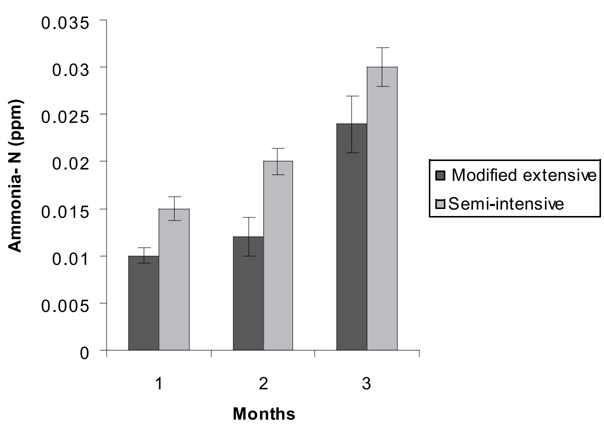

Fig. 1. Variation in ammonia nitrogen in water from different farming systems

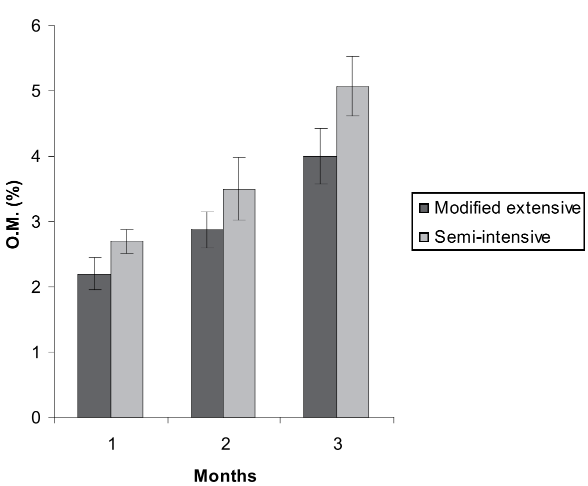

Fig. 2. Variation in soil organic matter content in different farming systems

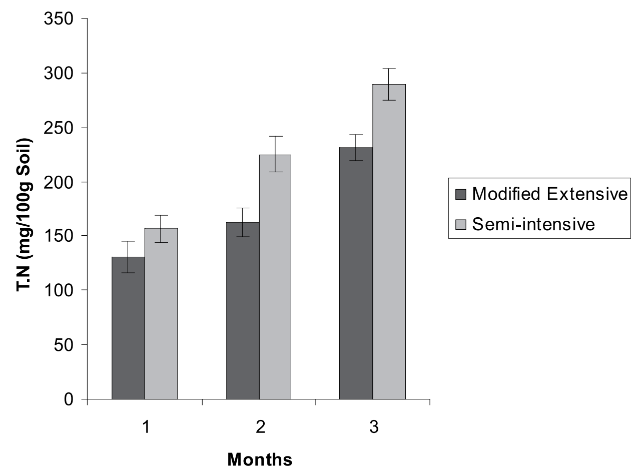

Fig. 3. Variation in total soil nitrogen content in different farming systems

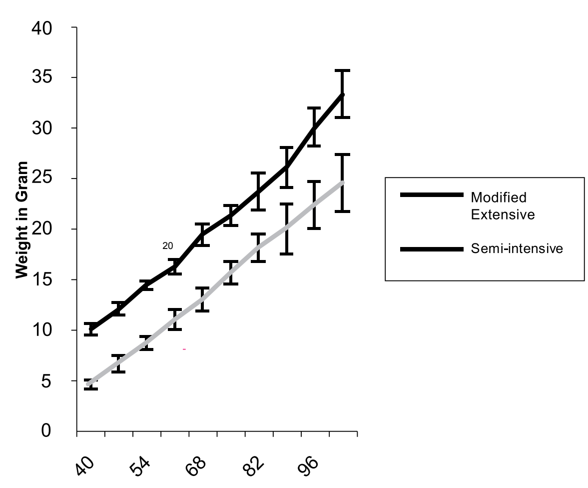

Fig. 4. Weight gain in shrimps in different farming systems

Table 4. Growth performance of shrimps in modified extensive and semi-intensive farm

