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Studies on the effect of stocking density on growth performance and survival of shrimp (*Penaeus monodon)* in grow out ponds

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Abstract

The present study was made to find out the favorable stocking density of *Penaeus monodon* in semi intensive (SI) shrimp culture system grow out ponds. The research work was conducted in FAHIM AQUA PARK, Shrimp Farm, Bemarta Union at sadar Upazilla, under Bagerhat district in Bangladesh. In grow out pond, *Peneaus monodon* healthy juveniles of average size 0.93 ± 0.04 g were stocked at three (10 m^2, 20 m^2 and 30 m^2) densities for a period of 120 days. Artificial feed (CP Feed) was distributed evenly four times daily. After the experimental period of 120 days estimated productions were (468.61 ± 19.02) and (778.97 ± 8.17) g/m^2 from low and high stoking densities respectively. Shrimps attained a final mean body weight of (48.95 ± 4.51), (37.42 ± 6.13) and (30.08 ± 5.07) g in T1 (10 m^2), T2 (20 m^2) and T3 (30 m^2) respectively. The highest survival rate (97.60 ± 1.27%) was obtained from low stoking density of T1 (10 m^2) compared to T3 (30 m^2). Higher specific growth rate (3.29 ± 0.07%) and low feed conversion ratio (1.37 ± 0.12) were found in the low stocking density of T1 (10 m^2). Individual growth performance, survival indicates effectively negative relation with stocking density.

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Introduction

Shrimp export and cultivation in Bangladesh has undergone rapid expansion over the last two decades. Shrimp and prawn together represent the second largest exportable items contributing to foreign exchange earnings of Bangladesh. Not only this sector earns valuable foreign exchange, but also employs significant numbers of rural workers and provides a livelihood for households throughout Bangladesh. Bangladesh is a vast delta having 1,47,570 square km area, of which coastal brackish water covers roughly 17%. The wider coastal tidal area 2.5 million hectares of Bangladesh is considered favorable for shrimp farming and 0.276 million hectares of land are currently under brackish water shrimp cultivation (Kabir and Eva 2014).

The contribution of fisheries sector is 4% to 5% in GDP and 8% to 10% to total export earnings, about 12 million people directly and 10 million people indirectly are associated with this sector for their livelihood. (Farhana 2017).

P. monodon is a marine crustacean that is widely reared for human food the black tiger shrimp and in Bangladesh locally called "Bagda". It has the fastest growth rate among a number of penaeid species reared in captivity and is the largest species of shrimp in the world. (Foster and Beard 1974).

In Bangladesh, culture of Bagda was started from 1970"s. From then this culture industry is growing and growing. Growth and production of cultured species are, to an extent, dependent on the population density (LeCren, 1962; 1965; Backiel and Le Cren, 1967). The optimum stocking density ensures sustainable aquaculture providing proper utilization of feed, maximum production, sound environment and health. In comparison to low stocking density, high stocking density exerts many negative impacts such as competition to optimize the stocking density for the target species in aquaculture desired production (Alokesh *et al.* 2013). Considering the above facts, it is necessary to study the stocking density of shrimp in order to propose the optimal stocking density. As per the literature survey, so far no studies have been taken up in this area to investigate the effect of stocking density on the survival rate and growth of shrimp. In this context, the present study is designed to elucidate the influence of stocking density and water exchange rate on the survival, growth and apparent feed conversion ratio of *P. monodon*.

Methodology

Experimental animal and Site of the experiments

The *Penaeus monodon* seeds were purchased from MKA Hatchery, Cox's Bazar district of Bangladesh and they were confirmed negative for the White Spot Syndrome Virus (WSSV) and Taura Syndrome Virus (TSV) through Polymerase Chain Reaction (PCR Assay) before packing. They were transported in oxygenated double-layered polythene bags with crushed ice packs between inner and outer covers of the bag and packed in a carton.

