Effect of different stocking density on growth, survival on *Litopenaeus vannamei* (Boone, 1931) in summer and monsoon crop in province of Gujarat States in India

Kotiya A.S.[1*]; Vadher K.H.[1]

Received: September 2020 Accepted: April 2021

Abstract

A shrimp Pacific White shrimp, *Litopenaeus vannamei* growth performance study during summer (S) and monsoon (M) was taken up for 120 days. The stocking density was 30, 40, 50, 60, 70 and 80pc/m^2 in six different treatments with three replicate. Experiment was conducted in 18 commercial culture pond having 0.5 ha size. The initial average body weight of shrimp post larvae during summer and monsoon crop at stocking was 0.06±0.01g and 0.06±0.04g, respectively. The data revealed significant (p<0.05) difference in mean growth during summer and monsoon crop at different stocking densities with individual final weights of 26.08±0.05 followed by 23.84±0.27, 19.94±0.07, 18.24±0.43, 16.92±0.23 and 14.61±0.49g and yields of 3721.5±68.4, 4440.5±125.1, 4548.05±56.9, 4948.4±96.4, 5064.8±82.1 and 4792.4±211.4 kg/pond at 30, 40, 50, 60, 70 and 80 shrimp/m^2, respectively. In contrast, there were statistically significant differences in mean growth and final yields during the monsoon crop. Final mean weights were 34.46±0.24 followed by 31.2±0.31, 28.46±0.12, 25.89±0.35, 20.86±0.11 and 18.20±0.42 g and yields were 5091.6±57.6 followed by 6143.6±67.15, 7457.6±100.9, 7905.06±283.2, 7799.2±277.3 and 7292.6±165.1 kg/pond at 30, 40, 50, 60, 70 and 80 shrimp/m^2, respectively. Better performance of shrimp was recorded in monsoon crop, average water temperatures was 26.17±0.15°C with compare to summer 29.86±0.11°C with low production. Larger shrimp were associated with lower stocking density in both the season while higher stocking density @70 shrimp/m^2 (summer crop) and 60 shrimp/m^2 (monsoon) produced higher yields.

Keywords: Growth, Survival, Shrimp, Crop, FCR and SGR

[DOI: 10.18331/SFS2021.7.3.7]

1- Department of Aquaculture, College of Fisheries Science, Junagadh Agricultural University, Veraval, Gujarat, India.

*Corresponding autor's Email: askotia@jau.in

Introduction

Aquaculture solely covers cultivation of aquatic plants (seaweed) and culture, rearing and fattening of aquatic animals, especially fish, shellfish in natural confined marine or freshwater environmental condition for food production Ayyat *et al.* (2011). The shrimp species like *Litopenaeus vannamei* shrimp can sustain in higher temperature or has an ability to maintain osmotic regulation over wide range of salinities ranging from 0.5 to 40ppt (Saoud *et al.*, 2003) is a best candidate species for shrimp aquaculture and most widely reared penaeid in the Western hemisphere (Saoud *et al.*, 2003). *L.vannamei* shrimp can be successfully reared at salinities of 5 to 35ppt (Ponce-Palafox *et al.*, 1997), ideal salinity for rearing this species is 15 to 25‰ (Boyd, 1989). Asia contributes more than 90% to the world's aquaculture production. Asia inland aquaculture production with 4.77 MT, from the total, crustaceans like shrimps, crayfish and crabs contribute 0.29 MT (FAO, 2018). India now takes the second position with regard to annual fisheries and aquaculture production, only after China (Jelte de Jong, 2017) and contributes to about 7.3% portion of the global aquaculture production (Vijayan *et al.,* 2017) and 5% of global fish trade (FAO, 2017) with 41,48,407 (10.0%) tonnes next to China 248,17,311 (60.1%) (FAO, 2016), export earnings from the sector has registered at 30,420.83 crore Indian Rupees (INR) during 2015-16 (US$ 4.69 billion) FAO (2017), providing directly or indirectly livelihood security to around 14.5 million people, dependent on fisheries and aquaculture (Kumar *et al.*, 2015).

Fish and shellfishes are accepted universally as arich source of complete diet for millions. Shrimps are called the “Pinkish Gold” of the sea because of its universal demand, unique taste, high unit value realization and increasing demand in the world market (Doan van bay, 2011), shrimp culture is one of the significantly immersing industry and foreign exchange earner through export. Shrimps *L.vannamei* was introduced in 2009 and is the major contributor to the overall aquaculture production in the country, is the candidate species of Indian shrimp farming Giri (2016). The yield from aquaculture is steadily growing @ 8% year^{-1}, and is faster than any other animal protein production source since the 1970s (Diana *et al.*, 2013). In aquaculture sector, Shrimp farming is one of the most profitable and fast growing in significantly reduce days of culture, of the aquaculture industry (Tacon, 1990) and hence the major% of brackish water fish growers preferred penaeid shrimp species, constructing vast land area devoted to shrimp farming (Martínez-Porchas *et al.,* 2010) occupying fifth position amongst the major shrimp farming countries in the world DAHDF (2016).

Almost all farming sector, for increasing bulk productionresulting in increasing stocking density that depends upon varieties and quality of

[DOI: 10.18331/SFS2021.7.3.7]

shrimp species (Sugathan *et al.,*2014) ultimately increase in feed input usually increases the deterioration of pond sediments (Blackburn *et al.,* 1988; Garnier and Barillier, 1991; Ray and Chien, 1992) and water quality. Optimum stocking density based on pond carrying is necessary for shrimp culture system, for maintaining a positivecorrelation between density and growth rate and achieve maximum biomass with minimum incidence ofphysiological and behavioral disorders (Ayyat *et al.,* 2011). Stocking density is inversely proportional to shrimp growth and is one of the most important factors in shrimp culture, high stocking density can affect growth and survival of shrimp due to stress response induced by crowding (Mena-Herrera *et al.,* 2006), intensify pressure on natural food resources (Hopkins *et al.,* 1988; Allan and Maguire, 1992b), reduces metabolism and food conversion efficiency (Sandifier *et al.,*1987; Martin *et al.,* 1998), and rises in total feed costs (New, 1987).

Coastal Aquaculture Authority (CAA) had approved and certified and permitted *L.vannamei* culture in the States of Andhra Pradesh, Tamil Nadu, Maharashtra, Gujarat, Orissa, Goa and UnionTerritories of Diu and Pondicherry. In Gujarat, shrimp farming is a fast growing industry. The *L.vannamei* farming initiated with 107 farms covering total1, 745 ha area in 2009, in 2014 rose to 1,037 farms in total 9, 951.12 ha. having the potential area available for this industry is 376,000 ha FAO (2016).

There is very limited research workswere done on the culture and growth performance of *L. vannamei* with different stockingdensities during summer and monsoon crop. So the present study was taken up, to evaluate thewater quality parameters, survival, and growth of *L. vannamei* culture in the different culturefarms with different stocking densities.

Materials and methods

The present study was under taken at commercial shrimp farms located at Datardi village, Dist: Amreli, Experiments was carried out at commercial shrimp farm, Datardi village, Taluka: Rajula, Dist: Amreli, Gujarat, India. (Latitude 20º 57’35.38” N and 71º 32’35.60” E and Longitude 20º 57’35.93” N and 71º 32’32.03” E) (Plate 1). There were total 22 nos of ponds in the farm out of this 18 were culture ponds and 2 were sedimentation ponds and 2 were reservoirs. The size of the culture pond was 0.50 ha, sedimentation pond was 0.6 ha and reservoir pond was 0.8 ha. 18 culture ponds were selected for experiment in summer and monsoon season during year as per experimental design (Plate 1).The availability of seawater was taken up through gravitational flow during high tide and wise versa. Two 10 HP Kirloskar motor pump, seawater was lifted from reservoir to feeder channel. Each pond is set with two inlet pipes (6” dia). Ponds were filled with seawater by inlet pipes, all the culture ponds were (1.7-1.8 m deep). The soil type was sandy clay. The minimum

[DOI: 10.18331/SFS2021.7.3.7]

water level in each pond was 1.5 m were around 3 to 5% of seawater was refilled against seepage and evaporation, the pond shape is rectangular.

Plate 1: Geographical location of Kavya Aqua Farm, Datardi, Tal: Rajula, Dist: Amreli.

Procurement of Litopenaeus vannamei seed

The shrimp, *Litopenaeus vannamei* post larvae (PL 09) were procured from commercial shrimp hatchery Blue Sea alliance Hatchery (Simar village). Post larvae were packed in oxygenated polythene bags and brought to Kavya Aqua Farm at Datardi. *L. vannamei* seeds were PCR tested. The PL was acclimatized in the farm with adequate aeration. The initial average weight of Post larvae was 0.06±0.01 (summer) and 0.06±0.02 (monsoon crop). The *L. vannamei* seeds were acclimated to a salinity level of 35ppt and confirmed negative for the white spot syndrome virus (WSSV) by the polymerase chain reaction. Each seeds were purchased Rs.0.55 paisa. The seed were brought to the farm site and bags were reserved in the pond water for some time to adjust the temperature. Then pond water was added gradually into the seed bag to regulate the salinity and pH subsequently the seed were released slowly in to the ponds, water level of the pond around 1.5-1.6 m, due to summer season.

Experimental design and experimental site

A complete randomized design (CRD) was employed in the present investigation. “S” represent summer crop and “M” represent monsoon crop. Other details are as under: No. of replication: Three ponds were stocked with *L. vannamei* post larvae

Treatment detail

T1= stocking density @30 nos/m^2,
T2= stocking density @40 nos/m^2,
T3= stocking density @50 nos/m^2,
T4= stocking density @60 nos/m^2,
T5= stocking density @70 nos/m^2,
T6= stocking density @80 nos/m^2.

[DOI: 10.18331/SFS2021.7.3.7]

Survival (%) was calculated at the end of harvest. Grobest feed pellets were fed to the stocked post larvae from 1st day onward with twice a day (for ten days), thrice a day (for fifteen days) and for four times daily at 7am,10am, 3pm and 9pm respectively till the end of crop.

Pond preparation, bio-secured method and water culture techniques followed as per (Gunalan *et al.,* 2011). Paddle wheel aerators were used and check trays were maintained from 30 days onwards to 120 days of culture. Sampling was taken by cast net operation at every fortnight interval after 30th days culture (DOC), sampling helps to identify and monitor shrimp heath, diseases identification and growth. The water level was measured by using a standard scale with cm marking at the centre of the ponds.

During harvest all the water from culture ponds drained to sedimentation pond and ultimately released to open creek. The water quality parameters like salinity, pH, temperature, dissolved oxygen and light transparency were measured by using hand Refractometer, pH pen, thermometer, and dissolved oxygen meter and secchi disc, respectively. Aeration was given to the entire culture period for all ponds. Totally 14 hp aerator (each of 2hp) was fixed for each culture pond. The aerators were placed in such a way that it could dissolve maximum dissolved oxygen (DO) into the pond water and makes the culture environment friendly.

Growth monitoring and sampling

Sampling was done at intervals of 15 days to estimate the body weight of shrimps. Shrimps were weighed using analytical balance to assess growth performance.