	Modified extensive			Semi-intensive		
Days of culture	Range of weight of individual prawns	Average weight (g)	Specific growth rate	Range of weight of individual prawns	Average weight (g)	Specific growth rate
40	8 - 11	10.1	-	4-5	4.59	-
47	9-14	12.13	2.61	4-7	6.7	5.4
54	12-17	14.45	2.5	6-10	8.78	3.86
61	14-19	16.32	1.73	9-14	11.09	3.33
68	16-20	19.5	2.54	11-15	13.1	2.37
75	19-23	21.35	1.29	12-18	15.72	2.6
82	20-24	23.72	1.50	16-20	18.22	2.1
89	23-28	26.09	1.36	18-23	20.01	1.33
96	27-34	30.12	2.05	20-24	22.4	1.61
103	30-35	33.34	1.45	22-27	24.58	1.32
109	34-37	35.6	1.09	24-28	26.12	1.01

The average growth rate of individual prawn is shown in Fig. 4 and the average specific growth rate of shrimp in each farm is given in Table 4. Shrimps of modified extensive farms showed higher growth rates compared to that of semi-intensive farm. The average body weight of shrimps at 109th day of culture was 35.6 ± 1.38 g and, 26.12 ± 1.08 g respectively for modified extensive and semi-intensive farms respectively.

The final harvest details of the farms are given in Table 5. The culture period was almost uniform in all the farming systems ranging from 103 to 115 days even though the final harvest date varied for farm to farm according to the convenience of the farmer and the market price. Total production (t/ha/crop) was found to be three times higher in the semi-intensive farm (4.2 ± 0.06) than the modified extensive farm (1.38 ± 0.02).

Table 5. Details of final harvest for each farming systems

	Modified extensive	Semi intensive
Stocking density	5 / m2	18 / m2
Culture period (days)	105 ± 2.72	112 ± 1.84
Total production	1.38 ± 0.02	4.2 ± 0.06
(t/ha/crop)		
FCR	1.35 ± 0.04	1.4 ± 0.04
Survival (%)	76 ± 1.23	87.3 ± 2.02
Harvest size (g)	35 ± 1.62	28 ± 2.18

Discussion

The present study aims to compare the productivity and environmental impact of farming practices of *P. monodon* in low saline (> 10 ppt) conditions in AP. The recommended salinity range for culture for *P. monodon* was reported to be 10-35 ppt (Muthu, 1980; Karthikeyan, 1994). But the recent studies indicate that *P. monodon* can be cultivated in low saline conditions also (Abraham and Sasmal, 2009; Manik, *et al*., 1978). Manik *et al*. (1978) reported that growth of *P. monodon* is positive even in low saline conditions. Abraham and Sasmal (2009) reported uniform productivity among low saline (4-9 ppt) medium saline (9-15 ppt) and high saline (15-26 ppt) shrimp farms, even though longer culture period could be adapted in low saline and medium saline ponds to attain shrimps with harvestable size.

The results of physico-chemical parameters of water such as transparency, total alkalinity and pH were found to be in conducive range in all the culture systems throughout the culture period. Since the culture was carried out in the winter season the average temperature was found to be lower than the optimum range (25-30 ^{0}C) given by Boyd and Arlow (1992). The temperature was not varying much in the ponds due to the continuous operation of aerators. The optimum range of pH was reported as 6.6 - 8.5 (Tsai, 1990). Dissolved oxygen values were well above the minimum requirement of 3.5 ppm for shrimp farming (Boyd and Arlow, 1992; Gicos, 1993).

The maximum acceptable level of ammonia by *P. monodon* is 0.21 ppm (Allan *et al*., 1990). In both the culture systems NH_3-N range was found to be less than this toxic level but the ammonia level was found to be increasing as the culture progressed. Ammonia level was always higher in the semi-intensive farm compared to the modified extensive farm. Soil pH was found to be slightly alkaline ranging from 7.6 to 7.8

in all the culture systems throughout the culture period and is favorable for the growth of tiger shrimp (Das *et al.*, 2001). Organic matter content and total soil nitrogen content in the pond bottom has shown an increasing tendency, as the culture progressed. This may be due to the accumulation of residual feed and metabolites of shrimp at the pond bottom (Das *et al.*, 2001).

