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# Impact of feeding strategies on the growth and nutrient discharge in the polyculture of carps using farm ponds

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ABSTRACT

The present study aimed at evaluating appropriate feeding strategies to obtain maximum fish production from farm ponds at low/minimum investment costs was carried out under the Tamil Nadu-Irrigated Agriculture Modernization Project financed by the World Bank. The study was carried out for 180 days at the Directorate of Sustainable Aquaculture, Thanjavur, in four, equal-sized, farm ponds with two treatments in duplicates by stocking 5 species (*Catla catla, Labeo rohita, Cirrhinus mrigala, Ctenopharyngodon idella* and *Cyprinus carpio*) in the ratio of 1:1:1:1:2. Treatment 1 (T1) involved the feeding strategy of pelleted feed with 20% CP (crude protein) broadcast twice a day whereas in Treatment 2 (T2), the same feed was provided four times a day as feed balls using feed trays. Among the five species, *C. carpio* (779±189.01 g) and *C. mrigala* (670±121.38 g) stocked in T2 attained the maximum weight. Production parameters such as gross production, net production, average daily growth rate were not significant between the treatments, however T2 showed comparatively better results than T1. Survival rate of fishes was recorded significantly higher in T1 (35.54±2.60%) than in T2 (29.6±2.36%). Nutrients such as total phosphorus, total nitrogen and total potassium were significant and highly discharged in T1 than in T2. Experiment revealed that feeding fishes in trays helped to monitor the weight gain and feed intake with reduced nutrient discharge, thereby proper feed management was obtained in T2 when compared to T1.

**Keywords:** Carps, Farm ponds, Feeding frequency, Feeding regime, Yield enhancement

India is the second leading country amongst the aquaculture-producing nations in the world being next only to China with a total fish production 14.164 MMT during 2019-20 (Anonymous 2020). As feed becomes the major input in fish farming, it constitutes the largest share of expenses in intensive and semi-intensive aquaculture. Excess feed is considered as one of the major source of wastes that affects water quality. In aquaculture, feed represents 30–70% of farm costs (Verdal *et al.* 2018). Inappropriate feeding practices in pond aquaculture system may lead to overfeeding and hence increased feed wastes would lead to high production cost. Conversely, less feeding may cause poor growth and high mortalities which may cause loss in aquaculture business. Under restricted feeding, animals can convert a greater part of feed to body weight without any negative effect on body growth and nutrient utilization than they are supposed to do under unrestricted feeding ration regime (Ali *et al*. 2003).

Excess nutrients released due to the overfeeding have important implications for the pond's hydro-chemical regime as well as in the development of natural food resources, both of which are extremely important for correct functioning of the pond ecosystem, and for the efficiency and sustainability of fish farming. Thus, this research focusses on the issues which contribute to the better understanding of the interconnection between fish production and applied feeding strategy with respect to water quality determinants.

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## MATERIALS AND METHODS

The present research work was carried out under TN-IAMP (Tamil Nadu-Irrigated Agriculture Modernization Project) in selected farm ponds of delta district Thanjavur (10° 47' 13.1964'' N and 79° 8' 16.1700'' E) of Tamil Nadu, India, through the Directorate of Sustainable Aquaculture, Thanjavur. Duration of research work was 180 days (5 December 2019 to 5 June 2020). The farm ponds were excavated under Government subsidy plans and these ponds presented identical conditions with regard to size (33 Cent/ 0.33 Acre/ 0.132 Hectare), shape (rectangular), water depth (1.5-2.0 m) and pond topography. Farm ponds located within a radius of 500 m were selected to avoid any possible interaction of microclimatic conditions.

