OBSERVATIONS ON THE EFFECT OF FERTILIZER AND FEED APPLICATIONS ON THE GROWTH OF *PENAEUS INDICUS* H. MILNE EDWARDS

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Abstract

Growth of *Penaeus indicus* in relation to phosphate fertilizer and feed applications was studied in marine microcosms. The 1st dose of fertilizer did not appear to have any bearing on Chlorophyll-a and zooplankton production. An increase in sediment phosphate was obvious following addition of 1st dose of fertilizer in the treated pools. Shrimp production was the highest in pools treated with fertilizer and feed and was the lowest in the control. Difference in shrimp growth among various treatments was highly significant except between control and the pools treated with feed alone.

Introduction

A rational approach towards marine fish harvest necessitates enhanced supply of food for the cultured species. This can be made possible by innovating techniques in mariculture systems towards the supply of the required nutrients so as to intensify phytoplankton production, a process analogous with the use of fertilizers to boost up agricultural crops.

The tremendous impact of supplementary feed in prawn culture system has already been established (Sedgewick, 1979; Ahmed Ali, 1982). Nevertheless, contributions on the combined effect of fertiliser along with artificial feed on marine shrimp growth are rather scanty except for the preliminary observations by Rubright *et al.* (1981), on the growth responses of *Penaeus stylirostris* to inorganic fertilizer and feed applications. The present account summarises investigations made to analyse the impact of phosphate fertilizer with and without supplementary feed in the nursery phase of the marine prawn *Penaeus indicus.*

Material and Methods

Because of the paucity of sea water ponds, the experiment was carried out in plastic pools, simulating marine micro environments. The experiment was set up in the prawn culture Laboratory of CMFRI at Narakkal during March to May, 1985.

Twelve Plastic pools (90 x 50 cm, 0.64 m^2 area) were filled with sea water after spreading a soil substratum (clay : sand = 1:6). The water level was maintained at 50 cm height.

The experiment was conducted in triplicate. Three of the 12 pools received only fertilizer (FR pools), another 3 pools received only feed (FD pools) and the last set of 3 pools were left without fertilizer or feed (C Pools). The fertilizer used was single super phosphate (0–16–0), the rate used being 3.63 g PO_4/pool (9.0 kg PO /ha). The application of the fertilizer was made in 2 doses of 2.42 g/pool (6.0 kg/ha) and 1.21 g/pool (3.0 kg/ha), the period of application being the 1st day and 25th day of the start of the experiment respectively. The fertilizer was allowed to dissolve gradually by keeping in a petridish on the soil substratum. Five days after the addition of fertilizer, the pools were stocked with post larvae-5 of *P. indicus*, the stocking rate being 200 nos/pool (31.25 lakhs/ha). The test animals had an initial average length/weight of 6.48 mm/0.60 mg. All the pools were aerated for 2 hours every day in the morning and evening.

Starting from the 2nd day of stocking, pellatised feed was supplied once a day in the FF and FD pools during the evening hours. The feed had a combination of feed base: *Squilla*, prawn waste, fish meal and ground nut oil cake: 59.3%, tapioca 37.0% and fish oil 3.7%. The protein composition of the feed was 24.5%. The feed was given @ 50 to 200% of the initial body weight of the larvae stocked in the FF and FD pools in a phased manner.

The pools were ecologically monitored biweekly for the water temperature, dissolved oxygen and pH. Salinity was maintained to 30 ± 1 ppt. Water samples were analysed weekly to estimate the phosphate, nitrite, nitrate and chlorophyll-a (Strickland and Parsons, 1968) and total ammonia (Zolarzano, 1969). Total Chlorophyll-a concentrations were considered proportional to the actual densities of phytoplankton in the samples.

Samples of soil collected every week from the pools were dried, powdered and analysed for the phosphate content (FAO, 1975).

