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Effects of fry stocking densities on growth, survival rate and production of *Hypophthalmichthys molitrix*, *Cyprinus carpio* var. *specularis* and *Labeo rohita* in earthen ponds at Natore fish farm, Natore, Bangladesh

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Abstract
The experiment was conducted to determine the effects of fish population density on the growth and production of carps fries (Silver carp, Mirror carp and Rui) in polyculture for a period of 90 days in earthen ponds. Mean individual stocking weight (wt) (g) of the fry of silver carp, mirror carp and rui were 0.10, 0.103 and 0.08 under treatment-I and were 0.17, 0.142 and 0.11 under treatment-II. In the ponds under both treatments, inorganic and supplementary balanced feed (50% per body weight) was used to the cultured ponds for spawn to fish fingerlings. During the experimental period, the ranges of water temperature (26 to 34 ^{0}C), transparency (28 to 41 cm), dissolved oxygen (2.45 to 5.5 mg/L), pH (7.0 to 8.5), total alkalinity (130 to 182 mg/L), and ammonia nitrogen (0.12 to 0.3 mg/L) found were within the productive limit and more or less similar in all the ponds under treatment-I and II. The survival rate of silver carp was 38.60 and 66.48 under treatments I and II. The survival rate of mirror carp was 31.20% and 45.50% under treatment I and II and the survival rate of rui was 31.51% and 53.35% under treatment I and II, respectively. The calculated net fish production of the ponds under treatment-I was 1905.13±141.95 kg ha^{-1} $90d^{-1}$ and that of the ponds under treatment-II was 3831.74±411.35 kg ha^{-1} $90d^{-1}$. It was found that net fish growth, survival rate and productions was better in treatment-II than treatment-I. Finally it is concluded that the growth, survival rate and production of fry up to fingerlings would be better by intervention of proper stocking density of various fish species in pond fish culture.

Keywords: Fish Population Density, Water Quality Parameter, Survival Rate, Specific Growth Rate, Fish Production

1. Introduction
Aquaculture could be one of the best options for the rural people, which can generate income, employment and food security and can contribute significantly to alleviate rural poverty [1]. The people of Bangladesh largely depend on fish as a principal source of animal protein, which contributes about 60% of the nation's animal protein intake [2]. Polyculture gives higher production than monoculture in extensive and semi-intensive systems because most of the available natural foods in the pond are utilized by fish in this culture system [3, 4, 5]. Polyculture may produce an expected result if fish with different feeding habits are stocked in proper ratios and combinations [6].
Hypophthalmichthys molitrix, a species of East-Asian origin, has a special economic and alimentary importance, which is mainly due to its nutritive and curative qualities, it's meat representing a high-quality animal protein source [7]. Silver carp is expected to have a strong impact on the pond ecology, because it is a very effective filter feeder [8]. It is a cheap fish that the farmer's family can afford to eat instead of selling [9].
The common carp is one of the most important farmed freshwaterfish species in the world [10]. Common carp through its bottom stirring activity makes nutrients available to the eutrophic pond water, which results in the development of rich algal communities upon which silver carp feeds [11].

Labeo rohita is the most important among the Indian major carp species used in polyculture systems. It has every high food value and commercial importance and is highly liked for its taste and flavor [12].

Most of the fish farmers of our country believe that higher density will give more production. So they release fish fingerlings or fry in very higher density and for this reason various abnormal situation occur in the pond including very low growth and production of fishes. On the other hand, if the fish population density is low in culture of fishes it may bring loss which may dishearten the farmers. Different scientists worked on stocking densities of fishes like [13, 14, 15, 16, 17, 18]. But there is lack of research on stocking density of carp fishes in the Natore area. Thus the aim of the present study was to evaluate the suitable stocking density of *Hypophthalmichthys molitrix, Cyprinus carpio var. specularis* and *Labeo rohita* and determine the survival, growth rate and production of carps spawn in the ponds.

2. Materials and Methods

2.1 Study period and site

The research was carried out at the Banbelgharia, the Government fish seed production farm, Natore Sadar Upazila under Natore district, Bangladesh (Figure 1) for a period of 3 months (April to June, 2012) in six experimental fish ponds. Each pond has inlet for watering but no outlet. The ponds were dependable on rainfall and deep tube well water.