Mean weight gain

The average weight gain was calculated according to Ching Shan and Lo- Chai (1990) using the following formula:

Weight gain (g)=Final weight (g)-Initial weight (g)

Specific growth rate (SGR)

SGR (specific growth rate) as percentage was calculated according to Ching Shan and Lo- Chai (1990) using the formula given below.

$$\text{SGR}(\%) = \frac{\text{W2 - W1}}{T_2\text{-}T_1} \text{ x } 100$$

Where,

T_2-T_1= Duration of the days (T_1= 0 day and T_2= 120th day)

W2= weight of fish at time T2,

W1 = weight of fish at time T1

Food conversion ratio (FCR)

The FCR (Food Conversation Ratio) was calculated according to El- Sayed (1999) using following formula:

$$\text{FCR}=\frac{\text{Amount of feed intake (g)}}{\text{Wet weight gain (g)}}$$

Protein efficiency ratio (PER)

Protein efficiency ratio is a measure of utilization of dietary protein. PER was calculated using the below given formula as per El- Sayed (1999).

$$\text{PER} = \frac{\text{Increment in body weight (g)}}{\text{Protein intake (g)}}$$

Average daily growth (ADG) (g)

[DOI: 10.18331/SFS2021.7.3.7]

Total 30 numbers of the *L. vannamei* were randomly selected during shrimp sampling collected by operating a cast net in the pond. The captured shrimps were weighted with electronic balance and average daily growth was calculated by the formula given by Chanratchakool *et al.* (1998) is as follows:

ADG (g) = (Present Weight (g) – Previous weight (g))/ No. of days

Survival (%)

The survival was estimated according to Ching Shan and Lo- Chai (1990) using the formula.

$$\text{Survival (\%)} = \frac{\text{No. of shrimp survived after rearing}}{\text{No. of shrimp stocked}} \times 100$$

The Physical- chemical parameters such as temperature, pH, dissolved oxygen, salinity, alkalinity, turbidity and ammonia was measured daily at morning 6am and analyzed at ten days intervals. Temperature ºC and pH was measured using multiparameter PCSTestrTM 35 (Eutech, USA), salinity was measured by using hand refractometer (Erma, Japan), Dissolved oxygen was measured by digital dissolved oxygen meter (Extech instruments, Taiwan), alkalinity was estimated by alkalinity test kit (Merck, Germany), turbidity was estimated by Sachhi-disc (Boyd, 1990) and ammonia was estimated by ammonia test kit (Merck, Germany).

Statistical analysis

Significance of variations in the water quality and growth parameters will be tested by using one way analysis of variance, (ANOVA) test. All data presented are expressed as means±standard deviation and was subjected to One Way Analysis of Variance (ANOVA). Significance difference between means was determined using Duncan's multiple-range test (DMRT). The level of significance was set up at $p \leq 0.05$.
)

Result

Effect of different stocking density on weight gain, average daily growth (ADG), specific growth rate (SGR), food conversion ratio (FCR), protein efficiency ratio (PER) in all the six treatments was measured for both the seasons.

Growth of L. vannamei in summer and monsoon crop

The growth of *L. vannamei* was measured at fortnight interval for 120 days in summer and monsoon crop. Few animals from each pond were collected by cast net and average body weight was calculated at each fortnight interval. Average daily growth (ADG), specific growth rate (SGR), food conversion ratio (FCR), protein efficiency ratio (PER) in all the six treatments were measured for both the seasons at the end of experiment. The initial weight of post larvae (PL) was 0.06 g±0.01 in all the treatments during stocking.

Mean weight gain

Initial weight (g) of *L. Vannamei* shrimp was Non significant (p<0.05) in both the crop, after 120 days of culture,

[DOI: 10.18331/SFS2021.7.3.7]

the result signifies among the treatment. There was significant difference among the treatments (p<0.05).

The highest weight gain was found in ST1 (26.1±0.04) followed by (23.9±0.26), (20.0±0.06) (18.30±0.43) (16.98±0.23) and low growth (g) was with (14.66±0.48) in the treatment all ST2, ST3, ST4, ST5, and ST6 respectively (Table 1). With respect to avg. wet weight gain(g), ST1 significantly differed from ST4, ST5, ST6, whereas ST2 and ST3 were not significantly different (p<0.05) among the treatment. Avg. wet weight gain (g) as observed in the respective treatment is shown graphically in (Fig. 1).

Table 1: The average total weight gain (g) (± S.E) of L. vannamei shrimp at fortnight intervals in earthen shrimp pond during summer crop

DOC	ST1	ST2	ST3	ST4	ST5	ST6
0	0.06±0.01[a]	0.06±0.01[a]	0.06±0.01[a]	0.06±0.01[a]	0.06±0.01[a]	0.06±0.01[a]
15	2.41±0.09[ab]	2.95±0.06[a]	1.90±0.06[b]	1.98±0.02[b]	2.02±0.03[b]	1.93±0.11[b]
30	4.36±0.11[ab]	4.74±0.03[a]	3.74±0.06[b]	3.87±0.08[b]	3.96±0.03[b]	3.77±0.18[b]
45	6.65±0.08[ab]	6.71±0.14[a]	5.58±0.11[c]	5.79±0.11[bc]	5.92±0.05[abc]	5.65±0.29[c]
60	9.68±0.08[a]	9.39±0.20[ab]	8.04±0.31[bc]	8.08±0.45[bc]	8.20±0.04[bc]	7.89±0.25[c]
75	13.2±0.06[a]	12.46±0.16[ab]	10.83±0.37[abc]	10.66±0.48[bc]	10.26±0.02[bc]	9.48±0.36[c]
90	17.2±0.21[a]	15.87±0.20[ab]	13.63±0.39[bc]	13.25±0.52[bc]	12.86±0.14[bc]	11.6±0.59[c]
105	21.7±0.06[a]	20.04±0.13[ab]	16.83±0.24[abc]	15.86±0.47[bc]	14.9±0.18[bc]	13.02±0.52[c]
120	26.1±0.04[a]	23.9±0.26[ab]	20.0±0.06[abc]	18.30±0.43[bc]	16.98±0.23[bc]	14.66±0.48[c]

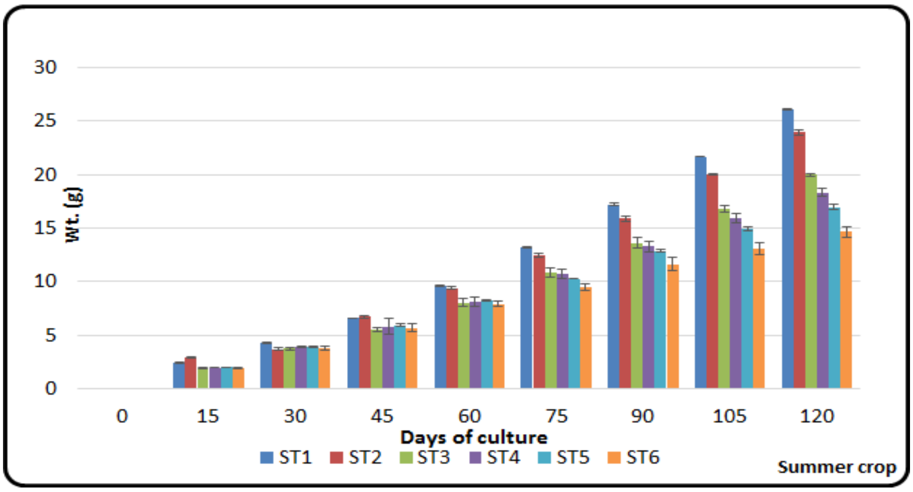


Figure 1: Effect of different stocking densities of L.vannamei shrimp on growth performance during summer crp in grow out ponds (± S.E).

During monsoon crop, the highest weight gain was recorded in MT1 (34.5±0.25) followed by (31.3±0.31), (28.5±0.13), (25.95±0.35), (20.91±0.11) and low with (18.26±0.42) in treatment MT2,MT3, MT4, MT5 and MT6, respectively. MT1 was significantly differ from MT5 and MT6, whereas MT2, MT3 and MT4 were not signficantly different (p<0.05) among all the treatment (Fig. 1).

[DOI: 10.18331/SFS2021.7.3.7]

SGR

The highest SGR and ADG recorded during summer crop was recorded in ST1 (1.98±0.001), followed by (1.87±0.003), (1.79±0.002), (1.79±0.007) , (1.42±0.004) and lowest was recorded in treatment ST6 (1.17±0.01) during the at 120 days of culture. Statistical analysis revealed that all treatment was significant (p<0.05) differen between the treatment. The SGR of cultured data revealed that, ST1 was significantly higher than all other treatment (Table 2 and Fig. 2) whereas during monsoon crop, the highest SGR was noted in MT1 (2.94±0.006) followed by (2.86±0.008), (2.79±0.003), (2.71±0.01), (2.53±0.004) and low with (2.41±0.01) in treatment MT2, MT3, MT4,MT5 and MT6 rspectively. The highest avg. growth (g) increment was recorded in low stocking density ST1 and MT1 with 26.01± 0.04 and 34.44±0.25 respectively followed by all other treatment (Tables 3 and 4).

Table 2: The average total weight gain (g) (± S.E) of L. vannamei shrimp at fortnight intervals in earthen shrimp pond during monsoon crop

DOC	MT1	MT2	MT3	MT4	MT5	MT6
0	0.06±0.02[a]	0.06±0.02[a]	0.06±0.02[a]	0.06±0.02[a]	0.06±0.02[a]	0.06±0.02[a]
15	2.4±0.09[ab]	2.79±0.08[a]	2.96±0.07[a]	1.89±0.01[ab]	1.51±0.03[b]	1.49±0.06[b]
30	4.78±0.09[a]	4.60±0.17[a]	4.85±0.12[a]	3.56±0.02[ab]	3.04±0.04[b]	2.85±0.05[b]
45	9.36±0.04[a]	8.87±0.18[a]	9.17±0.08[a]	7.33±0.04[ab]	6.33±0.12[b]	6.08±0.09[b]
60	14.0±0.15[a]	13.1±0.16[ab]	13.47±0.10[a]	11.29±0.12[abc]	10.39±0.03[bc]	9.84±0.21[c]
75	19.1±0.10[a]	18.1±0.37[ab]	17.72±0.21[ab]	16.20±0.26[abc]	14.13±0.13[bc]	13.04±0.09[c]
90	23.7±0.10[a]	22.3±0.26[ab]	21.25±0.12[abc]	19.28±0.31[abc]	16.5±0.11[bc]	15.19±0.32[c]
105	29.4±0.03[a]	27.1±0.08[ab]	24.82±0.21[abc]	22.29±0.15[abc]	18.59±0.11[bc]	16.65±0.29[c]
120	34.5±0.25[a]	31.3±0.31[ab]	28.5±0.13[abc]	25.95±0.35[abc]	20.91±0.11[bc]	18.26±0.42[c]

(Within Mean ± SE column with different superscript letters in all treatments are statistically significant (One way ANOVA; p<0.05 and subsequently Post Hoc Test).