The seeds were brought to the farm site during early in the morning. The seeds were acclimated to pond conditions before being stocked in ponds by allowing the plastic bag with the seeds to float in the big drums filling with pond water to equalize the water temperature. Then the pond water was added slowly in to the seed bag to adjust the salinity and pH. Subsequently the seeds released slowly in to the ponds. Before stocking initial weight of the seeds were measured. The shrimp healthy juveniles of average size 0.93 ± 0.04 g were stocked in grow out ponds of FAHIM AQUA PARK, Shrimp Farm for 120 days. Three stocking densities with three replications were selected in this study.

Stocking management

Water Quality Management, Water was exchanged were done five days once or depends upon the water and shrimp quality. CP (Indian) feed was used during the entire culture period, distributed manually and by using feeding trays. Simple trays measuring 0.5x0.5 m, made of nylon screen, bamboo strips. Pelleted CP feeds (manufactured and marketed by CP Aquaculture Private Ltd.) were used in the semi intensive ponds. Feeding frequency was four (6 am, 11 am, 5 pm and 10 pm) with a feeding rate prescribed by the feed manufacturer Feed was provided 25% of the body weight at 06.00 A.M. 20 % of the body weight at 11.00 A.M. 30% at 05.00 P.M. and 25% at 10.00 P.M. Shrimps were fed 10% of their body weight at first month and reduced to 7% at second month, 5% at third month and were continued till the end of the experiment.

Feed additives

*Probiotics (*Super PS. ZYMETIN. SUPER BIOTIC Bio-Trim). Vitamin C- 150 *Minerals* (K- MAX A SOILSODA MIX.CALMAG) were used.

Aeration

In order to supply adequate oxygen, paddle wheel aerators were introduced. Usually two-hour interval was considered after each feed application for operating aeration system. Aeration time was increased gradually with the increasing body weight of shrimp in culture ponds.

Growth measurement

Total length of post larvae was measured in millimeters using a metallic scale with 0.5 mm accuracy. One hundred post larvae were weighed by using digital electronic balance. (Mega Digital Scale). The growth gained by the shrimp was calculated by subtracting the previous weight from the corresponding weight at each sampling. Experimental data collected during the growth trial were:

i. Weight gain (g or mg):

Weight gain (g or mg) = Mean final weight – Mean initial weight

ii. Specific growth rate (% per day):

$$\text{Specific growth rate (\% per day)} = \frac{\ln W_2 - \ln W_1}{T_2 - T_1} \times 100$$

Where,

ln = the natural log,

W1 = Initial live body weight (g or mg) at time T1 (day)

W2 = Final live body weight (g or mg) at time T2 (day)

iii. Survival rate (%):

$$\text{Survival Rate (\%)} = \frac{\text{No. of total live shrimp}}{\text{Total no. of shrimp stocked}} \times 100$$

iv. FCR (Feed Conversion Ratio):

$$\text{Feed Conversion Ratio} = \frac{\text{Food given (g)}}{\text{weight gain (g)}}$$

v. Production:

$$\text{Production (g/m}^2) = \frac{\text{Survival rate} \times \text{Stocking density} \times \text{Weight gain (g)}}{100}$$

Statistical analysis

For the statistical analysis of the data, one-way ANOVA (Analysis of variance) was used to determine the effect of water quality and stocking densities on the growth performance of shrimp.

Data analysis was done by using the SPSS software (Statistical Package for Social Science) version-16 according to post-Hoc Tukey Kramer Test to identify the significance level of variance among the different treatment means.

Results

Water quality parameters

In the present study, crucial water quality parameters, like temperature, pH, alkalinity, dissolved oxygen (DO), transparency and hardness were monitored and presented in Table-1.

Table 1. Mean values of water quality parameters recorded from different treatments.

Parameters	Treatment 1	Treatment 2	Treatment 3
Temperature (°C)	30.66 ± 1.95	30.90 ± 2.10	30.78 ± 1.86
Salinity (ppt)	9.43 ± 0.01	9.42 ± 0.03	9.43 ± 0.06
pH	8.11 ± 0.12	8.05 ± 0.07	7.94 ± 0.06
Total Alkalinity (mg/l)	113.72 ± 0.88	112.52 ± 0.02	112.16 ± 0.07

Dissolved oxygen (mg/l)	6.31 ± 0.02	6.29 ± 0.01	6.28 ± 0.01

All the water quality parameters found within the acceptable range for shrimp culture. The pH of the control pond and treatment ponds were 8.11 ± 0.12, 8.05 ± 0.07 and 7.94 ± 0.06 respectively. The temperature found (30.66 ± 1.95, 30.90 ± 2.10, 30.78 ± 1.86 oC) respectively.