Four ponds (T1R1, T1R2, T2R1 and T2R2) were selected to study the influence of feeding strategy on the production in the farm ponds. The feeding strategy that was recommended and followed in the farm ponds was compared with the altered feeding strategy of giving the feeds 4 times a day in check trays. Therefore, Treatment 1 (2-times feeding) was compared with Treatment 2 (4-times

Table 1. Species wise growth and biomass harvested in farm ponds

| Species stocked | Mean final weight (kg) | | | Harvested weight of fishes (kg) | | | Mean final weight (kg) | | | Harvested weight of fishes (kg) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | T1R1 | T1R2 | Mean±SD | T1R1 | T1R2 | Mean±SD | T2R1 | T2R2 | Mean±SD | T2R1 | T2R2 | Mean±SD |
| *L. rohita* | 0.467 | 0.295 | 0.38±0.12 | 47.167 | 33.335 | 40.25±9.78 | 0.608 | 0.428 | 0.52±0.13 | 50.464 | 40.66 | 45.56±6.93 |
| *C. catla* | 0.494 | 0.320 | 0.41±0.12 | 50.882 | 34.56 | 42.72±11.54 | 0.475 | 0.405 | 0.44±0.05 | 40.375 | 38.07 | 39.22±1.63 |
| *C. mrigala* | 0.631 | 0.371 | 0.5±0.18 | 62.469 | 41.552 | 52.01±14.79 | 0.626 | 0.670 | 0.65±0.03 | 51.958 | 62.98 | 57.47±7.79 |
| *C. idella* | 0.250 | 0.332 | 0.29±0.06 | 24.75 | 36.852 | 30.80±8.56 | 0.373 | 0.344 | 0.36±0.02 | 31.332 | 32.336 | 31.83±0.71 |
| *C. carpio* | 0.538 | 0.411 | 0.48±0.09 | 109.75 | 93.708 | 101.73±11.34 | 0.779 | 0.774 | 0.78±0.004 | 130.87 | 143.96 | 137.42±9.26 |
| Total | 2.918 | 2.14 | 2.53±0.55 | 295.02 | 240.01 | 267.51±38.9 | 3.64 | 3.40 | 3.52±0.17 | 305.00 | 318.01 | 311.51±9.19 |
| Overall mean | 0.486 | 0.357 | 0.42±0.09 | 49.17 | 40.00 | 44.59±9.34 | 0.61 | 0.57 | 0.59±0.03 | 50.83 | 53.00 | 51.92±1.53 |

feeding). Each treatment had duplicate ponds as T1R1, T1R2, T2R1 and T2R2. While the method of feeding in T1R1 and T1R2 was pellet broadcasting on the water surface, in T2R1 and T2R2, the same feed was given as feed balls after soaking and making a dough.

These balls were equally placed in 4 check trays fixed in the 4 corners of the pond. About 5-6% feed of the body weight was given during the first month of stocking while 3-4% feed of body weight was given in the subsequent months. The feeding time and feeding place were fixed for both treatments as 9.00 AM and 6.00 PM for two times feeding in T1 while 9.00 AM, 12.00 PM, 3.00 PM and 6.00 PM for four times feeding in T2.

All the four ponds were stocked uniformly with 5 carp species, viz. *Catla catla, Labeo rohita, Cirrhinus mrigala, Ctenopharyngodon idella* and *Cyprinus carpio* in a same stocking ratio (1:1:1:1:2). Animals were stocked at a stocking density of 13,636 fingerlings/ha with an average biomass (±3.93 kg) uniformly in both treatments. Commercial pellet feed with 20% CP (crude protein) was fed to the fishes throughout the trial. The dose of lime (30 kg) and cow dung (1320 kg) were calculated for the culture area and applied. Before stocking, all the water quality parameters (*p*H, temperature, alkalinity, TDS, dissolved oxygen and ammonia) were analysed and found suitable.

The farm ponds under study were periodically monitored for collection of water sample, fish sampling, feeding monitoring, fertility monitoring and technical guidance to the farmers. Samples were regularly analyzed at the water quality laboratory, Thanjavur Centre for Sustainable Aquaculture (TCeSA), as per the standard methodology and the parameters were recorded. Variations in the climatic conditions and pond hydro-biological parameters were recorded to moderate the errors that would normally influence the results. The recorded data were statistically analysed using Graphpad prism software (Version 6.1), and one-way ANOVA analysis revealed significant relationships in growth performance at $P<0.05$.