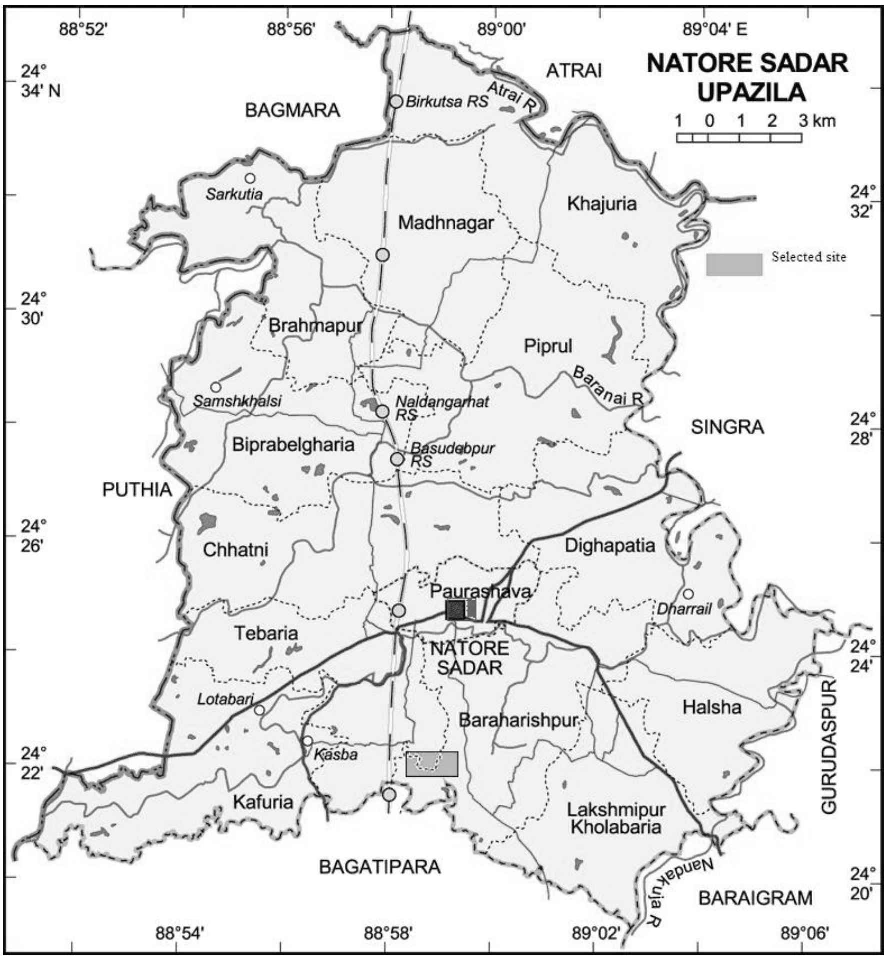

Fig. 1: Map of Natore Sadar Upazila showing study area

2.2 Experimental design

The experiment was conducted in Completely Randomized Design (CRD). The ponds were two treatments each having three replications. Under treatment-I, the population density of Silver carp, Mirror carp and Rui was 7817 fry/decimal (i.e. 2432 silver carp + 2425 mirror carp + 2960 Rui) and under treatment-II fish population density was 6253 per decimal (1945 silver carp + 1940 mirror carp + 2368 Rui).

2.3 Pond preparation, stocking and fertilization

Ponds under the treatment I were new made and the Treatment II were renovated, dried and cleaned of aquatic vegetation manually. Liming (Cao) was done in all the ponds at rate 1 kg/decimal before 7 days of fertilization. Seven days after liming, Urea and Triple Super Phosphate (TSP) were applied at the rate of 100g/decimal and 100g/decimal respectively as initial doses. Sumithion was done in all the ponds at rate 100 ml/decimal after watering. Fertilization of the ponds under treatment I and treatment II was done with the application of Urea (4 kg/decimal) and triple super phosphate (2 kg/ decimal). TSP was dissolved in water for 24 hours in a plastic bucket and then applied by spreading over the pond surface. Urea was dissolved in a bucket and then applied by spreading with a mug on the pond surface. Fertilization was done fortnightly.

2.4 Water quality parameters

Water quality parameters such as water temperature (^{0}C), pH, dissolved oxygen (mg/L), total alkalinity (mg/L)), transparency (cm), were recorded between 10 AM and 12 PM. Water temperature was recorded using a Celsius thermometer at 15-20 cm depth. Water transparency was measured by a Secchi-disk. Dissolved oxygen was measured by the aid of a water quality test kit (HACH kit model FF-2, made in USA). The negative logarithm of the hydrogen ion concentration or pH of water was measured by using HACH kit (model FF-2, cat. No. 2430-01, made in USA).Total alkalinity (mg/L) was determined by titrimetric method using methyl orange indicator.