The dissolved oxygen, alkalinity, transparency and hardness was more or less similar. The average result of water quality parameters of three treatments have been presented in Table 1.

Growth performance of Penaeus monodon

The growth of *Penaeus monodon* in different treatments under three different stocking densities was different.

The different growth performance namely weight gain (g), specific growth rate (%), survival rate (%), FCR, Net production (g/m $^{-2}$) are shown in Fig. 1.

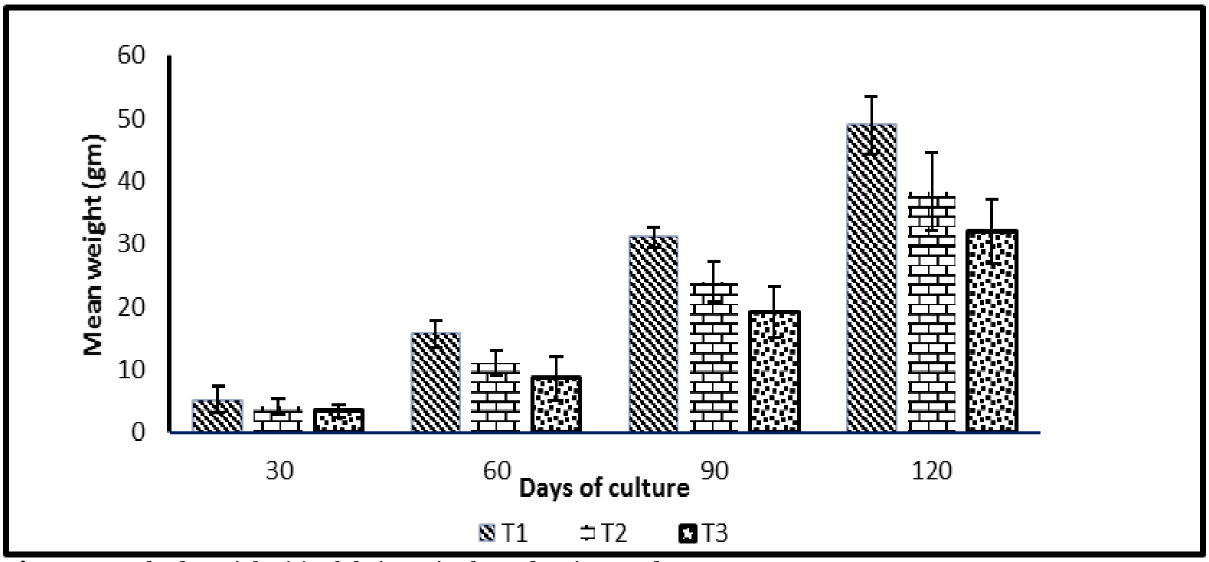

Fig. 1. Mean body weight (g) of shrimps in three density ponds.

Mean weight gain (g)

At the first step of the study, the initial weight of the shrimps was 0.93 ± 0.04, 0.93 ± 0.04 and 0.93 ± 0.04 g in T_1, T_2 and T_3 treatments, respectively.

At the end of the study, the mean final weight of the harvested shrimps was 48.95 ± 1.32, 37.42 ± 0.24 and 32.01 ± 0.22 g in T_1, T_2 and T_3 treatments, respectively.

The mean weight gain found with mean value of 48.00 ± 1.32, 37.49 ± 0.24 and 30.08 ± 0.22 g in T_1, T_2 and T_3 treatments, respectively. Among the treatments, the mean weight gains of shrimp at different stocking densities were very highly significantly different *($p \leq 0.001$)* from each other.

The mean weight gain (g) of three treatments are shown in the Fig 2.