The accumulation of ammonia and organic content is maximum in semi-intensive farm and is minimum in modified extensive farm because of the excess feeding related to higher biomass in semi-intensive farms (Millamena, 1990). Accumulation of extra feed and other organic matter led to the enhancement of total organic load, total soil nitrogen and ammonia- nitrogen level in semi-intensive farm. Feed is the major contributor for organic load in shrimp farms and the increase in level of total nitrogen in intensive shrimp farms is a common phenomenon (Boyd, 1992). Martin *et al*. (1998) reported that 38% of the total organic nitrogen input in a shrimp pond is accumulated at the pond bottom. Several authors reported that there is an association between the input of feed in aquaculture ponds and the accumulation of organic matter (Avnimelech and Lacher, 1979; Avnimelech and Ritvo, 2003).

Shrimps of modified extensive farms excel in growth compared to the other system. The weekly growth rate has shown significant differences ($p<0.05$) towards the end of culture period. The better growth performance in modified extensive farm could be due to the minimal biomass (stocking density) available in the ponds. Even though the management practices in semi-intensive farm followed was also same as that of modified extensive, the individual growth was less and could be attributed to the overcrowding of shrimps due to higher stocking densities in semi-intensive farm. Previous studies of Apud *et al*. (1986), Maguire and Leedow (1993) and Corre (1993) also indicate that as the stocking density increases total production may increase but the individual growth of shrimp decreases.

Total production among the culture systems was maximum in the semi-intensive farm due to the higher stocking rate. Shrimp production in semi-initensive farm was found to be three times higher than that of the modified extensive farm. Gicos (1993) also reported similar variations in total production from Philippines in different farming systems such as traditional, extensive, semi-intensive and intensive farming systems. Yields equivalent to 5 t/ha/year from Thailand (Kunguankij *et al*., 1976) and 10 t/ha/year from Taiwan (Liao, 1977) were reported with proper feeding and aeration strategies. In the present study the FCR was found to be almost similar in both semi-intensive and modified extensive farms. Similar value for FCR was also reported in South East Asian countries in shrimp farms (Corre, 1993).

Considering the factors such as less organic load accumulation, better growth rate of individual prawn, optimum FCR and higher survival rates, modified extensive culture practices are much more eco-friendly and sustainable than that of semi-intensive farm even though the production is higher in the latter. These results positively indicate the need for the adoption of moderate stocking density and use of good management practice for the protection of environmental and economic sustenance of shrimp farming in India. This can be achieved by standardizing the optimum stocking rates, optimum feeding strategy and use of bioremediators for reducing organic load in the pond.

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References

Abraham, T. J. and D. Sasmal. 2009. Influence of salinity and management practices on the shrimp (*Penaeus monodon*) production and bacterial count of modified extensive brackishwater ponds. *Turk. J. Fish. Aquat. Sci.*, 9: 91-98.

Allan, G. L., G. B. Maguire and S. J. Hopkins. 1990. Acute and chronic toxicity of ammonia to *juvenile Metapenaeus macleayi* and *Penaeus monodon* and the influence of low dissolved oxygen levels. *Aquaculture*, 91: 265-280.

APHA. 1998. *Standard Methods for the Examination of Water and Waste Water. 19th edition. American Public Health Association and Water pollution Control Federation, Washington DC, USA*, 1328 pp.

Apud, F. D., K. Gonzalez and N. Deatras. 1986. Survival, growth and production of *P. Monodon* Fabricius at different stocking densities in earthen ponds with flow through systems and supplemental feeding. *Fish. Res. J. Philipp.*, 6(2): 1-9.

Avnimelech, Y. and M. Lacher. 1979. A tentative nutrient budget for intensive fish ponds. *Israeli J. Aquacult.*, 31: 3-8.

Avnimelech, Y. and G. Ritvo. 2003. Shrimp and fish pond soils: processes and management. *Aquaculture*, 220: 549-567.