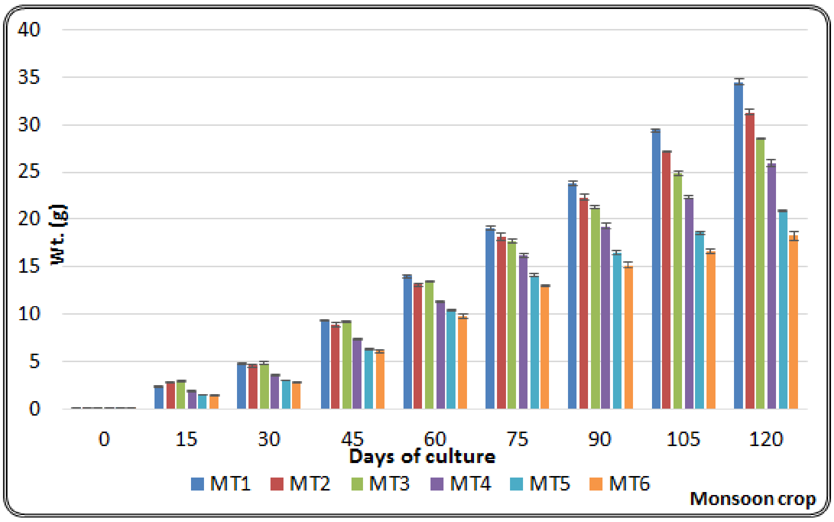


Figure 2: Effect of different stocking densities of *L.vannamei* shrimp on growth performance during monsoon crop in grow out ponds (± S.E).

[DOI: 10.18331/SFS2021.7.3.7]

ADG

Statistical analysis revealed that all treatment was significant (p<0.05) differen between the treatment. The ADG (summer crop) of cultured data revealed that, ST1 was significantly higher than all other treatment. (Tables 3 and 4; Fig. 3) whereas during monsoon crop, the highest ADG was noted in MT1 (0.29±0.011) followed by (0.26±0.01), (0.240.01), (0.24±0.01), (0.15±0.00) and low with (0.15±0.01) in treatment MT2, MT3, MT4,MT5 and MT6 rspectively (Tables 3 snd 4; Fig. 4).

Table 3: Effect of different stocking densities on growth performance (g) of L vannamei shrimp reared during summer crop in earthen grow out ponds at 120 DOC.

Items	Stocking density of shrimp (NOS/M^2)					
	ST1	ST2	ST3	ST4	ST5	ST6
Initial weight (g)	0.06±0.01	0.06±0.01	0.06±0.01	0.06±0.01	0.06±0.01	0.06±0.01
Final weight (g)	26.07±0.04^{a}	23.92±0.26^{ab}	20.0±0.06^{abc}	18.3±0.43^{bc}	16.9±0.23^{bc}	14.6±0.48^{c}
Weight gain (g/pc)	26.01±0.04^{a}	23.86± 0.26^{ab}	19.94±0.06^{abc}	18.24±0.43^{bc}	16.84±0.23^{bc}	14.54± 0.48^{c}
ADG (g/pcs/day)	0.22±0.006^{a}	0.20± 0.008^{ab}	0.17±0.013^{abc}	0.15±0.004^{bc}	0.14±0.003^{bc}	0.12±0.009^{c}
SGR (%/day)	1.98±0.001^{a}	1.87±0.003^{ab}	1.79±0.002^{abc}	1.79±0.007^{abc}	1.42±0.004^{bc}	1.17±0.01^{c}

(Within Mean ± SE column with different superscript letters in all treatments are statistically significant (One way ANOVA; p<0.05 and subsequently Post Hoc Test).

Table 4: Effect of different stocking densities on growth performance (g) of L vannamei shrimp reared during Monsoon crop in earthen grow out ponds at 120 DOC.

Items	Stocking density of shrimp (PCS/M^2)					
	MT1	MT2	MT3	MT4	MT5	MT6
Initial weight (g)	0.06±0.02	0.06±0.02	0.06±0.02	0.06±0.02	0.06±0.02	0.06±0.02
Final weight (g)	34.5±0.25^{a}	31.3±0.31^{ab}	28.5±0.13^{abc}	25.9±0.35^{abc}	20.9±0.11^{bc}	18.2±0.42^{c}
Weight gain (g/pc)	34.44±0.25^{a}	31.24±0.31^{ab}	28.44±0.13^{abc}	25.84±0.35^{abc}	20.84±018^{bc}	18.14±0.42^{c}
ADG (g/pcs/day)	0.29±0.011^{a}	0.26±0.01^{ab}	0.240.01^{abc}	0.24±0.01^{abc}	0.15±0.00^{bc}	0.15±0.01^{c}
SGR (%/day)	2.94±0.006^{a}	2.86±0.008^{ab}	2.79±0.003^{ab}	2.71±0.01^{abc}	2.53±0.004^{bc}	2.41±0.01^{c}

(Within Mean ± SE column with different superscript letters in all treatments are statistically significant (One way ANOVA; p<0.05 and subsequently Post Hoc Test).

[DOI: 10.18331/SFS2021.7.3.7]

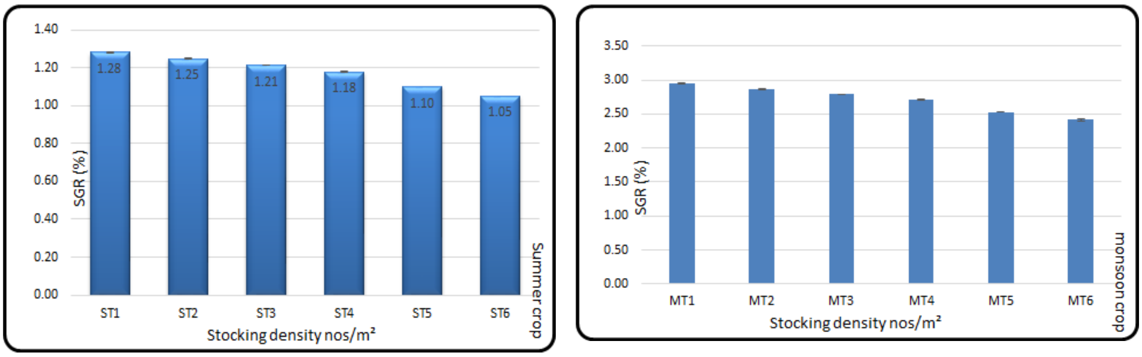


Figure 3: Effect of stocking densities on Specific Growth Rate (SGR %) performance of *L vannamei* shrimp reared during summer and monsoon crop in grow out ponds (± S.E).

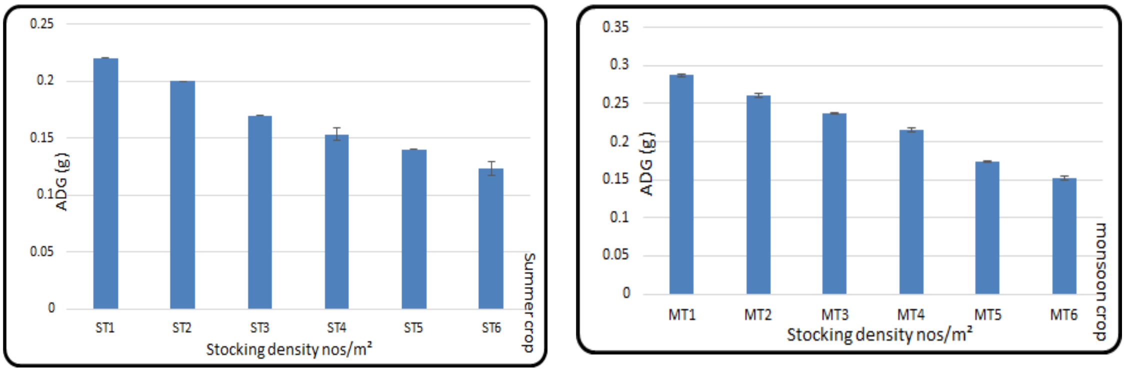


Figure 4: Effect of different stocking densities on Average Daily Ratio (ADG) of *Litopenaeus vannamei* in earthen grow out ponds during summer and monsoon crop (± S.E).

Survival%

The data for survival of *L. Vannmaei* shrimp in the respective treatment are detailed (Table 5). The highest survival rate during summer crop was found in ST1 (95.13±1.88%) followed by (92.8±2.81%), (90.93±3.42%), (89.93±3.82%), (85.23±5.62%) and low with (81.66±7.11%), in the treatment ST2, ST3, ST4, ST5, and ST6 respectively whereas during monsoon crop the dat revealed that low stocking density has higher survival% than all other treatment with MT1 (98.30±0.81%) followed by (98.03± 0.61%), (95.10±1.13%) (92.30± 2.62%) (89.00±2.75%) and lower during experiment duration was (86.10±2.49%). Statistical analysis of survival (%) was carried at the end of culture. There was significant difference among all the treatments (p<0.05) and in both the crop (Table 5 and Fig. 5).

FCR

Feed conversion ration indicate the quantum of feed consumed (kg) by the shrimp against the total biomass at end of shrimp cultured (kg). Maximum feed intake and higher FCR by cultured shrimp were during summer crop revealed that, almost all treatment were Non significant (p<0.05). The highest FCR at the end of crop, ST6 (1.51±0.08) followed by (1.46±0.10), (1.42±0.03), (1.34±0.05), (1.28±0.06), and low in (1.16±0.04) in ST5, ST4, ST3, ST2 and ST1 respectively whereas during monsoon crop the highest FCR

[DOI: 10.18331/SFS2021.7.3.7]

recorded was in treatment MT6 (1.42±0.03), followed by (1.35±0.08), (1.32±0.04), (1.28±0.05), (1.23±0.01), and low FCR in (1.13±0.01) in treatment MT5, MT4, MT3, MT2 and MT1 rspectively. With respect to FCR, MT1 significantly differed from MT6, whereas MT2, MT3, MT4 and MT5 were not significantly different (p<0.05) among the treatment (Fig. 6).

Table 5: Comparing the effect of different stocking densities on growth performance (g) of L vannamei shrimp reared during summer and monsoon crop in earthen grow out ponds.

Items		Stocking density of shrimp (NOS/M^2)					
		30	40	50	60	70	80
Yield (kg)	S	3721.57±68.54^{b}	4440.52±125.1^{ab}	5002.86±62.60^{ab}	5443.33±106.05^{ab}	6077.80±98.58^{a}	5559.25±245.2^{ab}
	M	5091.68±57.64^{b}	6143.64±67.15^{ab}	7457.60±100.55^{ab}	7905.05±283.28^{a}	7799.20±277.37^{a}	7292.65±165.11^{ab}
Total Feed used (kg)	S	4327.37±88.15^{a}	5688.49±430.7^{ab}	6721.90±312.2^{ab}	7731.92±343.4 ^{ab}	8880.04±781.6 ^{b}	8424.59±816.7 ^{b}
	M	5771.01±123.6^{a}	7563.55±184.1^{ab}	9545.24±398.17^{ab}	10452.52±35.11^{b}	10546.79±522.7^{b}	10353.90±267.4^{b}
Survival%	S	95.13 ± 1.88^{a}	92.8 ± 2.81^{ab}	90.93 ± 3.42^{ab}	89.93 ± 3.82^{ab}	85.23 ± 5.62^{ab}	81.66 ± 7.11^{b}
	M	98.30 ± 0.81^{a}	98.03 ± 0.61^{a}	95.10 ± 1.13^{ab}	92.30 ± 2.62^{ab}	89.00 ± 2.75^{ab}	86.10 ± 2.49^{b}
FCR	S	1.16±0.04^{a}	1.28±0.06^{a}	1.34 ± 0.05^{a}	1.42±0.03^{a}	1.46±0.10^{a}	1.51±0.08^{a}
	M	1.13±0.01^{a}	1.23±0.01^{ab}	1.28±0.05^{ab}	1.32±0.04^{ab}	1.35±0.08^{ab}	1.42±0.03^{b}

(Within Mean ± SE column with different superscript letters in all treatments are statistically significant (One way ANOVA; p<0.05 and subsequently Post Hoc Test).