2.5 Estimation of growth, survival and production

The survival rate was estimated by the following formula:

$$\text{Survival rate (\%)} = \frac{\text{No. of harvested fishes}}{\text{Initial no. of fishes}} \times 100$$

$$\text{Weight gain (g)} = \text{Meanfinal weight (g)} - \text{Mean initial weight (g)}$$

$$\text{SGR (\% per day)} = \frac{\text{Ln (final weight)} - \text{Ln (initial weight)}}{\text{Culture period (days)}}$$

2.6 Statistical analysis

Water quality, growth, survival rates (%) and fish production were subjected to using computer Microsoft Office and Excel.

3. Results and Discussion

3.1 Physical parameters

Throughout the experimental period a number of physicochemical parameters of water such as water depth, transparency, water temperature, pH, dissolved oxygen total alkalinity, ammonia were identified. The results of all the water quality parameters of all the ponds have been given in Table 1.

Table 1: Fortnightly fluctuations of physical parameters of ponds under treatment I and treatment II during the experimental period

Parameters	Treatment I				Treatment II			
	R_1	R_2	R_3	Mean	R_1	R_2	R_3	Mean
Water depth (m)	0.89±0.04	0.91±0.03	0.89±0.04	0.90±0.02	0.89±0.050	0.89±0.034	0.92±0.024	0.90±0.021
Transparency (cm)	35.38±5.60	35.13±5.77	34.50±5.53	35.00±4.88	34.13±2.29	33.38±2.26	33.38±2.13	33.63±1.40
Water temperature	30.00±2.93	30.13±2.70	30.00±2.88	30.04±2.81	30.13±2.16	30.00±2.20	29.75±1.98	29.96±2.06

All water quality parameters tested throughout the experimental period revealed that all parameters were within the permissible limits in pond water for fish culture as reported by [19].

The mean values of water depth under treatment-I and treatment-II were 0.90±0.02m and 0.90±0.021m respectively. Because of high seepage and high evaporation of water, the water depth of the fish ponds was shallower than 1m, although the supply of water was present from a water-supply system of a deep tube-well. Jhingran [20] stated that a depth of about 2m of a pond is suitable from the view point of biological productivity. Rahman [21] and Hossain et al. [22] stated that pond should not be shallower than 1 m and deeper than 5m and optimum depth should be 2m.

The mean values of water transparency of the ponds under treatment-I and treatment-II were 35.00±4.88 cm and 33.63±1.408 cm respectively. Hossain *et al.* [23], Hossain *et al.* [24], and Chakraborty and Mirza [25] recorded almost similar transparency values of pond water in similar experiments. Kohinoor [26] recorded transparency values ranging from 15 to 58 cm. Hossain *et al.* [23], Hossain *et al.* [24] found the transparency range between 17±2.65 to 24±2.65 cm in nursery, grow out and brood stock ponds at Natore Government Fish Farm in Bangladesh.

The mean values of water temperature of the ponds under treatment-I and treatment-II were 30.04 ± 2.81, 29.96±2.07 respectively. Aminul [27] stated that the water temperature ranged from 25 to 35 ^{0}C is suitable for fish culture. Priyadarshini *et al.* [28] recorded almost similar temperature values of pond water in carp rearing pond. So, the temperature of the experimental ponds was within the acceptable range for nursery ponds that agrees well with the findings of Haque *et al*. [29, 30] and Kohinoor *et al.* [31].

3.2 Chemical parameters

The results of the different chemical parameters of the experimental ponds recorded during the experimental period have been presented in the Table 2.

Table 2: Fortnightly fluctuations of chemical parameters of ponds under treatment I and treatment II during the experimental period

Parameters	Treatment I				Treatment II			
	R_1	R_2	R_3	Mean	R_1	R_2	R_3	Mean
Dissolved oxygen (mg/L)	3.58±0.97	3.72±0.94	3.72±0.93	3.67±0.91	4.51±0.30	4.55±0.31	4.66±0.27	4.56±0.50
p^H	8.08±0.62	7.95±0.47	7.98±0.50	8.00±0.43	7.90±0.45	7.75±0.51	7.73±0.43	7.79±0.43
Total Alkalinity	153.50±14.27	155.38±16.41	158.13±16.01	155.67±12.23	156.63±11.33	157.88±12.08	157.75±15.78	157.42±10.37
NH_3-N (mg/L)	0.20±0.08	0.18±0.07	0.21±0.08	0.20±0.07	0.20±0.05	0.20±0.08	0.21±0.06	0.20±0.05

The mean values of dissolved oxygen content recorded in the present experiment under treatment-I and treatment-II were 3.67 ± 0.91 and 4.56±0.50 mg/l respectively which is similar to the findings of Rahman *et al.* [32] who recorded DO as 3.82±0.72 to 4.84±0.78 in nursery pond. Hossain *et al.* [23], Hossain *et al.* [24], and Chakraborty and Mirza [25] found more or less similar results.