Boyd, C. E. 1992. Shrimp bottom soil and sediment management. *In*: J. Wyban (Ed.), *Proc. of the Special Session on Shrimp Farming*, World Aquaculture Socity, Baton, Rounge, L, A. p. 166-181.

Boyd, C. E. and W. F. Arlow. 1992. Pond monitoring and management. In: A. W. Fast and A. G. Lester (Eds.) *Marine Shrimp culture: Principles and Practices*. Elsevier, Amsterdam. P. 36-42.

Chakraborti, R. K., D. D. Halder, N. K. Das, S. K. Mandal and M. L. Bhowmick. 1986. Growth of *penaeus monodon* Fabricius under different environmental conditions. *Aquaculture*, 51(3 & 4): 190-194.

Corre, V. 1993. The shrimp farming industry in Phillipines. *Proceedings of the Aquaculture Workshop for SEAFDEC/AQD Training Alumni*. SEAFDEC Aquaculture Department, Iloilo, Philippines. 173 pp.

Das, S. K., J. K. Sahoo and D. N. Saksena. 2001. Sediment characteristics and benthic biomass in relation to *P. monodon*. Fabricius in low saline confined pond. *Indian J. Fish.*, 48(1): 55-61.

De Silva, S. S. and T. A. Anderson. 1995. *Fish Nutrition in Aquaculture*. Chapman and Hall publishers, United Kingdom. 309 pp.

FAO, 1970. *Physical and Chemical Methods of Soil and Water Analysis.* FAO soil soils Bulletin No.10. Rome, Italy. P. 178-179.

Gicos, A. 1993. Shrimp grow out culture techniques in the Phillipines. *Proc. of the Aquaculture Workshop for SEAFDEC/AQD Training Alumni*. SEAFDEC Aquaculture Department, Iloilo, Philippines. 173 pp.

Karthikeyan, J. 1994. Aquaculture (shrimp farming) – its influence on environment. *Proc. on Our Environment, its Challenges to Development Projects"*. American Society of Civil Engineers and Jadavpur University, Calcutta. P. 1-7.

Kunguankij, P., B. Sirikul and K. Chotiyapotta. 1976. On the monoculture of jumbo shrimp (*P. monodon* Fabricius). *Phuket- Mar. Fi*sh. Stn., 7: 10 pp. (Mimeo).

Liao, I. C. 1977. A culture study on grass prawn *Penaeus monodon* in Taiwan: The patterns, the problems and prospects. *J. Fish. Soc. Taiwa*., 5(2): 11-29.

Maguire, G. B. and M. Leedow. 1993. A study of the optimum stocking density and feeding rates for school prawns *Metapenaeus macleayi* (Haswell) in some Australian brackish water farming ponds. *Aquaculture*, 30: 285-297.

Manik, R., R. Kahar and B. Tiensogrusmee. 1978. The culture of shrimp, *Penaeus monodon* in low saline pond. *Bull. Brackishwat. Aquacult. Dev. Cent*., 4(1&2): 288-292.

Martin, J. M., Y. Veran, O. Guerlorguet and D. Pham. 1998. Shrimp rearing: stocking density, growth, impact on sediment, waste output and their relationships studied through the nitrogen budget in rearing ponds. *Aquaculture*, 164: 135-149.

Millamena, O. M. 1990. Organic pollution results from excess feed and metabolite build-up: Effect on *Penaeus monodon* post larvae. *Aquaculture*, 9: 143-150.

Muthu, M. S. 1980. Site selction and type of farms in coastal aquaculture of prawns. *Proceedings on Shrimp Farming*. The Marine Products Export Authority. Bombay, p. 97-106.

Navas, K. A. and M. J. Sebastian. 1989. Effect of salinities on the survival and growth of *Penaeus monodon* Fabricius. *Indian J. Fish*., 36(3): 257-261.

Tsai, C. K. 1990. Water quality management. In: D. M. Akiyama (Ed.), *Proc. of South East Asia Shrimp Farm Management Workshop*. American. Soyabean Association, Singapore. p. 56-63.

Walkley, A. and C. A. Black. 1934. Estimation of soil organic carbon by chronic acid liberation method. *Soil Sci*., 37: 29-38.