Growth studies of the test animals were carried out based on total length measurements of random samples of 25 shrimp per pool every week. On harvesting, survival rate and average total length (mm)/weight (mg) were noted. Average values of triplicate pools were taken in reckoning the

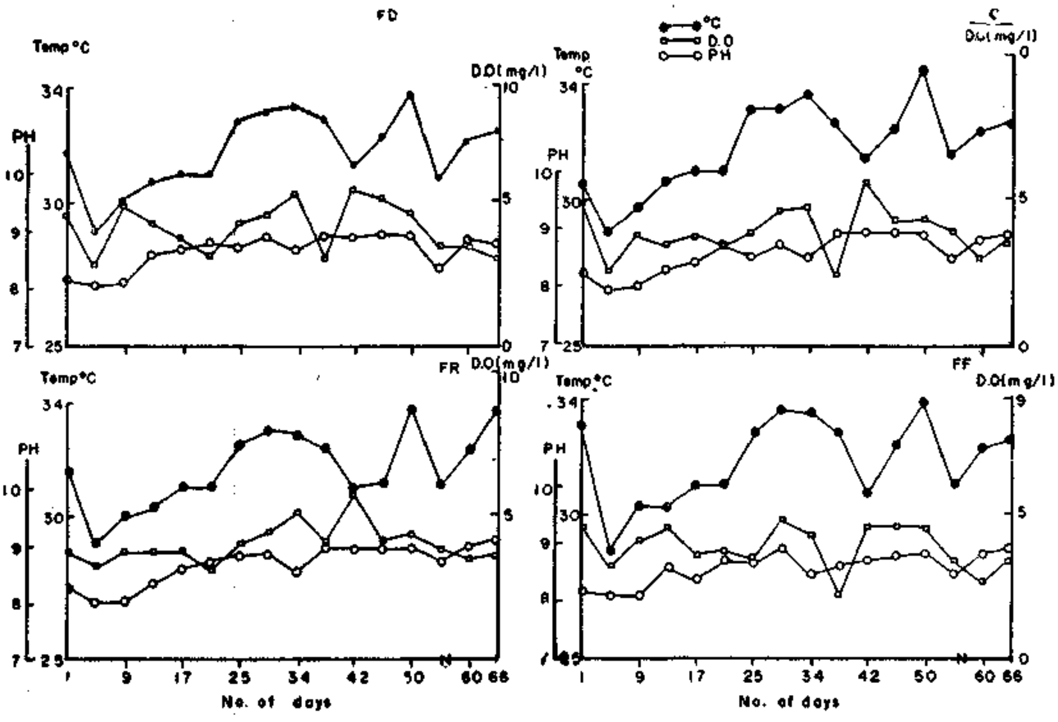

FIG. 1. Average water temperature, pH and dissolved oxygen in various treatments.

data. The experiment was run for a period of 66 days.

Observations

Hydrology (Fig. 1)

Water temperature, dissolved oxygen and pH in all the pools followed almost the same pattern, irrespective of the treatment. However, temperature and pH were found to show an increasing trend towards the end of the experiment in all the treatments.

Total ammonia nitrogen was at the maximum being 0.705, 0.581, 0.410 and 0.573 µg at/l in the FR, FF, FD and C pools respectively on the 42nd day of culture irrespective of the treatments (Table 1). Simultaneously during this period, the pH values were at a higher level (8.45–9.13) in these pools. Interestingly, during this period, the Chlorophyll-a concentration was also at a high viz. 31.813 µg/l and 50.297 µg/l in the FR and FF pools respectively.

Nitrite-nitrogen in the FD and C pools was at a maximum viz. 7.467 µg at/l and 6.356 µg at/l respectively on the 55th day of the experiment (Table 1). In the FR pools, the concentration was at a higher level (3.995 µg at/l) towards the second half of the experiment, while the FF pools showed a low nitraite–nitrogen (0.574 to 1.742 µg at/l) throughout the culture period.