Hossain *et al.* [23] and Hossain *et al.* [24] found the DO range between 5.43±0.39 (mg/l) to 5.09±0.23 (mg/l) in nursery, grow out and brood stock ponds at Natore Government Fish Farm in Bangladesh. The mean values of pH under treatment-I and II were 8.00±0.43 and 7.79±0.43 respectively. Priyadarshini *et al.* [28] recorded pH values 7.73±0.08 to 8.08±0.07 in carp rearing pond. The pH values also agree well with the findings of Rahman *et al.* [32], Hossain *et al.* [23], Hossain *et al.* [24] and Chakraborty and Mirza [25], Kohinoor *et al.* [31], Chakraborty *et al.* [33], Rahman and Rahman [34]. Hossain *et al.* [23], Hossain *et al.* [24], found the pH value between 6.64±0. 95 to 8.32±0.75 (mg/l) in nursery, grow out and brood stock ponds at Natore Government Fish Farm in Bangladesh.

The mean values of total alkalinity of the ponds under treatment-1 and treatment-II were 155.67±12.23 and 157.42±10.37 mg/l respectively. According to Alikunhi [35] total alkalinity more than 100 ppm should be present in highly productive waterbodies. According to Boyd [19] total alkalinity of productive ponds should be 20 ppm or more and fish production increases with the increase of total alkalinity. Hossain *et al.* [23], Hossain *et al.* [24], reported alkalinity varied from 110±5.05 to 117±7.17 cm in nursery pond. Hossain *et al.* [23] found the alkalinityvaried between 169.7±17 (mg/l) to 305.3±19.9 (mg/l) in nursery, grow out and brood stock ponds at Natore Government Fish Farm in Bangladesh.

Concentration of total ammonia were 0.20±0.05 to 0.20±0.07 mg/l which is more or less similar with the findings of Alim *et al.* [18] who recorded ammonia-nitrogen content ranges from 0 mg/l to 1.00 mg/l. Wahab *et al.* [36], Kadir *et al.* [37] and Milstein *et al.* [38] recorded NH_3-N of 0.09 to 0.99 mg/l, 0.11 to 0.52 mg/land 0.6 to 0.29 mg/l, respectively. Hossain *et al.* [23], Hossain *et al.* [24], found the ammonia between 0.03±0.0 (mg/l) to 0.21±0.08 (mg/l) in nursery, grow out and brood stock ponds at Natore Government Fish Farm in Bangladesh.

3.3 Growth performance of the experimental fishes

The growth performance of silver carp, mirror carp and rui in terms of mean individual stocking weight (g), survival (%), mean individual harvesting weight (g), SGR (% body weight per day), gross production (kg ha^{-1} $90d^{-1}$), net production (kg ha^{-1} $90d^{-1}$), in different species compositions are shown in Table 3, 4 and 5.

Table 3: Growth performance of *Hypophthalmichthys molitrix* under treatment I and II

Parameters	Treatment-I					Treatment-II				
	R1	R2	R3	Average	± STD	R1	R2	R3	Average	± STD
Mean individual stoking wt (g)	0.1028	0.1032	0.1029	0.10	0.00	0.17	0.18	0.17	0.17	0.01
Survival (%)	38.36	37.10	40.33	38.60	1.63	55.27	79.05	65.13	66.48	11.95
Mean individual harvesting wt (g)	9.80	10.25	9.50	9.85	0.38	29.06	26.90	31.33	29.10	2.22
SGR (% bw d^{-1})	5.06	5.11	5.03	5.07	0.04	5.71	5.56	5.83	5.70	0.13
Gross production (kg ha^{-1} 90 d^{-1})	2258.42	2276.04	2299.57	2278.01	20.65	5835.17	7294.90	7637.91	6922.66	957.28
Net production (kg ha^{-1} 90 d^{-1})	2196.67	2214.28	2237.81	2216.25	20.64	5773.40	7233.14	7576.15	6860.90	957.29