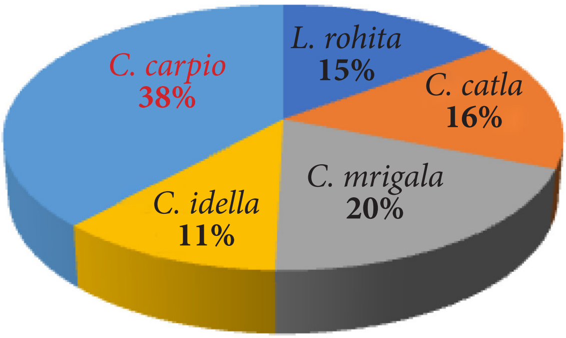
## RESULTS AND DISCUSSION

Growth and production parameters of fishes stocked and grown in farm ponds, where impact of different feeding strategies was experimented are presented in Tables 1, 2 and 3. All the physico-chemical and biological parameters of water quality were found suitable and within the range during the experiment (Table 4). In T2 ponds, the mean values of water quality parameters and pond water fertility factors are given in Table 4. The statistical analysis revealed no significant difference ($P>0.05$) between water temperature, TDS, dissolved oxygen, *p*H, alkalinity and GPP during the culture period; while total phosphorus, total nitrogen and total potassium were found significantly different ($P<0.05$). During the present research work, most of the water quality parameters were within the acceptable range as suggested by Boyd and Zimmermann (2000). During the experiment, TDS (total dissolved solids) ranged from 0.30±0 to 0.38±0.05 ppt (Table 4). The variation in the range of TDS may be due to use of supplementary feeds (Ogbeibu and Edutie 2006).

Table 2. Biomass production parameters of fishes in the farm ponds

| Species | Initial biomass (kg) | | Final gross biomass (kg) (Mean±SD) | | % in final gross biomass | | Net biomass produced (kg) (Mean±SD) | | % in total net biomass | |
|---|---|---|---|---|---|---|---|---|---|---|
| | T1 | T2 | T1 | T2 | T1 | T2 | T1 | T2 | T1 | T2 |
| *L. rohita* | 0.681 | 0.681 | 40.25±9.78 | 45.56±6.93 | 15.05 | 14.63 | 39.57±9.78 | 44.88±6.93 | 15.01 | 14.59 |
| *C. catla* | 0.741 | 0.741 | 42.72±11.54 | 39.22±1.63 | 15.97 | 12.59 | 41.98±11.54 | 38.48±1.63 | 15.93 | 12.51 |
| *C. mrigala* | 0.735 | 0.735 | 52.01±14.79 | 57.47±7.79 | 19.44 | 18.45 | 51.28±14.79 | 56.73±7.79 | 19.46 | 18.45 |
| *C. idella* | 0.627 | 0.627 | 30.80±8.56 | 31.83±0.71 | 11.51 | 10.22 | 30.17±8.56 | 31.21±0.71 | 11.45 | 10.15 |
| *C. carpio* | 1.146 | 1.146 | 101.73±11.34 | 131.42±9.26 | 38.04 | 44.12 | 100.58±1.34 | 136.27±9.26 | 38.16 | 44.30 |
| Total | 3.93 | 3.93 | 267.51±38.9 | 311.51±9.19 | 100 | 100 | 263.58±38.90 | 307.58±9.20 | 100 | 100 |

T1




T2

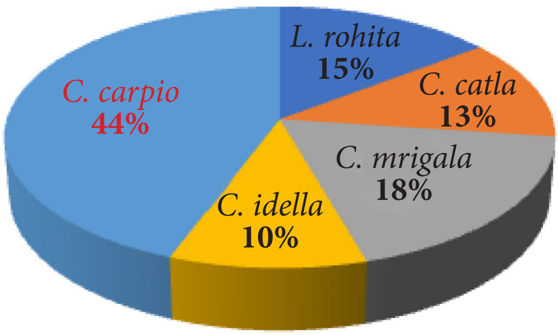



Fig. 1. Mean contribution (%) of individual species in net biomass production in the ponds where different feeding strategies were investigated.