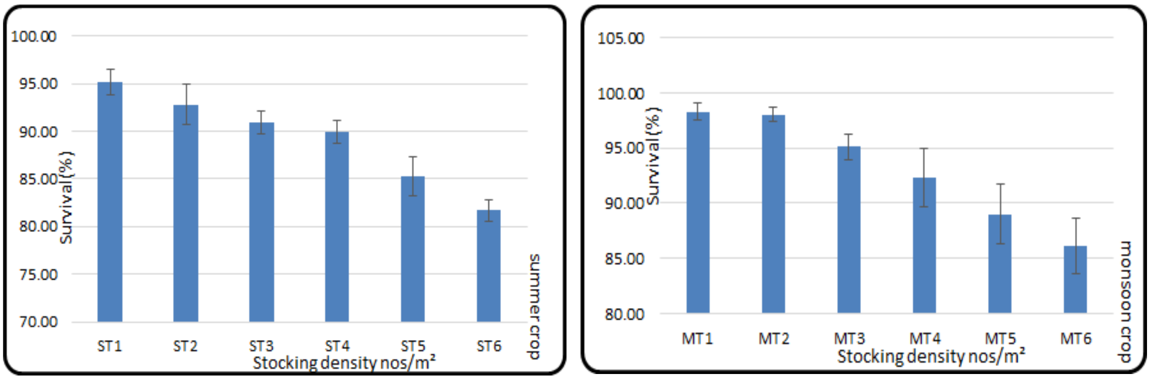


Figure 5: Effect of different stocking densities on Survival (%) of *L.vannamei* in earthen grow out ponds during summer and monsoon crop (± S.E).

Yield

From the yield (summer crop) data, it shows that the highest yield (kg) was obtained from treatment ST5 (6077.80±98.58) followed by (5559.25±245.2), (5443.33±106.05), (5002.86±62.60), (4440.52±125.1) and low in (3721.57±68.54) in the treatment ST6, ST4, ST3, ST2 and ST1, the same highest yield trend was followed during monsoon crop, MT5 (7799.20±277.37), MT4 (7905.05±283.28) treatment followed by MT3 (7457.60±100.55), MT6 (7292.65±165.11), MT2 (6143.64±67.15) and lowest yield in MT1 (5091.68±57.64). in both the season 60 and 70pc/m^2 significantly differed from 30pc/m^2 whereas all other treatment is at par. (Table 5 and Fig 7 to 10).

[DOI: 10.18331/SFS2021.7.3.7]

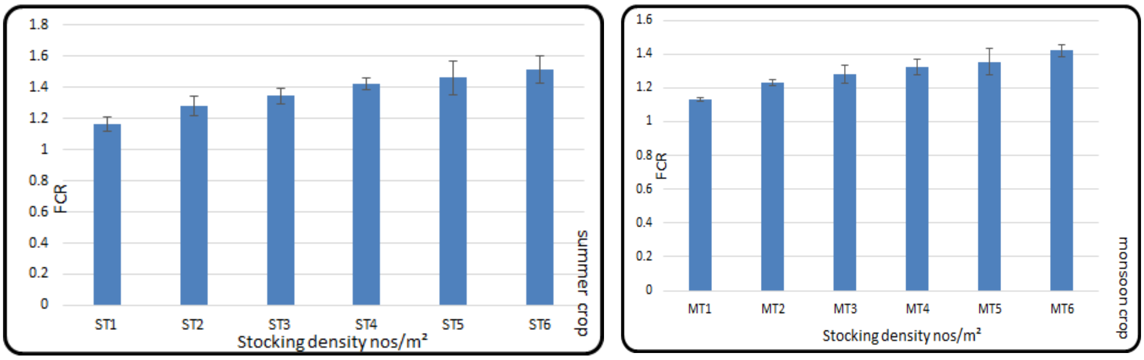


Figure 6: Effect of different stocking densities on Feed Conversion Ratio (FCR) of *L. vannamei* in grow out ponds during summer and monsoon crop (± S.E).

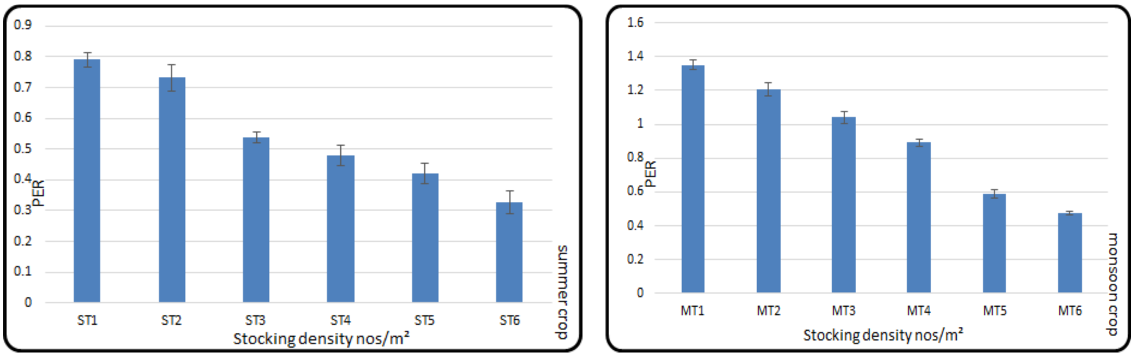


Figure 7: Effect of different stocking densities on Protein Efficiency Ratio (PER), of *L.vannamei* in grow out ponds during summer and monsoon crop (±S.E).

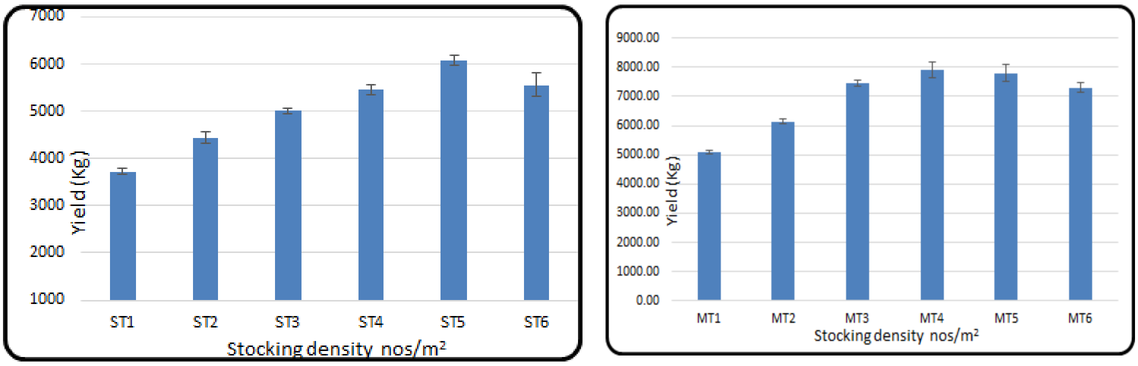


Figure 8: Effect of different stocking densities on total yield (kg) after rearing 120 days of *L.vannamei* in grow out ponds during summer and monsoon crop (± S.E).

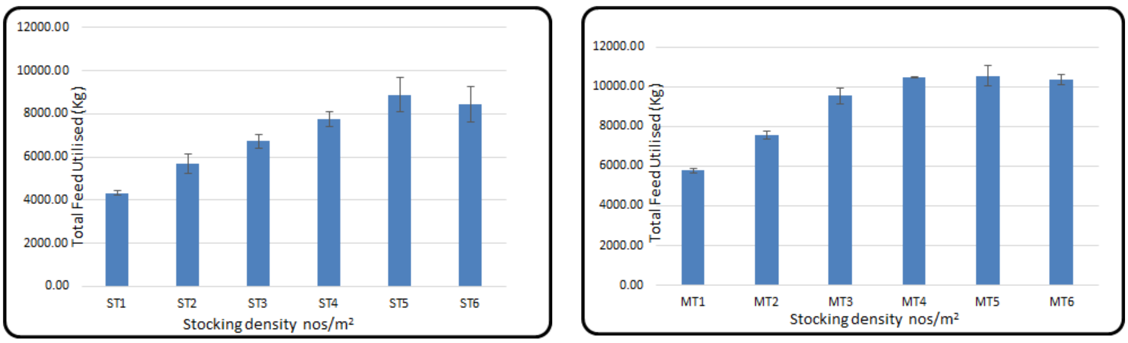
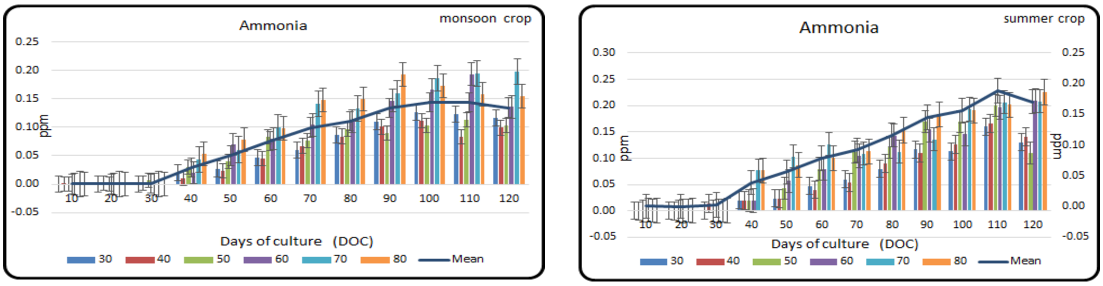


Figure 9: Effect of different stocking densities on total feed utilized (kg) for rearing *L.vannamei* in grow out ponds during summer and monsoon crop (± S.E).

[DOI: 10.18331/SFS2021.7.3.7]

[DOI: 10.18331/SFS2021.7.3.7]



Figures 10.1 to 10.7 : Average of water quality parameter of *L. vannamei* shrimp culture pond in different stocking density during summer and monsoon crop.

Discussion

The present study is the report on the culture of *L. vannamei* in the two different season with different stocking density. This study shows that stocking density affects growth of *L. vannamei*. Several authors have reported on the growth and survival of *L. vannamei* in different salinities and densities (Wyban *et al.*,1988; Emberson *et al.*,1999; Samocha *et al.*, 1999).The maintenance of good water quality is essential for optimum growth and survival of shrimp. Good water quality is characterized by adequate dissolved oxygen, temperature, pH and salinity. Excess feed, faecal matter and metabolites exert tremendous influence on the water quality of the shrimp farm (Soundarapandian and Gunalan, 2008). Kurup *et al.* (2002) stated that in recent years, a growing interest has been noticed in the farming of this species in India. Karplus *et al.* (1987) stated that two main difficulties for rearing culture species are cannibalism and social suppression of growth, according to New *et al*. (2000), high stocking densities of shrimp are less profitable due to space and feeding behavior, this result in low stocking densities and less environmental impacts. Density dependent population growth is now a well-established phenomenon (New *et al.*, 2000; Tidwell *et al.*, 2004; Zaki *et al.*, 2004). Effect of stocking density on growth in summer and monsoon crop is discussed herewith.