Specific growth rate (%)

The mean specific growth rates in weight were 3.29 ± 0.07, 3.17 ± 0.27, 2.94 ± 0.13 % in T_1, T_2 and T_3 treatments, respectively. The highest value was obtained from T_1 and the lowest value was obtained from T_3. There was highly significant difference *($P \leq 0.01$)* in specific growth rate (SGR %) of shrimp among the three treatments. The SGR of three treatments are shown in the Fig 3.

Survival rate (%)

After 120 days he mean survival rates were found at 97.60 ± 1.27 %, 92.70 ± 2.96 % and 83.55 ± 1.48 % in T_1, T_2 and T_3 treatments, respectively. The highest value was obtained from T_1 (99.60%) and the lowest value was obtained from T_3 (87.55%). There was significant difference *($P \leq 0.05$)* in survival rates of shrimps among the treatments. The survival rates are shown in the Fig 4.

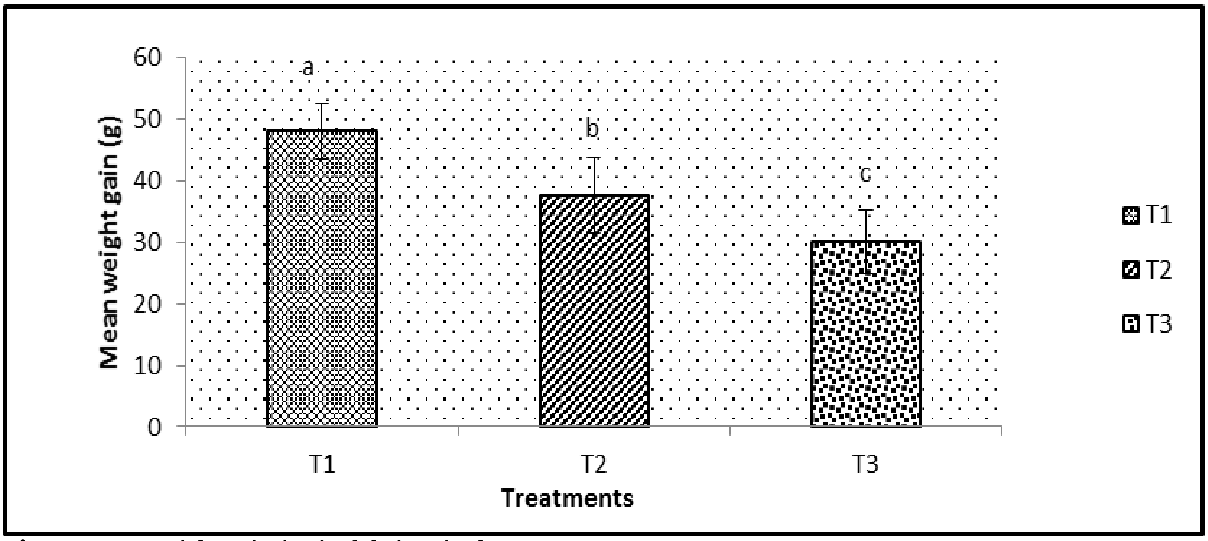

Fig. 2. Mean weight gain (mg) of shrimp in three Treatments.

Feed conversion ratio (FCR)

The mean Feed conversion ratios were in 1.38 ± 0.12, 1.86 ± 0.08 and 2.67 ± 0.25 T_1, T_2 and T_3 treatments, respectively. The highest value was obtained from T_3 (2.67) and the lowest value was obtained from T_1 (1.38). Among the treatments, the mean FCR values at different stocking densities were very highly significantly different *($p \leq 0.001$)* from each other. The FCR of three treatments are shown in the Fig 5.