TABLE 1. *Concentration of mean ammonia nitrogen, nitrate nitrogen and nitrite nitrogen in (µg at/l) various treatments*

Treatment	Parameters	Sampling days						
		1	5	13	25	42	55	66
FR	NH_3	0.007	0.025	0.007	0.173	0.705	0.070	0.013
	NO_3N	1.072	—	7.858	17.455	9.293	1.679	0.119
	NO_2N	—	1.155	—	2.549	3.995	2.322	1.095
FF	NH_3	0.007	0.020	0.010	0.153	0.581	0.125	0.064
	NO_3N	0.238	—	2.034	15.761	2.412	3.900	0.438
	NO_2N	0.574	1.617	1.181	1.742	1.629	0.981	1.048
FD	NH_3	0.042	0.020	0.010	0.165	0.410	0.074	0.059
	NO_3N	1.191	0.476	2.782	15.906	3.284	1.541	0.438
	NO_3N	0.534	0.561	1.742	1.715	1.121	7.467	1.550
C	NH_3	0.027	0.008	0.145	0.153	0.573	0.132	0.047
	NO_3N	—	0.143	4.450	16.204	2.160	2.486	—
	NO_2N	0.534	0.534	1.742	1.775	1.689	6.356	1.589

FR = Fertilizer alone, FF = Fertilizer and feed, FD = Feed alone, C = Control.

Nutrients (Table 1; Fig. 2)

Observations on the nutrient parameters in the water indicated a higher phosphate content (FR-22.952 µg at/l; FF-20.57 µg at/l) in the fertilized pools immediately after the addition of the first dose. But subsequently, a sharp decline in the phosphate concentration in these pools was apparent reflecting its utilization (Fig. 2). In contrast, the water phosphate content in the untreated pools remained at a low level (FD-0.436 to 2.13 µg/at/l; C-0.436 to 6.038 µg at/l).

Nitrate-nitrogen was the highest on the 25th day of the experiment, the value being 17.455, 15.761, 15.906 and 16.204 µg at/l in the FR, FF, FD and C pools respectively

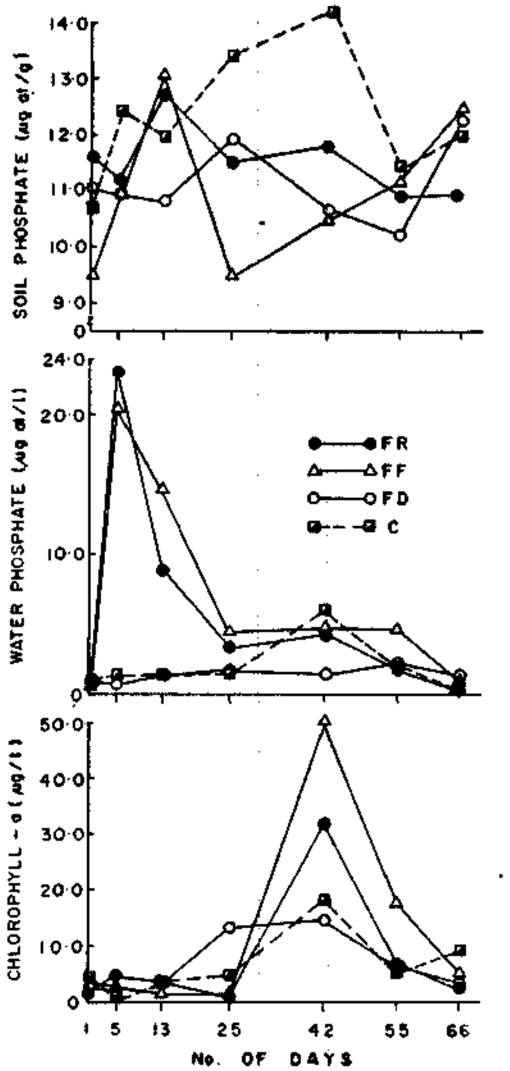

FIG. 2. Average concentration of Chlorophyll - a, water phosphate and soil phosphate in various treatments.

and declined thereafter towards the end of the experiment.