SGR (%) of L. vannamei shrimp during summer and monsoon crop

In the present investigation, values of SGR obtained for *L. vannamei* shrimp reared under captive condition at different stocking density significant (p<0.05) differences in SGR was recorded among the treatment. Highest SGR was recorded in the ST1 and lowest in ST6. Similar observation was recorded by Araneda *et al.* (2008), Williams *et al.* (1996) and Sookying *et al.* (2011) they reported that that increasing density and shrimp biomass had negative effect on growth. The SGR in the MT1 was significantly higher than that of the MT2, MT3, MT4 and MT5 and MT6 (p<0.05). In the previous study of Xu *et al.* (2015) stated that at 300 no m^{-3} stocking density, after 6-week, the cultured shrimp performed well with growth rates between 1.14 and 1.30 g $week^{-1}$. In the present study SGR was 2.93, 2.87, 2.79, 2.71, 2.53 and 2.42%. Similar observation was done by Araneda *et al.* (2008), Williams *et al.* (1996) and Sookying *et al.*

(2011) who reported that that increasing density and shrimp biomass had negative effect on growth.

ADG (g) of L

Few authors have reported on the growth and survival of *L.vannamei* stock in different salinity and densities in culture ponds (Samocha *et al.*,1993; Wyban *et al.*, 1998; Samocha *et al.*, 1999). In the present studies, ADG (g) of *L.vannamei* shrimp was higher in lower stocking density, ranged between 0.22 to 0.12gd^{-1}. This statement was in agreement with Wyban and Sweeney (1989) stated that the *P. vannamei* cultured at densities of 45 shrimp/m^2, growth rate was 0.70–1.8 gwk^{-1} under seawater conditions. Reid and Arnold (1992) reported that *P. vannamei* reached 0.61 gwk^{-1}at a stocking density of 970–2132 shrimp/m^3. Araneda *et al.* (2008) recorded that at 90 shrimp/m^2 stocking density, the average growth rate of 0.38 gwk^{-1} and low at stocking density of 180 shrimp/m^2 with 0.33 gwk^{-1}. This result is in agreement with the known fact that Hanson and Goodwin (1977); Maguire and Leedow (1983) and Allan and Maguire (1992b) reported the growth reduction in shrimp at higher densities. In the present study it was clearly indicated that at 80pcs/m² the ADG (g) was lowered compared to 70nos/m², low stocking density significantly higher (p<0.05) mean weight growth (g) was observed with *L.vannamei* shrimp in treatment ST1 followed by treatment ST2 and ST3, ST4, ST5 and ST6 respectively. Comparing the effect of stocking density, ADG was lower in treatment ST6 (0.12±0.005) followed by ST5 (0.14±0.00), ST4, ST3 (0.17±0.001), ST2 (0.20±0.001) and ST1 (0.22±0.001).

L. vannamei shrimp during summer and monsoon crop

In the present study ADG during monsoon was higher than summer having 0.28, 0.26, 0.23, 0.21, 0.17 and 0.15g, this statement was in agreement with Sandifer *et al*. (1988) observed that there was little effect of stocking density on growth and survival of *L. vannamei* at densities ranging from 2-100 shrimp/m^2. Lee and Shleser (1984) reported that mean weight and ADG curves were strongly affected by stocking density. Lanari *et al.* (1989) revealed that both low stocking density and water exchange rate delayed the inflection point of the curves, indicating a higher food availability and better water quality, the data in the present study showed the same trend. Similarly, Wyban *et al*. (1988) resolved that growth of *L. vannamei* was unaffected by stocking densities ranging from 45-100 shrimp/m^2. The negative effects of agonistic shrimp behaviour, poor water quality, and limited food availability associated with high stocking densities can be mitigated by providing conducive biotic and abiotic environment.

Survival of L. vannamei shrimp in summer and monsoon crop

Most penaeid shrimps are known to be euryhaline species growing in a wide range of salinities, at least during their nursery stages. The results of the present study indicate that the survival rate was above 80% with increase in salinities. In present investigation stocking density was higher in ST1 (95.13±1.88) followed by ST2

[DOI: 10.18331/SFS2021.7.3.7]

(92.8±2.81), ST3 (90.93±3.42), ST4 (89.93±3.82), ST5 (85.23±5.62), and ST6 (81.66±7.11), this is in agreement with Wyban and Sweeney **(**1989) reviewed in intensive shrimp culture, increasing stocking density from 45 to 100 shrimp/m^2 did not appear to affect shrimp growth or survival. Whereas during monsoon crop, the survival% were 98.3, 98.03, 95.10, 92.3, 89.00 and 86.10% at MT1, MT2, MT3, MT4, MT5 and MT6 respectively. Values of survival rates decreased significantly (p<0.05) with increasing shrimp density. However, the differences between the densities of 30 to 40 nos/m^2 were not significant differed (p>0.05). The same trend was obtained by Wyban *et al.* (1987) using shrimp densities from 5 to 20 pcs/m^2 of *P. vannamei,* and Sandifer *et al.* (1987) using densities from 10 to 40 pcs/m^2 of *P. monodon*. These values of survival rates are economically, technically good, acceptable and agree with what found by Nunes and Parsons (1998) for semi-intensive culture system. Stokes *et al.* (1988) increased stocking densities up to 100/m^2 have had no apparent effect on *P. vannamei* growth or survival additionally. Wyban *et al.* (1988) stated that *P. vannamei* capable of fast growth to 20 grams with high survival when stocked at 100/m^2. Shrimp survival ranged from 83.3% at the highest stocking density (80 shrimp/m^2) to 99.20% at stocking densities of 30 shrimp/m^2. These values are lower than those reported by Samocha (2001), who reared *P. vannamei* juveniles in seawater at a stocking density of 2200 shrimp/m^2, for 92 days whereas Ayaz *et al.* (2015) reported that rearing *L.vannamei* shrimp had 74.2 to 100% survival obtained in salinity 50 to 35ppt respectively. However, our survival results were higher compared with those recorded for juvenile *P. merguiensis* reared for 92 d^{-1} in seawater at a stocking density of 500 shrimp/m^2 (Cheong *et al.*, 1988). Green *et al.* (1997) and Martinez *et al.* (1998) stated, shrimp survival was quite good. Wyban *et al.* (1988) stated that increasing stocking density from 45 shrimp/m^2 to 100 shrimp/m^2 in the experimental pond had little effect on shrimp. Big sized organisms are dominant to small organisms at feeding will trigger competition in place utilization, especially at high density. This social interaction between individuals has an effect on inhibiting growth and survival especially in increasing population density conditions (Haran *et al*., 2004; Arnold *et al.*, 2006).

Effect of different stocking density on Feed Conversion Ratio (FCR) during summer and monsoon crop

In the present studies, the effect of stocking density on the feed conversion ratio (FCR) of *L.vannamei* shrimp. The values of feed conversion ratios were 1.16, 1.28, 1.34, 1.42, 1.46 and 1.51, at 30, 40, 50, 60, 70 and 80 nos of shrimp /m^2stocking density respectively. Similar results were already recorded by Paul Raj (1999), Ramakrishna (2000), and Soundarapandian and Gunalan (2008). Gunalan *et al.* (2011) stated that, during pond experiment, in his study the average FCR was 1.36 for all ponds because of quality of the feed, feed management, water quality, pond bottom management and other effective farm management. Values of FCR increased with increased

[DOI: 10.18331/SFS2021.7.3.7]

shrimp density. Increasing stocking density reduced feed conversion efficiency (Sandifer *et al.,* 1987). The results of the present experiment agreed with the literatures under the same conditions (Apud *et al.,* 1983; Clifford, 1992 and Allan and Maguire, 1992a). Debnath *et al.* (2013) stated that the overall average FCR of *P. monodon* in the present study after 120 days was 1:1.2 in semi-intensive ponds. It is highly satisfactory when compared with the findings of 1:1.69 and 1:1.78 by Liao (1981) in semi-intensive (Apud *et al.,* 1983; Clifford, 1992; Allan and Maguire, 1992b). Feed conversion value of 3-5 for fish, mussel, and other unprocessed feeds and 1.5-2.5 (Apud *et al.,* 1983). FCR of higher than 2 (Lin, 1992) for artificial diets (by dry weight) is acceptable. The overall poor result in FCR might be because of insufficient food utilization due to turbid water or due to deficiencies in essential nutrients such as essential amino acids (Bahrevar and Faghani-Langroudi, 2015). Digestibility of fish plays important role in lowering FCR by efficient utilization of feed. Stocking density impaired the growth of white shrimp in our study. Meanwhile, different sources of the same species have different growth performance, and the conditions of experiments also impacted the growth of the same species (Xu and Pan, 2012; Xu *et al.,* 2012).

Effect of different stocking density on Protein Efficiency Ratio (PER) during summer and monsoon crop

Rearing of *L. vannamei* at low salinity for long-term, dietary protein levels strongly affected the shrimp final body weight, weight gain, specific growth rate, feed conversion ratio, protein efficiency ratio and survival rate. With the increase of dietary protein levels, feed conversion ratio and protein efficiency ratio mostly decreased. In the present investigation, PER was higher in low stocking density with 0.79, 0.73, 0.53, 0.47, 0.42 and 0.32, this statement is in agreement with Hu *et al.* (2008). With low level dietary protein Nattakul *et al.* (2009) stated that PER values could be efficiently used for protein synthesis by shrimp PER ranged between 1.91-2.38. PER of white shrimp fed commercial diet (30%CP) was 1.88±0.08 (Cruz-Suarez, 2007). Similar results have been reported for grass prawn, *P. monodon* (Shiau and Peng, 1992) and *L. vannamei* (Huang *et al.,* 2003; Liu *et al.,* 2005; Hu *et al.,* 2008; Xia *et al.,* 2010).

During monsoon crop, PER was higher in low stocking density with 1.35, 1.20, 1.04, 0.89, 0.58 and 0.47.This is in agreement with Hu *et al.*(2008) and with low level dietary protein Nattakul *et al.* (2009) stated that PER values could be efficiently used for protein synthesis by shrimp. PER ranged between1.91-2.38. PER of white shrimp fed commercial diet (30%CP) was 1.88±0.08 (Cruz-Suarez, 2007).

Growth performance of L. vannamei shrimp during summer and monsoon crop

Biotic and abiotic factors in culture ponds are severely affected when temperature goes beyond 40°C, temperature and salinity may also affect the protein requirement (Guillaume, 1997). In the present study, due to bright sunny days, rise in salinity was recorded in the culture

[DOI: 10.18331/SFS2021.7.3.7]

pond, which was in the range of 38.1 to 55.60 ppt in all ponds. Such observations were in agreement with the findings of various investigators who stated that *L. vannamei* shrimp grows in sea water 50 ppt and more (Zhu *et al.*, 2004) whereas Tsuzuki *et al.* (2007) and Bowden (2008) stated that at low salinity, shrimp encountered with an adverse effect on feed conversion, oxygen consumption rate, metabolism, digestive enzyme activities, and immunity, Zeng (2013) stated that osmoregulation resulting in low SGR and PER and high FCR and finally causing a decline in the growth performance of aquatic animals.