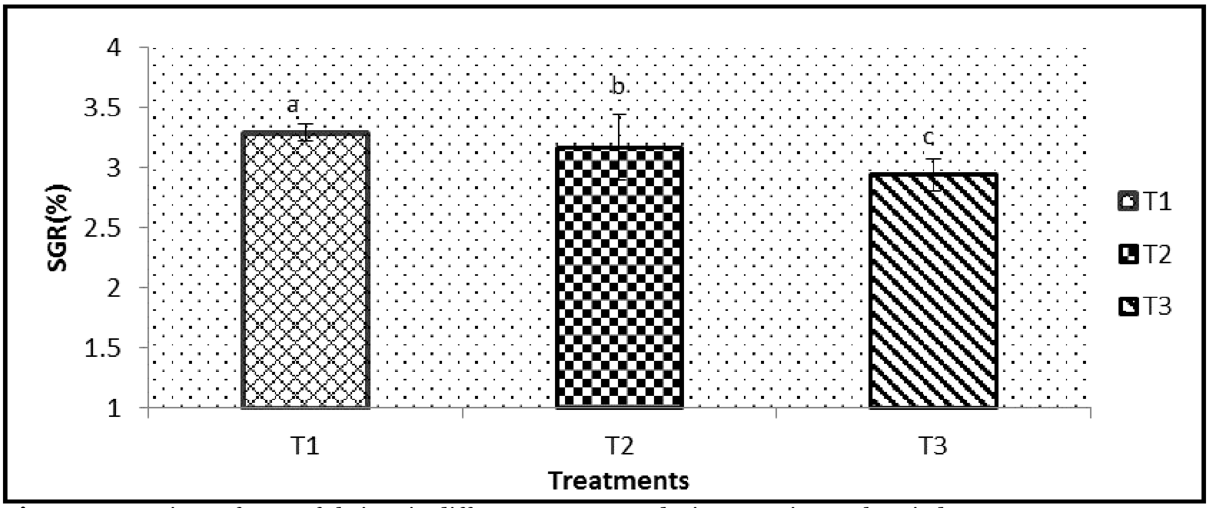

Fig. 3. Comparison of SGR of shrimp in different treatments during experimental period.

Total production (g/m²)

The mean total production of *Penaeus monodon* were 468.61 ± 19.02, 695.08 ± 17.68 and 778.97 ± 8.17 g/m^2 in T_1, T_2 and T_3 treatments, respectively. Net production at harvest was very high significantly differed *($P \leq 0.001$)* between high density and low-density ponds.

The comparative analysis on shrimp production data among the treatments with three different stocking densities were shown in Fig 6.

Discussion

In the present study water temperature was found to fluctuate between 28.10°C and 33.20 °C.

The cultured shrimp grows best in a temperature range from 24-32°C (Fast and Lannan, 1992). Chiu, (1988) reported that the optimum temperature for *P. monodon* culture is 25°C to 32°C. The best range of water pH for shrimp culture is 7-9 determined by Boyd and Fast, (1992). Chiu, (1988) Noted that optimum range of pH is 6.8-8.7 for shrimp culture. The pH range in all the experimental ponds indicated that the water was alkaline with pH ranging from 7.9-8.2.