Table 4: Growth performance of *Cyprinus carpio* under treatment I and II

Parameters	Treatment-I					Treatment-II				
	R1	R2	R3	Average	± STD	R1	R2	R3	Average	± STD
Mean individual stoking wt. (g)	0.103	0.103	0.103	0.103	0.00	0.143	0.133	0.150	0.142	0.009
Survival (%)	31.22	29.69	32.70	31.20	1.50	44.55	43.19	48.77	45.50	2.91
Mean individual harvesting wt (g)	9.50	10.65	11.03	10.39	0.80	11.30	11.41	12.00	11.57	0.38
SGR (% bwd^{-1})	5.03	5.16	5.19	5.12	0.09	5.19	4.95	4.87	5.00	0.17
Gross production (kg ha-1 90 d^{-1})	1775.37	1900.99	2162.20	1946.19	197.34	2174.43	2288.84	2410.54	2291.27	118.07
Net production (kg ha-1 90 d^{-1})	1713.61	1839.23	2100.43	1884.42	197.33	2112.67	2227.08	2348.77	2229.51	118.07

Table 5: Growth performance of *Labeo rohita* under treatment I and II

Parameters	Treatment-I					Treatment-II				
	R1	R2	R3	Average	± STD	R1	R2	R3	Average	± STD
Mean individual stoking wt (g)	0.08	0.08	0.08	0.08	0.00	0.11	0.11	0.11	0.11	0.00
Survival rate (%)	30.15	31.35	33.04	31.51	1.45	48.57	54.73	56.76	53.35	4.26
Mean individual harvesting wt (g)	6.50	7.58	7.67	7.25	0.65	8.15	8.00	8.12	8.09	0.08
SGR (%bw d^{-1})	4.83	5.00	5.01	4.95	0.10	4.81	4.78	4.79	4.80	0.02
Gross production (kg ha-1 90 d^{-1})	1432.11	1741.92	1855.39	1676.47	219.10	2284.81	2503.59	2611.34	2466.58	166.38
Net production (kg ha-1 90 d^{-1})	1370.35	1680.16	1793.63	1614.71	219.10	2223.06	2441.84	2549.58	2404.82	166.38

In the present study, the specific growth rates of silver carp was 5.07% and 5.70% under treatments I and II (Table 3). The specific growth rates of mirror carp was 5.12% and 5.00% under treatment I and II (Table 4) and the specific growth rates of rui was 4.95% and 4.80% under treatments I and II (Table 5).Hossain et al.,(2013) reported SGR of silver carp fry ranges from 1.91±0.40 to 2.55±0.43% at stocking density of 123500 ha^{-1}. Priyadarshini *et al.* [28] obtained SGR of *Cyprinus carpio* fry 3.47 %. Hossain and Islam [17] reported the SGR (bwd^{-1}) prawn, catla, rohu and silver carp ranged from 3.99 to 4.26%, 3.71% to 3.83%, 2.49 to 2.55% and 2.44% to 2.59% respectively. The specific growth rate in treated pond II was higher. Desilva and Davy [39] stated that SGR of fish fed on high protein and energy diet shows higher value but fish fed on supplement feeds made on farm shows SGR value between 3-4% per day. From the above discussion it can be concluded that the higher specific growth rates in treatment-II (where fish population density 6253) was due to the maximum use of natural feed for silver, mirror and rui compared to those in treatment-I (where fish population density was 7817). There may be another reason that fry was comparatively small for which it did not create negative impacts on the growth and production of carps cultured in the treatment-II than those of treatment-I.

The survival rates were different in different experimental ponds. The survival rate of silver carp, mirror carp and rui was 38.60% and 66.48%; 31.20 and 45.50 and 31.51% and 53.35% in treatment I and II, respectively. Hossain *et al*. [23] found the survival rate of silver carp 55.05 to 63.11 % in nursery pond which is similar to the treatment II. Priyadarshini *et al.* [28] obtained survival rate of *Cyprinus carpio* fry 52.12% in manure applied pond. Hossain *et al*. [23] reported survival rate of bata (*Cirrhinus reba)* fry ranges from 52.15, 51.10 and 55.18 % in nursery pond.

3.4 Production

The total gross production of all species combined was 1966.89±141.98 kg ha^{-1} $90d^{-1}$ and 3893.50±411.35 kg ha^{-1} $90d^{-1}$ in treatments I and II, respectively. The highest total gross production of all species combined was recorded in treatment-II and lowest in treatment-I. The total net production of all species combined was 1905.13±141.97 kg ha^{-1} $90d^{-1}$ and 3831.74±411.35 kg ha^{-1} $90d^{-1}$ in treatments I and II, respectively. The highest total net production of all species combined was recorded in treatment-II and lowest in treatment-I. Total net production of all species combined among different treatments are shown in Figure 2.