Ayaz *et al*. (2015) stated higher weight gain was recorded in 35-40 ppt than in 45-50ppt salinity. Suwirya *et al*. (1986) reported that shrimp growth rate is influenced by salinity level. The final mean weight at the end of the culture showed great differences among different stocking densities, since, it was recorded that the increasing stocking density resulted in a marked decrease in the mean weight of the post larvae. In the present study, *L. vannamei* shrimp mean weight gain (g) by 120DOC was higher in ST1 (26.08±0.05g) followed by ST2 (23.84±0.27), ST3 (19.94±0.07), ST4 (18.24±0.43), ST5 (16.92±0.23) and ST6 (14.61±0.49g). Such observations were in agreement with the findings of various investigators (Wyban *et al.,* 1987; Tidwell *et al.,* 2004; Zaki *et al.,* 2004; Sherif and Mervat, 2009). They recorded an inverse relationship of mean weight with the increasing stocking density. Williams *et al*. (1996) reported that the growth rate between (0.50-0.95) g week^{-1} at high salinity with 107 m^{-2} and 100 m^{-2} densities is very different. As per Samocha *et al.* (2004) in the indoor experiment conducted at low salinity gained growth rate between (2.20-2.31) g week^{-1} of *L. vannamei.* Sowers and Tomasso (2006) obtained a moderate growth rate of *L. vannamei* of (1.17-1.23g) weeks^{-1} on different salinity. Duy *et al*. (2012) reported that at salinity 20 - 23 ‰ with a 10 m^{-2}density of *Penaeus monodon* growth was slower than salinity 30-33‰ various authors have also studied the effect of varying stocking densities (Maguire and Leedow, 1983; Wyban *et al.,*1987; D'Abramo *et al.,* 1989; Lanari *et al.,*1989; Ray and Chien, 1992; Allan and Maguire, 1992b; Daniels *et al.,* 1995; Khouraiba *et al.,* 1996; Zaki and Abdel-Halim, 1997; Martin *et al.*, 1998; Marques *et al.*, 2000; El-Sherif, 2001) growth in shrimp culture systems based on stocking density (Cailout *et al.,* 1976; Sedgwick, 1979; Maguire and Leedow, 1983). Wyban (1987) showed a negative co-relation between stocking density and growth whereas few author stated that an inverse relationship is known to exist between the stocking density and the survival and growth rates (Sandifer and Smith, 1976; Emmerson and Andrews, 1981). Arnold *et al.*(2006) observed the lower wet weights at high stocking densities, reduced space and natural food source availability. Big size shrimp were found to be more common in low stocking densities. In contrast, the percentage of small size groups was found in high stocking densities. This shows that there is a denser stocking effect with shrimp size composition (Haran *et al.,* 2004). Many studies illustrated that artificial substrates

[DOI: 10.18331/SFS2021.7.3.7]

could increase shrimp growth and survival (Moss and Moss, 2004; Arnold *et al.*,2006). As per Annoy (2004) the stocking density of the species is possible to stock up to 150/m^2 in pond culture and even higher upto 400/m^2 in controlled recirculated tank culture. Such observations were in agreement with the findings of various investigators, Arnold *et al.*(2006) reported that in high stocking densities, smaller shrimps are in greater dominance by bigger shrimps. Tidwell *et al.* (1999) stated the possibility of best economic results at optimum stocking density. Chakraborty *et al.* (1993) stated that mean body weight gain of *P. monodon* shrimps was higher in low stocking density whereas result depicted by Wahab *et al.* (2003) shows the effect of temperature on shrimp size *P. vannamei*. Shrimp with small size growth are at a good temperature >30°C with better FCR. Medium sized shrimp, optimized temperature equal 30°C. While the shrimp with a large size optimum temperature 27°C. It is further explained that shrimps have optimum temperature according to size and tend to decrease with increasing shrimp size.

During monsoon season due to onset of raining, temperature drop of 2 to 4ºC lower than the environment, but it can be much lower if massive low-pressure systems. As a result of the dissolution of carbon dioxide (CO), rain is actually a weak solution of carbonic acid with a pH of 6.2 to 6.4. These two physical factors tend to lower the temperature and pH of the shrimp ponds. Additionally, as a consequence of dilution, salinity and hardness also decrease due to the reduction in ion concentrations in solution. Other physical changes directly related to rain include the increase of suspended solids due to the transport of soil material from the pond levies. Higher pond turbidity negatively impacts sunlight penetration and causes abrupt crashes of the phototrophic populations.

Increasing stocking density of fish and shrimp in ponds usually increases the deterioration of pond bottom soil (Ray and Chien, 1992), increases the vulnerability of prawns to disease (Doubrovsky *et al.*, 1988), decreases shrimp growth (Sandifier *et al.*, 1987; Ray and Chien, 1992; Daniels *et al.*, 1995; Palomino *et al.*, 2002), increases pressure on natural food resources (Hopkins *et al*., 1988; Allan and Maguire, 1992a), reduces food conversion efficiency (Sandifier *et al.*, 1987 and Martin *et al.*, 1998), and rises the total food costs (New, 1987). This statement is in agreement with Hanson and Goodwin (1977), Maguire and Leedow (1983) and Allan and Maguire (1992b) as per Wyban and Sweeney (1989) stated that in three experimental grow-out pond trials were conducted by rearing white shrimp, *Litopenaeus vannamei.* Shrimp were stocked at a density of 45 shrimp m^{-2},and excellent growth and production were achieved in replicated trials.

Several studies reported decreased growth with increasing density, whereas others showed increasing growth with increased density Hecht and Uys (1997) or no effect of density Hengsawat *et al*. (1997). The differences in outcome are due to the varying abilities of different species to counteract environmental stress. Even within the same species, different individuals can exhibit a different response. In present study, the mean weight gain (g) was 34.5g, 31.28g, 28.4g, 25.8g, 20.8g and 18.2g in MT1, MT2, MT3, MT4, MT5 and MT6 after 120 days respectively decreased significantly with increasing stocking density ($p<0.05$). If good water quality and pond bottom conditions are kept clean from shrimp sludge and sufficient food is available, the negative relationship between stocking density and shrimp growth may be uncoupled up to a certain threshold density, beyond which agonistic shrimp behaviour may suppress growth.

Conclusion

After 120th days of pond culture during summer crop, the mean weight gain (g), survival %, SGR% and FCR of the shrimp at harvest were 26.08, 23.84, 19.94, 18.24, 16.92 and 14.61g; 95.1, 92.8, 90.9, 89.9, 85.2 and 81.6 %; 1.98, 1.87, 1.79, 1.79, 1.42 and 1.17%; 1.16, 1.28, 1.34, 1.42, 1.46 and 1.51; 0.79, 0.73, 0.53, 0.47, 0.42 and 0.32 whereas during monsoon crop, 34.5g, 31.3, 28.5, 25.9, 20.9 and 18.2; 98.3, 98.03, 95.1, 92.3, 89.00 and 86.1%; 2.94, 2.86, 2.79, 2.71, 2.53 and 2.41; 1.13, 1.23, 1.28, 1.32, 1.35 and 1.42 at stocking density 30, 40, 50, 60, 70 and 80 nos/m^2 respectively. The results of this study indicate that at high density, the growth of juvenile shrimp is excellent but then after as the growth progresses, it was noted that *L. vannamei* shrimp individual biomass (g) get suppressed. At the end of the culture period, it was recorded that, higher stocking density above (60pc/m^2) should be released in grow-out pond for better and faster growth. For this reason, it is important to determine the shrimp density that is most economical for the farmer. The results of this study may help farmers and biologists to choose a suitable stocking density for the production of white shrimp in earthen pond. Our results suggest that 60-70 pc/m^2 is a suitable range for the grow-out stage of white shrimp in the Saurashtra area pond. The mechanism by which stocking density impacts shrimp growth and health is complicated, and the physiological parameters and growth effects may not be fully explained.

Acknowledgment

The authors are thankful to the Director of Research, Junagadh Agricultural University, Junagadh for constant encouragement. They are also grateful to Dr. A. Y. Desai, Principal and Dean, Junagadh Agricultural University, Veraval for extending facilities and to Dr. G. S. Vala (Research Scientist) for offering valuable comments on the manuscript.

References

Allan, G.L. and Maguire, G.B., 1992a. Effects of PH and salinity on survival, growth and osmoregulation in *Penaeus monodon* Fabricius, *Aquaculture,* 107, 33-47.

Allan, G.L. and G.B. Maguire, 1992b. Effects of stocking density on production of Penaeus monodon model farming systems. *Aquaculture,* 107,49-66.

Apud, F.D., Primavera, J.H. and Torres, P.L., 1983. Farming of prawns and shrimps. Southeast Asian Fisheries development center. *Extension Manual*, 5, 1-67.

Araneda, M., P´erez, E.P. and Gasca-Leyva, E., 2008. White shrimp *Penaeus vannamei* culture in freshwater at three densities: condition state based on length and weight. *Aquaculture,* 283, 13–18.

Arnold, S.J., Sellars, M.J., Crocos, P.J. and Coman, G.J., 2006. An evaluation of stocking density on the intensive production of juvenile brown tiger shrimp (*Penaeus esculentus*). *Aquaculture,* 256, 174–179.

Ayaz, M., Sumara, K., Vadher, K.H. and Ishakani, A.H., 2015. Effect of higher salinities on growth and survival of pacific white shrimp, *Litopenaeus vannamei* (Boone, 1931). *Journal of Applied and Natural Science,* **7** (**2**), 885-888.

Ayyat, M.S., El-Marakby, H.I. and Sharaf, S.M., 2011. Effect of dietary protein level, stocking Blackburn, T.H., B.A. Lund, and M.D. Krom (1988). V- and N-mineralization in the sediments of earthen fishponds. *Marine Ecology Progress Series,* 44, 221-227.

Bahrevar, R. and Faghani-Langroudi, H., 2015. Effect of fish meal replacement by blood meal in fingerling rainbow trout (*Oncorhynchus mykiss*) on growth and body/fillet qualitytraits. *AACL Bioflux*, 8(**1**), 34–39.

Blackburn, T.H., Lund, B.A. and Krom, M.D., 1988. C and N mineralization in the sediments of earthen marine fish pond. *Marine Ecology Progress Series,* 44, 221–227.

Bowden, T.J., 2008. Modulation of the Immune System of Fish by Their Environment. *Fish & Shellfish Immunology*, 25, 373-383.

Boyd, C.E., 1989. Water quality management and aeration in shrimp farming. 2nd ed. Alabama Fisheries and Allied Aquacultures Departmental. Agricultural Experiment Station. Auburn University, Alabama, USA.

Boyd, C.E., 1990. Water quality in ponds for aquaculture. Alabama Agricultural Experiment Station. Auburn University, Alabama.

Cailout, C.W., Norris, J.P., Heald, E.J. and Tabb, D.C., 1976. Growth and yield of pink shrimp (*Penaeus duorarum)* in feeding experiments in concrete tanks. *Transactions of the American Fisheries Society*, 105, 259–266.

Chakraborty, S.C., Paul, A.K. and Hossain, M.A., 1993. Effect of stocking density on growth of tiger shrimp (*Penaeus monodon* fab.) fed on commercial formulated diets Bangladesh. *Fish. Res.*, 1(**1**), 53-63.

Chanratchakool, P., Turnbull, J.F., Funge-Smith, S.J., Mac Rae, I.H. and Limsuwan, C., 1998. Health Management in Shrimp Ponds. Aquatic Animal Health research Institute, Department of Fisheries, Katsetsart University Campus, Jatujak, Bangkok, Thailand.

Cheong, L., Chan, F.K., Chou, R., Wong, F.J. and Lim, A., 1988. Observations on the culture of shrimp in raceways. *Singapore Journal of Principles Industrial*, 16, 1–12.

Ching, S.C. and Lo- Chai, C., 1990. Growth characteristics and relationships among body length, body weight and tail weight of *Penaeus monodon* from a culture environment in Taiwan. *Aquaculture*, 91, 253-263.