The initial biomass in both the treatments was similar (3.93 kg) (Table 4). No significant difference (P>0.05) was found between mean final body weight of individual fish at harvest (kg), average weight of fishes at harvest (kg) and average growth rate of the individual fish species (kg/ha/day). But mean surviving candidates of fishes and mean survival rate of fishes (%) were found significantly different (p<0.05). ADG rate was 1.86 kg/ha/day (16.77%) higher in the ponds fed 4 times with check tray, where the growth rate for each fish was observed 3.21 g/day (Table 3) which is higher than the reported ADG by James and Andrew (1989).

In the trial ponds, the mean contribution of individual species (in percentage) of the total production is depicted in Fig.1. Among the stocked carps in T1, the maximum average weight was found with *C. mrigala* which was 0.50±0.18 kg and minimum with *C. idella* (0.29±0.06 kg) (Table 1). In T2, the maximum by the *C. carpio* was 0.78±0.004 kg and the minimum by the *C. idella* (0.36±0.02 kg) (Table1). Although they were stocked equally, the maximum difference in harvested mean biomass was found with *C. carpio* that was 17.83 kg higher in T2 than that of T1 (Table 1).

In the analysis of biomass production, it was seen that the fishes in T2 ponds contributed higher than the fishes in T1 (Table 2) with an exception of *C. catla.* This might be due to the surface feeding habit of Catla, the pellet broadcasting would have been effected much with easy availability to

Table 3. Estimated production parameters in the farm ponds

| Treatment/ feeding strategy | Species stocked | Treatment | Stocking density/ ha | Mean survival rate (%) | Gross production / ha | Net biomass produced (kg) | Net biomass production (kg/ ha) | Average daily growth rate (kg/ha/day) | Difference in net biomass among treatments | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | kg/ha | % |
| T1/ Two times a day with pellet broadcasting | Carps alone (rohu + catla + mrigal + grass carp + common carp) | T1R1 | 13636 | 33.70 | 2235 | 291.09 | 2205.227 | 12.251 | 333.26 | 16.69 |
| | | T1R2 | 13636 | 37.38 | 1818.235 | 236.08 | 1788.462 | 9.936 | | |
| | | T1 (Mean±SD) | 13636 | 35.54±2.60 | 2026.62±294.69 | 263.58±38.90 | 1996.85±294.70 | 11.09±1.64 | | |
| T2/ Four times a day with check tray | Carps lone (rohu + catla + mrigal + grass carp + common carp) | T2R1 | 13636 | 27.93 | 2310.61 | 301.07 | 2280.83 | 12.67 | | |
| | | T2R2 | 13636 | 31.27 | 2409.17 | 314.08 | 2379.39 | 13.22 | | |
| | | T2 (Mean±SD) | 13636 | 29.6±2.36 | 2359.89±69.69 | 307.58±9.20 | 2330.11±69.69 | 12.95±0.39 | | |