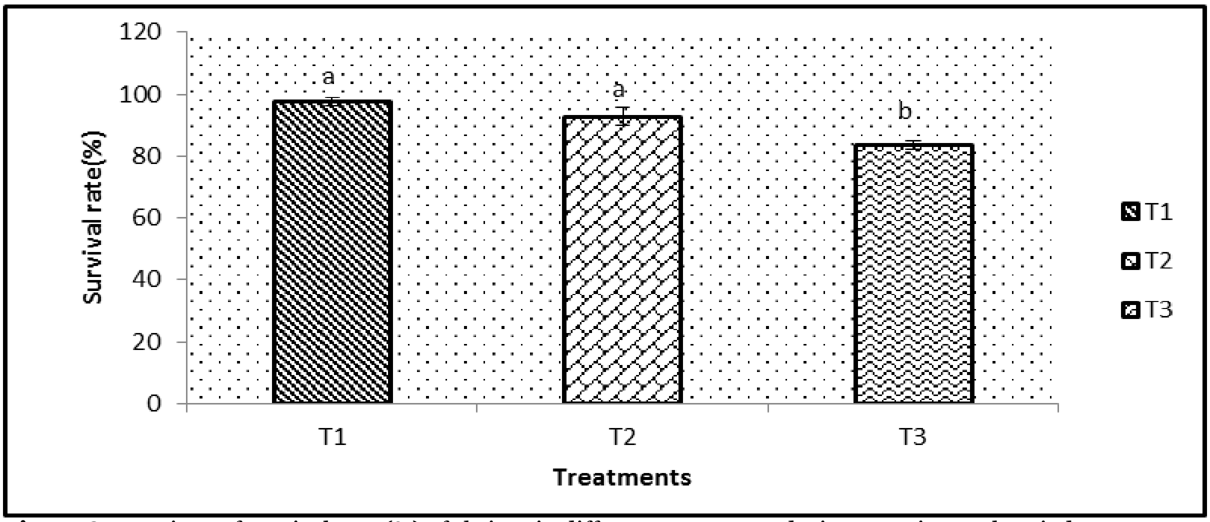

Fig. 4. Comparison of survival rate (%) of shrimp in different treatments during experimental period.

This values of pH in this study were in optimum range. Pakrasi, (1978) and Banerjea, (1967) considered 4-8 ppm of DO as favorable range for shrimp culture. Dissolved oxygen level in water of experimental ponds as recorded in the present study agreed well with findings of Wahab *et al.,* (1995) who recorded lower dissolved oxygen ranging from 2.0 to 7.2 mg/l during their experiment. (Boyd and Fast, 1992). Chiu, (1988), Apud, (1989) mentioned that the optimum range of salinity for *P. monodon* farming would be 10 ppt to 25 ppt. Verghese *et al.*, 1975, Liao, 1981, have observed a direct influence of salinity on the growth of *Penaeus monodon*.

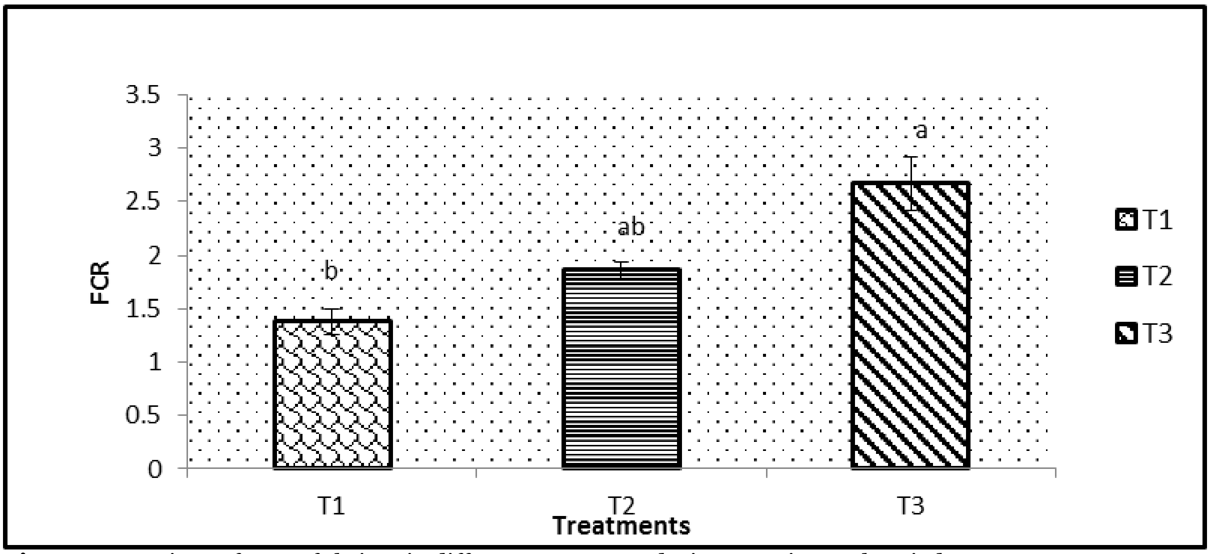

Fig. 5. Comparison of FCR of shrimp in different treatments during experimental period.