Clifford, H.C., 1992. Marine shrimp pond management: a review. In: Wyban, J. (Ed.), proceedings of the Special Session on Shrimp Farming World Aquacult. Soc., Baton Rouge, LA, pp. 238-253.

Cruz-Suarez, L.E., Martha, N.L., Claudio, G.B., Mireya, T.S., Ulrike, S. and Denis, R.M., 2007. Replacement of fish meal with poultry by-product meal in practical diets for *Litopenaeus vannamei*, and digestibility of the tested ingredients and diets. *Aquaculture*, 272(**1-4**)**,** 466-476.

D'Abramo, L.R., Heinen, J.M., Robinette, H.R. and Collins, J.S., 1989. Production of freshwater prawn (*M.rosenbergii*) stocked as juveniles at different densities in temperate zone ponds. *J. World Aquacult. Soc.*, 20, 81-89.

DAHDF, 2016. Press Information Bureau, Department of Animal Husbandry, Dairying & Fisheries, Ministry of Agriculture and Farmers Welfare, Government of India.

Daniels, W.H., Abramo, D., Fonden, L.R. and Durant, M.D., 1995. Effects of stocking density and feed on pond production characteristics and revenue of harvested freshwater prawns *Machrobrachium rosenbergii* stocked as size-graded juveniles. *Journal of the World Aquaculture Society*, 26(**1**), 38-47.

Debnath, P.P., Karim, M., Quazi, K. and Kudrat-E-Kabir, A.Z.M., 2013. Comparative Study on Growth Performance of Bagda (P. monodon, Fabricius, 1798) in Traditional and Semi-intensive Culture Systems. *Science and Technology*, 3(**1**), 1-16.

Diana, J.S., Egna, H.S., Chopin, T., Peterson, M.S., Cao, L., Pomeroy, R., Verdegem M., Slack, W.T., Bondad-Reantaso, M.G. and Cabello, F., 2013. Responsible aquaculture in 2050: valuing local conditions and human innovations will be key to success. *BioScience*, 63(**4**), 255-262.

Doan van bay, 2011. Black tiger shrimp value chain analysis in bac lieu province Vietnam, Master thesis in fisheries and aquaculture management and economics, The Norwegian College of Fisheries Science University of Tromso, Norway and Nha Trang University, Vietnam. 78.

Doubrovsky, A., Paynter, J.L., Sambhi, S.K., Atherton, J.G. and Lester, R.J.G., 1988. Observations on the ultrastructure of baculovirus in Australian *Penaeus monodon* and *Penaeus merguiensis*. *Australian Journal of Marine and Freshwater Research*, 39, 743-749.

Duy, H.N., Coman, G.J., Wille, M., Wouters, R. and Quoc, H.N., 2012. Effect of water exchange, salinity regime, stocking density, and diets on growth and survival of domesticated black tiger shrimp *Penaeus monodon* (Fabricius, 1798) reared in sand-based recirculating systems. *Aquaculture*, 338-341, 253-259.

El-Sayed, A.F.M., 1999. Alternative dietary protein sources for farmed tilapia (*Oreochromis* spp.). *Aquaculture*, 179, 149-168.

El-Sherif, M.S., 2001. Studies on growth performance of prawn (*M.rosenbergii*) as affected by type of feeding and stocking density. *Mansoura University Journal of Agricultural Sciences*, 26, 4141-4149.

Emberson, C.R., Samocha, T.M. and Wood, G.F., 1999. Use of ground saline water for commercial production of *Litopenaeus vannamei* in the Sonora desert, Arizona, USA. In: 99 Book of Abstracts: World Aquacult. Soc. Ann. Conf., Sydney, Australia. 668 P.

Emmerson, W.D. and Andrews, B., 1981. The effect of stocking density on growth, development and survival of *Panaeus indicus* larvae. *Aquaculture*. 23, 45-47.

FAO, 2016. Aquaculture Newsletter. 54, 7 P. Available at http://www.fao.org/3/a-i5451e.pdf accessed on 6th March, 2015.

FAO, 2017. Aquaculture Production in India. Aqua Aquaria India. Kerala, India.

FAO, 2018. The state of world fisheries and aquaculture. Food and Agriculture Organization of the United Nations, Rome, pp. 17-20. Available at http://www.fao.org/ 3/I9540EN/ i9540en.pdf accessed on 5th September, 2018.

Garnier, J. and Barillier, A., 1991. Synthse et degradation de la matiere organique dans les ecosystems aquatiques: boucle microbienne et staut trophique. *Oceanis*, 17 (**5**), 561-580.

Giri, S., 2016. Extent of adoption of pisciculture technology in Jagatsinghpur district of Odisha. M.Sc. Thesis, Orissa University of Agriculture and Technology, Bhubaneshwar,

Green, B.W., Teichert, D.T., Boyd, C.E., Wigglesworth, J., Corrales, H., Zelaya, R., Martinez, D. and Ramírez, E., 1997. Effect of diet protein on semi-intensive production of *Penaeus vannamei* during the rainy season. In: Fifteenth Annual Technical Report. Pond Dynamics/Aquaculture CRSP, Burke D., Baker J., Goetze B., Clair D., Egna H., eds. Oregon State University, Corvallis, Oregon, 77-83.

Guillaume, J., 1997. Protein and amino acids. In: D'Abramo, L.R., Conklin, D.E., Akiyama, D.M. (Eds.), Crustacean Nutrition. World Aquaculture Society, Baton Rouge, LA, pp. 26–50.

Gunalan, B., Soundarapandian, P., Kumaran, R., Anand, T., Kotiya, A.S., Maheswaran, C. and Pushparaj, N., 2011. Growth of Cultured White Leg Shrimp *Litopenaeus Vannamei* (Boone 1931) In Different Stocking Density. *Advances in Applied Science Research*, 2(**3**), 107-113.

Hanson, J.E. and Goodwin, H.L., 1977. Shrimp and Prawn farming in the western hemisphere. Dowden, Hutchinson and Ross, Stroudsberg, PA, 439P.

Haran, N., Mallo, J. and Fenucci, J., 2004. Density influence on growth and development of the petasma in juvenile shrimps *Pleocticus muelleri* (Decapada, Penaeoidea). I*nvest. Mar*, 32, 11–18.

Hecht, T. and Uys, W., 1997. Effect of density on the feeding and aggressive behaviour in juvenile African catfish,

[DOI: 10.18331/SFS2021.7.3.7]

Clarias gariepinus. *South African Journal of Science*, 93, 537-541.

Hengsawat, K., Ward, F.J. and Jaruratjamorn, P., 1997. The effect of stocking density on yield, growth and mortality of African catfish (*Clarias gariepinus* Burchell 1822) cultured in cages, *Aquaculture*. 152 (**1/4**), 67-76.

Hopkins, J.S., Baird, M.L., Grados, O.G., Maier, P.P., Sandifier, P.A. and Stokes, A.D., 1988. Impacts of intensive shrimp production on the culture pond ecosystem. *Journal of the World Aquaculture Society*, 19 (1), 37A.

Hu, Y., Tan, B., Mai, K., Ai, Q., Zheng, S. and Cheng, K., 2008. Growth and body composition of juvenile whiteleg shrimp, *Litopenaeus vannamei*, fed different ratios of dietary protein to energy. *Aquaculture Nutrition*, **14:** 499-506.Huang, K., Wang, W. and Lu. J. 2003. Protein requirements in compounded diets for *Litopenaeus vannamei* juveniles. *Journal of Fisheries Science in China*, 10, 308-321.

Huang, K., Wang, W. and Lu, J., 2003. Protein requirements in compounded diets for *Litopenaeus vannamei* juveniles. *Journal of Fisheries Science in China*, 10, 308-321.

Jelte de jong, 2017. Aquaculture in India, Report Rijksdienstvoor Ondernemend Nederland.

Karplus, I., Hulata, G., Wolforth, G.W. and Halevy, A., 1987. The effect of size grading juvenile *Macrobrachium rosenbergii* prior to stocking on their population structure and production in Polyculture. II. Dividing the population in structure into three fractions. *Aquaculture*, 62, 85-95.

Khouraiba, H.M., El-Sherif, M.S. and Al-Farsi, E.M., 1996. Effect of stocking density and dietary protein level on growth performance and feed utilization of shrimp (*Penaeus Japonicus*) juvenile, in nursery system. *Egyptian Journal of Applied Science*, 11, 262-284.

Kumar, P., Sanjay, K., Sudhakar, D., Kumar, S.S. and Himabindu, ??., 2015. An Overview of Fisheries and Aquaculture in India. *Agro Economist*, 2, 1-6.

Kurup, B.M., Ranjeet, K. and Hari, B., 2002. An eco-friendly farming of giant freshwater prawn. *Infofish*, 5, 48-55.

Lanari, D., Ballestrazi, R. and Tibaldi, E., 1989. Effects of fertilization and stocking rate and the performance of *Penaeus japonicus* in pond culture. *Aquaculture*, 83, 269-279.

Lee, C.S. and Shleser, R.A., 1984. Production of *Penaeus vannamei* in cattle manure-enriched ecosystems in Hawaii. *Journal of the World Aquaculture Society*, 15, 52-60.

Liao, I.C., 1981. Status and problems of grass prawn culture in Taiwan. Paper presented at the ROC- Japan Symposium on Mericulture, Taipei, Taiwan, R.O.C. pp. 1-35.

Lin, C.K., 1992. FCR and farm size of intensive shrimp culture in Thailand. *Asian Shrimp News*, 10, 1.

Liu, D.H., He, J.G., Liu, Y.J., Zheng, S.X. and Tian, L.X., 2005. Effects of dietary protein levels on growth performance and immune condition of Pacific white shrimp, *Litopenaeus*

[DOI: 10.18331/SFS2021.7.3.7]

vannamei juveniles at very low salinity. *Acta Scientiarum Naturalium Universitatis Sunyatseni*, 44**,** 217-223.

Maguire, G.B. and Leedow, M.I., 1983. A study of the optimum stocking density and feed rate for school prawns marketable *Litopenaeus vannamei*in green house enclosed raceways in the Arizona desert using ground saline water. In: Book of Abstracts. World Aquacult, Soc. Ann. Conf., Sydney, Australia, 669.

Marques, H.L.A., Lombardi, J.V. and Boock, M.V., 2000. Stocking densities for nursery phase culture of the freshwater prawn (*M.rosenbergii*) in cages. *Aquaculture*, 187, 613-623.

Martin, J.L., Veran, , Guelorget, Y.O. and Pham, D., 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.

Martinez, J.L., Veran, Y., Guelorget, O. and Pham, D., 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.

Martínez-Porchas, M., Martínez-Córdova, L.R., Porchas-Cornejo, M.A. and López-Elías, J.A., 2010. Shrimp polyculture: a potentially profitable sustainable but uncommon aquacultural practice. *Reviews in Aquaculture*, 2, 73-85.

Mena-Herrera, A., Gutierrez-Corona, C., Linan-Cabello, M. and Sumano-Lopez, H., 2006. Effects of stocking densities on growth of the Pacific white shrimp (*Litopenaeus vannamei*) in earthen ponds. *The Israeli Journal of Aquaculture Bamidgeh*, 58(**3**), 205-213.

Moss, K.R.K. and Moss, S.M., 2004. Effects of artificial substrate and stocking density on the nursery production of Pacific white shrimp *Litopenaeus vannamei*. *Journal of the World Aquaculture Society*, 35, 536–542.