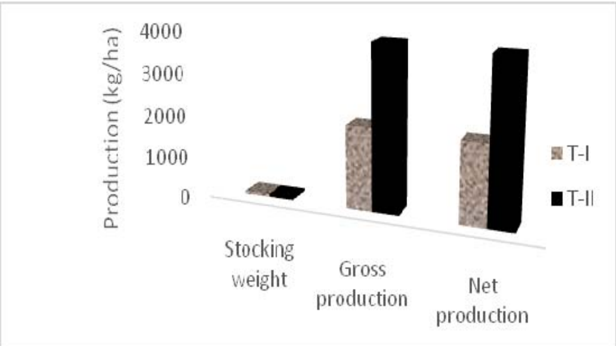

Fig 2: Per hectare stocking weight, gross production and net production in kilogram under treatment I and Treatment II

In the present experiment, calculated gross and net productions of silver, mirror and rui of the ponds under treatment-I were 2278.01±20.65 and 2216.25±20.64 kg ha^{-1} $90d^{-1}$; 1946.19±197.34 and 1884.42±197.33 kg ha^{-1} $90d^{-1}$ and 1676.47±219.10 and 1614.71±219.10 kg ha^{-1} $90d^{-1}$ respectively. Calculated gross and net productions of silver, mirror and rui of the ponds under treatment-II were 6922.66±957.28 and 6860.90±957.29 ha^{-1} $90d^{-1}$; 2291.27±118.07 and 2229.51±118.07 ha^{-1} $90d^{-1}$ and 2466.58±166.38 and 2404.82±166.38 ha^{-1} $90d^{-1}$ respectively. Results indicate that higher gross and net productions of fries were obtained from treatment-II stocked with 6253 fry/decimal than that of treatment-I stocked with 7817 fry/decimal. Bakeer and Tharwat [40] found similar tends in case of silver at stocking density of 500 and 1000 fish/pond. Hossain *et al.* [23] reported production of silver carp ranges from 2058.48±26.68 to 2276.01±85.95 kg/ha/60 days at stocking density of123500ha^{-1}. Priyadarshini *et al.* [28] obtained gross production of *Cyprinus carpio* fry 2309.01 g/tanks/months fed with feed and manure. Saha *et al.* [41] obtained a gross production of 1385.15 to 1995.60 kg $ha^{-1}$by 8 weeks rearing of rohu (*Labeo rohita*) fingerlings at 0.6 to 0.8 million ha^{-1} stocking densities. Rahman *et al.* [42] obtained a production of 1869.10 kg ha^{-1} by rearing *Labeo calbasu* at a stocking density of 0.8 million hatchling ha^{-1}.

Alim *et al.* [18] found in an experiment on polyculture that a 20% increase in large carps stocking did not affect the survival rate of large carps and the production of rohu and catla (but not common carp) and small fish. Hepher *et al.* (1989) found in an experiment on the effect of fish density and species combination on growth and utilization of natural food in ponds' that combined yield of all species in the polyculture was highest at the density of 1300 silver carp/ha (2116 kg/ha in 156 days). At 2600 silver carp/ha density the inhibition of growth rate of silver carp itself, reduced total yield as compared with the lower density (1300 silver carps/ha). Lakshmanan *et al.* [44] conducted an experiment on "Preliminary study on the rearing of carp fingerlings" and found that in the experiment of polyculture of fry of major carps under three densities, viz. 62,500, 93,750 and 125,000 per hectare (i.e. 250, 375 and 500 per decimal), with the species ratio of 3:4:1:2 of *Catla catla*, *Labeo rohita*, *Cirrhina mrigala* and *Cyprinus carpio var. communis* respectively.

4. Conclusion

All of the physico-chemical parameters of the ponds under treatment-I and treatment-II were more or less similar but the higher production of fish was recorded under treatment-II (where fish population density was 6253 per decimal) than that of treatment-I (where fish population density was 7817 per decimal). Stocking wt of fishes in treatments I and II was same but size of the fishes in treatment-II was some large and there was no competition among food, suitable environment, oxygen requirements etc. In this case specific growth rate of carp species was high and production was better. So, the lower fish population density was more suitable and better and did not affect fish production. In case of higher fish population densities, fish population was together and was competition among food, environment and oxygen requirements.

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