The water salinity in this experiment was varied between 8.0 ppt and 12.5 ppt in all the ponds which was with in optimum range for the growth of *Penaeus monodon*. In the present study alkalinity was founding fluctuate between 101.97 and 122.41 mg/L in all ponds. For successful culture of *P. monodon* alkalinity is recommended to be >80 mg/L (Hansell, 1993). In the present experiment the mean weight gain obtained 48.00 ± 4.51, 37.49 ± 6.13 and 30.08 ± 5.07 g in T1, T2 and T3 treatments, respectively. The results of this experiment were in agreement with the results of Suresh and Shailender (2012) who showed a general pattern that the higher growth was observed in the lower stocking densities and the lower growth was observed in the higher stocking densities.

The specific growth rate (SGR) was found to be high in T1 (3.29 ± 0.07%) followed by T2 (3.17 ± 0.27%) and T3 (2.94 ± 0.13%) which indicate that the growth rate is higher in lower densities which agree with LeCren, (1965) who reported that the growth rate is inversely related to stocking density. Shrivastava *et al.,* (2017) reported the highest SGR were observed in the T10 and lowest in T40. Washim *et al.,* (2016) reported the highest SGR (6.01 ± 0.18) % in T1 (3 Nos per m^2) and lowest SGR (5.71 ± 0.02) % in T3 (7 Nos per m2) for SPF shrimp *P.monodon*. The similar trend has also been found by Chakraborty *et al.,* (1997), Sookying *et al.,* (2011), Araneda *et al.,* (2008), Shakir *et al.,* (2014) Krishna *et al.,* (2015).

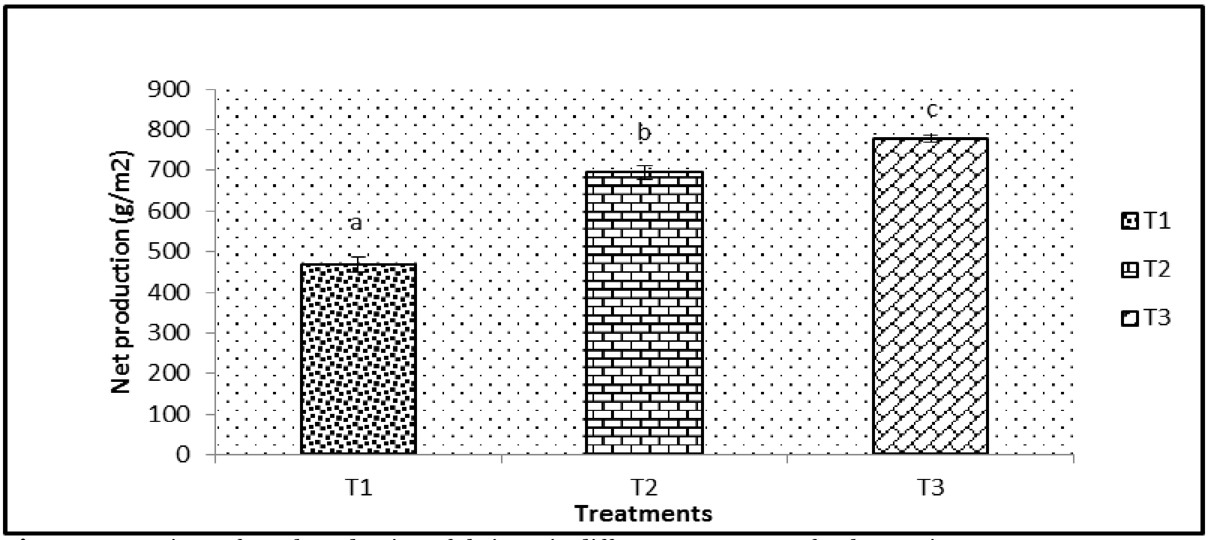

Fig. 6. Comparison of Total production of shrimps in different treatments after harvesting.