Table 4. Physico-chemical parameters and fertility factors of water in the farm ponds

| Treatment | Physico-chemical parameters | | | | | Fertility factor | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Temp. (°C) | TDS (PPT) | *p*H | Alkalinity (mg/l) | D. O. (mg/l) | Total nitrogen (mg/l) | Total P (mg/l) | Total potassium (mg/l) | Gross primary productivity (gC/m³/h) |
| T1R1 | 28.75±2.36 | 0.33±0.05 | 8.25±0.25 | 184.61±10.55 | 4.53±0.14 | 1.54±0.02 | 0.22±0.01 | 1.27±0.01 | 0.45±0.02 |
| T1R2 | 28±2.45 | 0.35±0.06 | 8.40±0.50 | 189.69±7.29 | 4.27±0.26 | 1.41±0.02 | 0.23±0.02 | 1.22±0.01 | 0.48±0.02 |
| T1 (Mean±SD) | 28.38±0.53 | 0.34±0.01 | 8.33±0.11 | 187.15±3.59 | 4.40±0.18 | 1.48±0.09 | 0.225±0.01 | 1.245±0.04 | 0.47±0.02 |
| T2R1 | 28.75±2.75 | 0.38±0.05 | 8.34±0.25 | 193.73±7.63 | 4.39±0.25 | 1.25±0.05 | 0.20±0.01 | 1.29±0.01 | 0.51±0.03 |
| T2R2 | 28.25±3.30 | 0.33±0.05 | 8.46±0.26 | 189.63±3.32 | 4.42±0.28 | 1.59±0.02 | 0.23±0.02 | 1.37±0.01 | 0.46±0.02 |
| T2 (Mean±SD) | 28.5±0.35 | 0.355±0.035 | 8.4±0.08 | 191.68±2.89 | 4.41±0.02 | 1.42±0.24 | 0.22±0.02 | 1.33±0.06 | 0.49±0.04 |

Catla compared to other fishes. The contribution of common carp was higher in both treatments (T1 and T2) because of the higher stocking of common carp. Since common carp population was higher and their feeding habits also support feeding with check trays, the production would have been higher. These results were similar to the findings of Nasreen (2017) who found that the growth performance of *C. carpio* was the best by feeding three meals a day and the feeding frequencies had positive effect on fish survival rate ($P<0.05$).

The net biomass production in T2 ponds was 16.69% higher than that of T1 (Table 2). This sort of higher growth resulting due to increased feeding frequency was proved by Jamabo *et al*. (2015). This may be due to the fact that feed consumed in a day is an essential consideration in fish feed management as it influences growth, survival, feed conversion, water quality as well as profit maximization.

The average survival rate of fishes was 5.94% higher in the ponds (T1) where 2 times feeding with pellet broadcasting was practised (Table 3), which is statistically significant ($p<0.05$). This implies that the four times feeding in check trays would impact the survival of fishes at the early stages as the fishes might require feed at more places. The less survival in the ponds fed with check trays could also be compared with the findings of Houlihan *et al*. (2001), where it was observed in a case of access to feed is restricted (like check trays) or the ration size is reduced. To overcome this survival loss, multiple location of feed trays can be encouraged in the fish farming.

Based on the results of the study, the ponds fed four times with check trays (T2) showed better production/ha and also had a suitable water quality (Table 4) during the experiment which is a testimony of minimum wastage of food and high food intake with better food conversion ratio. There was equal GPP and no deficiency of oxygen in the ponds in both the treatments signifying the complimentary effect of multiple feeding through trays. The finding is similar to the reports of Limbu and Jumanne (2014) who observed that optimal feeding scheme enhances growth, pond water quality, survival, size uniformity, helps in minimizing wastage and eventually upsurges production.

Considering the foregoing, it can be ascertained that the four times feeding could do no harm to the fish but support the growth and help to maintain the water quality parameters within the optimal range; provided that multiple location of feeding might be a complimentary factor for meeting their feeding demands and also to improve the survival. The release of nutrients in the culture water can also be reduced to ensure the effective utilization of feed by the fishes.

In the experiment with modified feeding strategies, the harvests revealed that four times feeding in Treatment 2 could support the production better than the two times feeding in Treatment 1 with improved water quality and net biomass production. The results of the study confirmed that the four times feeding was beneficial in enhancing the production in the farm ponds with minimal nutrients discharge. Further research can be recommended with enhanced number of check trays and enhanced feeding frequency per day to check the results.

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