Nattakul, Y., Orapint, J., Nontawith, A., Suphol, P. and Chaweng, T., 2009. Effect of dietary protein level on growth and immunity of *Litopenaeus vannamei*, Boone 1931. *Songklanakarin Journal of Science and Technology*, 31(**1**), 15-20.

New, M.B., 1987. Feed and Feeding of Fish and Shrimp. A Manual on the Preparation and Preservation of compound Feeds for shrimp and Fish in Aquaculture. Report ADCP / REP / 87 / 26. United Nations development Program, Food and agriculture organization of the United Nations, Rome, 275 P.

New, M.B., D'Abramo, L.R., Valenti, W.C. and Singholka, S., 2000. Sustainability of freshwater prawn culture. Pages 429-433 in M.B. New and W.C. Valenti, editors. Freshwater Prawn Culture. The Farming of *Macrobrachium rosenbergii*. Blackwell Science Ltd., Oxford, London.

Nunes, A.J.P. and Parsons, G.J., 1998. Food handling efficiency and particle size selectivity by the southern brown shrimp *Penaeus subtilis* fed a dry pelleted feed. *Marine and*

[DOI: 10.18331/SFS2021.7.3.7]

Freshwater Behaviour and Physiology, 31, 193-199.

Palomino, G., Contreras, F., Sanchez, A. and Rosas, C., 2002. Density and water exchange-dependent growth and survival of Litopenaeus setiferus post-larvae. *Journal of the World Aquaculture Society*, 32(**2**), 167 –176.

Paul Raj, B.B., 1999. Ecofriendly feed and management system for sustainable shrimp culture. *Fish World*, 5, 13–17.

Ponce-Palafox, J., Martinez-Palacios, C.A. and Ross, L.G., 1997. The effects of salinity and temperature on the growth and survival rates of juvenile white shrimp, *Penaeus vannamei*, Boone, 1931.*Aquaculture*,157, 107-115.

Ramakrishna, R., 2000. Culture of the tiger shrimp *Penaeus monodon* (Fabricus) in low saline waters. M.Sc. Thesis, Annamalai University, 31 P.

Ray, W.M. and Chien, Y.H., 1992. Effects of stocking density and aged sediment on tiger prawn, Penaeus monodon, nursery system. *Aquaculture*, 104, 231-248.

Reid, B. and Arnold, A.R., 1992. The intensive culture of the Penaeid shrimp *Litopenaeus vannamei*Boone in a recirculating raceway system. *Journal of the World Aquaculture Society*, 23(**2**), 146-153.

Samocha, T.M., Lawrence, A.L. and Biedenbach, J.M., 1993. The Effect of Vertical Netting and Water Circulation Pattern on Growth and Survival of *Penaeus vannamei* Postlarvae in an Intensive Raceway System. *Journal of Applied Aquaculture*, 2(**1**), 55-64.

Samocha, T.M., 2001. Zero water exchange, various studies show successful shrimp production. *Global Aquaculture Advocate*, 4, 31–32.

Samocha, T.M., Lopez, I.M., Jones, E.R., Jackson, S. and Lawrence, A.L., 2004. Characterization of intake and effluent waters from intensive and semi-intensive shrimp farms in Texas. *Aquaculture Research*, 35, 321-339.

Samocha, T.M., Lawrence, A.L., Bray, W.A., Collins, C.A., Castille, F.L., Lee, P.G. and Davies, C.J., 1999. Production of marketable *Litopenaeus vannamei* in green house enclosed raceways in the Arizona desert using ground saline water. 1999, In: Book of Abstracts. World Aquacult. Soc. Ann. Conf., Sydney, Australia. 669P.

Sandifer, P.A. and Smith, T.I.J., 1976. Effects of population density on growth and survival of *Macrobrachium rosenbergii* reared in recirculation water management systems. In Avault, J.W. and Miller, R. (Editors) Proc. 6th Annual Workshop *World Maricult. Soc.* Lousiana State Univ. Press. Baton Rouge, pp. 43-53.

Sandifier, P.A., Hopkins, J.S. and Stokes, A.D., 1987. Intensive culture potential of Penaeus vannamei. *Journal of the World Aquaculture Society*, 18(**2**), 94-100.

Sandifer, P.A., Hopkins, J.S. and Stokes, A.D., 1988. Intensification of shrimp culture in earthern ponds in South Carolina: progress and prospects. *Journal of the World Aquaculture Society*, 19(**4**), 218-226.

Saoud, I.P., Davis, D.A. and Rouse, D.B., 2003. Suitability studies of inland well waters for *Litopenaeus vannamei* culture. *Aquaculture*, 217, 373-383.

Sedgwick, R.W., 1979. Effect of ration size and feeding frequency on the growth and feed conversion of Juvenile *Peneaus merguensis* de Man. *Aquaculture*, 16, 279-298.

Sherif- El, M.S. and Ali Mervat, A.M., 2009. Effect of rearing systems (Monoand Poly-Culture) on the Performance of Freshwater Prawn (*M.rosenbergii*) Juveniles. *Journal of Fisheries and Aquatic Science*, 1-12.

Shiau, S.Y. and Peng, S.Y., 1992. Utilization of different carbohydrates at different protein levels in grass prawn, *Penaeus monodon*, reared in sea water. *Aquaculture*, 101, 241-250.

Sookying, D., D'Silva, F.S., Allen, D.D. and Hanson, T.R., 2011. Effects of stocking density on the performance of Pacific white shrimp *Litopenaeus vannamei* cultured under pond and outdoor tank conditions using a high soybean meal diet. *Aquaculture*, 319, 232–239.

Soundarapandian, P. and Gunalan, B., 2008. Recent technology for the survival and production of giant shrimp *Penaeus monodon* along south east coast of India. *International Journal of Zoological Research*, 4(**1**), 21-27.

Sowers, A.D. and Tomasso, J.R., 2006. Production characteristics of *Litopenaeus vannamei* in low-salinity water augmented with mixed salts. *Journal of the World Aquaculture Society*, 37, 214-217.

Stokes, A. D., sandifer, P.A., Hopkins, .T.S. and Smiley, R., 1988. Further studies on density effects in intensive pond culture of *Penaeus vannamei* (Abstract). *Journal of the World Aquaculture Society*,19(**1**), 68A.

Sugathan, S., Manilal, A. and Selvin, J., 2014. Development of Novel Probiotic for the Management of Shrimp Vibriosis. Scholar's Press, USA., p. 188.

Suwirya, K., Azwar, Z.I. and Rochimat, D.T., 1986. Pemeliharaan benur windu *Penaues monodon* dengan berbagai tingkat kadargaram dalam kondisi laboratorium, *Journal Penelitian Budidaya Pantai*, 2(**1**), 34-39.

Tacon, A.G.J., 1990. Standard methods for the nutrition and feeding of farmed fish and shrimp. The Essential Nutrients. Argent Laboratories Press, Redmond, Washington, USA.

Tidwell, J.H., Coyle, S., Weibel, C. and Evans, J., 1999. Effects and interactions of stocking density and added substrate on production and populations structure of fresh water prawn *Machrobrachium rosenbergii. Journal of the World Aquaculture Society*, 30**,** 174-179.

Tidwell, J.H., Coyle, S.D. and Dasgupta, S., 2004. Effects of stocking different fractions of size graded juvenile prawns on production and population structure during a temperature-limited growout period. *Aquaculture*, 231, 123-134.

Tsuzuki, M.Y., Sugai, J.K., Maciel, J.C., Francisco, C.J. and Cerqueira, V.R., 2007. Survival, Growth and Digestive Enzyme Activity of Juveniles of the Fat Snook (*Centropomus parallelus*) Reared at Different Salinities. *Aquaculture*, 271**,** 319-325.

Vijayan, K.K., Kumar, S. and Alavandi, S.V., 2017. Emerging pathogens in

[DOI: 10.18331/SFS2021.7.3.7]

Brackish water aquaculture and challenges in aquatic health management. *In:* Proceedings of International Symposium on aquatic Animal Health and Epidemiology for sustainable Asian Aquaculture, April 20-21, 2017, ICAR-National Bureau of Fish Genetic Resources, Lucknow, India: 140-144.

Wahab, M.A., Bergheim, A. and Braaten, B., 2003. Water quality and partial mass budget in extensive shrimp ponds in Bangladesh. *Aquaculture*, 218, 413-423.

Williams, A.S., Davis, D.A. and Arnold, C.R., 1996. Density-dependent growth and survival of *Penaeus setiferus* and *Penaeus vannamei* in a semi-closed recirculating system. *Journal of the World Aquaculture Society*, 27, 107–112.

Wyban, J.A., Lee, C.S., Sato, V.T., Sweeney, J.N. and Richards Jr., W.K., 1987. Effect of stocking density on shrimp growth rates in manure-fertilized ponds. *Aquaculture*, 61(**1**), 23-32.

Wyban, J.A., Sweeney, J.N. and Kanna, R.A., 1988. Shrimp yields and economic potential of intensive round pond systems. *Journal of the World Aquaculture Society*, 19(**4**), 210-217.

Wyban, J.A. and Sweeney, J.N., 1989. Intensive shrimp growout trials in a round pond. *Aquaculture,* 76(**3-4**)**,** 215-225.

Xia, S., Li, Y., Wang, W., Rajkumar, M., Paramasivam, K., Vasagam, K. and Wang. H., 2010. Influence of dietary protein levels on growth, digestibility, digestive enzyme activity and stress tolerance in white-leg shrimp, *Litopenaeus vannamei* (Boone, 1931), reared in high-density tank trials. *Aquaculture Research,* 41**,** 1845-1854.

Xu, W.J. and Pan, L.Q., 2012. Effects of bioflocs on growth performance, digestive enzyme activity and body composition of juvenile *Litopenaeus vannamei* in zero-water exchange tanks manipulating C/N ratio in feed. *Aquaculture,* 356, 147-152.

Xu, W.J., Pan, L.Q., Zhao, D.H. and Huang, J., 2012. Preliminary investigation into the contribution of bioflocs on protein nutrition of *Litopenaeus vannamei* fed with different dietary protein levels in zero-water exchange culture tanks. *Aquaculture,* 350**,** 147-153.

Xu, W.J., Morris, T.C. and Samocha, T.M., 2015. Effects of C/N ratio on biofloc development, water quality, and performance of *Litopenaeus vannamei* juveniles in a bioflocbased, high-density, zero-exchange, outdoor tank system. *Aquaculture,* 453, 169-175.

Zaki, M.A. and Abdel-Halim, A.M.M., 1997. Growth of fresh water prawn *M.rosenbergii* under different organic fertilization regimes and stocking densities. *Egyptian Journal of Aquatic Research*, 75**,** 283-292.

Zaki, M.A., Nour, A.A., Abdel-Rahim, M.M. and Srour, T.M., 2004. Effect of stocking on survival, growth performance, feed utilization and production of marine shrimp *Penaeus semisulcatus* in earthen ponds. *Egyptian Journal of Aquatic Research*, 30(**B**), 429-442.

Zeng, L., Lei, J.L. and Liu, B., 2013. Effects of Salinity on Growth and

[DOI: 10.18331/SFS2021.7.3.7]

Muscle Composition of Juvenile Turbot *Scophthalmus maximus. Journal of Fisheries of China*, 37**,** 1535-1541.

Zhu, C., Dong, S., Wang, F. and Huang, G., 2004. Effects of Na/K ratio in seawater on growth and energy budget of juvenile *Litopenaeus vannamei*. *Aquaculture,* 234(**1**)**,** 485–496.