In the present experiment highest survival rate was found for T1 (97.60 ± 1.27%) followed by T2 (92.60 ± 2.96 %) and finally T3 (83.55 ± 1.48 %) in the current study. Similar result was reported by Shrivastava *et al.,* (2017) where high stocking density resulted significant *($p<0.05$)* reductions in survival. Washim *et al.,* (2016) reported that the high survival rate (74± 3.69%) was found at low stocking density T1 (3 Nos per m^2) and low rate of survival (70.93 ± 4.89%) was found at high stocking density T3 (7 Nos per m^2) for *Penaeus monodon*. Krishna *et al.,* (2015) reported that the survival rate decreased with the increasing stocking densities. Shakir *et al.,* (2014), Suresh and Shailender, (2012), Zaki *et al.,* (2004) and Li *et al.,* (2006) found the same trend. Reduced survival at high density is probably due to cannibalism during moulting process which is a very common phenomenon prevailing in crustaceans observed by Rouse *et al.,* (1991) and Jones. The higher survival rates observed in the present investigation may be compared with the previous works. Siddhraraju and Menon, 1982 reported the higher survival rates of 85.67% at the stocking rate of 30/m^2, 81 to 89% at the stocking rate of 40 per per m^2 and 65 to 100% at the stocking density of 50 per m^2 for *P. monodon*. They also showed the higher survival rates of 100% of the stocking densities of 5, 10 and 15 per m^2 and 97% at the stocking density of 20 per m^2 for *P. monodon*. It is well known that predation by fishes and green crabs *S. serrata* may cause poor survival rate of shrimp in the fish farm. The absence of these problems perhaps may be one of the reasons for the higher survival rate of the present study. In semi-intensive culture, stocking density was comparatively high but aerator was used to maintain the DO level optimum that also enhanced survival rate. Other reasons for high survival rate was the use of Vitamin C- 150 for shrimp which was responsible for better survival rate in the present study. In the present study the better result was found in treatment T1 (1.38 ± 0.12) where the stoking density was low. Similar result was obtained by Shrivastava *et al.,* (2017) for *Fenneropenaeus merguiensis*. FCR is always a prime concern for shrimp farmers. Chanratchakool *et al.,* (1993) stated that the total FCR varies depending on the stocking density; quality of feed and the size at which the shrimps are harvested, but ideally it should not be higher than 2.

Highest value of FCR was obtained for T40, whereas lowest one was recorded in T10. Krishna *et al.,* (2015) recorded FCR 2.18, 2.39, 2.45, 2.68, 3.12 at stocking densities of 40, 50, 60, 70, and 80 per m^2. The feed conversion ratio (FCR) increases with the increase in the density of shrimps which was in accordance with the findings of Shakir *et al.,* (2014) Zaki *et al.,* (2004), Chakraborty *et al.,* (1997) who studied the effect of stocking density of marine shrimp on the FCR. Sandifer *et al.,* (1987) noticed that increasing stocking density reduces the feed conversion efficiency.

This decrease is probably due to crowding at high densities leading to stress in the organisms (Foster and Bread, 1974). Large organisms were also seemed to dominate smaller ones during feeding and in competition for space particularly in the higher density treatments. This agrees with Arnold *et al.,* (2006), who reported that high densities lead to greater dominance and hierarchy placement of large organisms over small ones in terms of feed, refuge and reproduction. The results of the present study clearly show that the higher production rate (778.97 ± 8.17) g/per m2 was obtained for the stocking density of 30 m^2 followed by the order of the stocking densities of 20 per m2 (695.08 ± 17.68) g per m2, 10 per m^2 (468.62 ± 19.02) g per m2.

The results of the present study clearly show that the higher production rate (778.97 ± 8.17) g/m^2 was obtained for the stocking density of 30 per m^2 followed by the order of the stocking densities of 20 per m^2 (695.08 ± 17.68) g/m^2 and (468.62 ± 19.02) g/m^2. From this it shows that the higher production rate was observed for the higher stocking density of 30 per m^2 and as per the stocking density the production rate was steadily decreased towards the lower stocking densities and thus the lower production rate was recorded for the lower stocking density of 10 per m^2. This similar trend was found by Washim *et al.,* (2014), Shakir *et al.,* (2014). Shuresh and shailender, (2012) showed that the higher production rate (1181 g/m^2) was obtained for the stocking density of 50 per m^2 followed by the order of the stocking densities of 40 per m^2 (989 g/per m2), 30 per m2 (785 g/m^2). 20 per m2 (553 g/m^2) and 10 per m^2 (281 g/m^2). Direct relationship was observed between stocking density and production.

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