Chlorophyll-a (Fig. 2)

In the fertilizer treated FR and FF pools, chlorophyll-a concentration reached a high of 31.813 µg/l and 50.297 µg/l respectively on the 42nd day, 17 days after the 2nd application of fertilizer while in the non-treated FD and C pools, the chlorophyll-a was at a moderate level throughout the experiment. However, none of the treated pools showed any immediate reflection of the 1st treatment of fertilizer. Beyond the 55th day, the chlorophyll-a content did not indicate any marked difference between the fertilized and unfertilized pools.

Zooplankton (Fig. 3)

Zooplankton community was dominated by rotifers (73.68%) followed by copepods along with nauplii larvae (13.76%), ciliates (6.63%) and tintinnids (5.2%). Other minor forms encountered were larvae of bivalves, polychaetes, nematodes, synacocysts and streptothecae.

Rotifer stock in all the pools showed a peak on the 25th day, irrespective of the

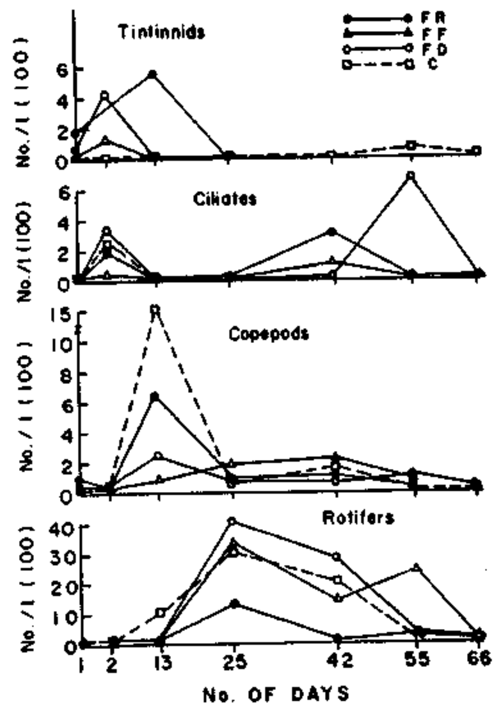

FIG. 3. Average numerical abundance of zooplankton in various treatments.

effect of the 1st dose of fertilizer, thereby suggesting the occurrence of an inherent population (Fig. 3). But subsequently, a sharp decline was noticed in the rotifer bloom in all the pools except in the FF pools indicating its utilizaton. In the FF pools, another spurt of rotifer bloom was discernible on the 55th day.

Copepod population was found to be richer in the control pools during the initial phase of the experiment suggesting the occurrence of an inherent population. However, in the treated pools, no such correlation was noticed.

Ciliates indicated a sudden increase on the 5th day in all the pools except the FF pools. The effect of second application of fertilizer was evident in the FR and FF pools on the 42nd day, while the maximum ciliate concentration of 669 no/l was noticed in the FD pools on the 55th day. Nevertheless, in all the pools, the ciliates declined in their concentration towards the end of the experiment.

Tintinnids also showed an increase on the 5th day of the start of the experiment, depleting immediately after the 13th day. In the C pools tintinnid population was meagre althrough the experiment period.

Soil phosphate (Fig. 2)

Total phosphate content of the sediment was at a comparatively higher concentration in all the pools irrespective of the treatments. Neverthless, in the FR and FF pools, a sharp increase to 12.74 and 13.77 µg at/g respectively was obvious on the 13th day. In the FD and C pools, the concentration was found to maintain a steady level throughout the experiment.

TABLE 2. *Effects of various treatments on the growth of* P. indicus

Treatments	No. of* days of culture	Initial mean total length mm/ weight (mg)	Final total length (mm) mean and SD	Final mean weight (mg)	Survival %	Growth rate per day (mm)
FR	62	6.48/0.60	24.09 ± 7.74	144.33	15.00	0.3162
FF	62	,, ,,	26.47 ± 3.85	120.03	75.60	0.3198
FD	62	,, ,,	20.94 ± 4.77	92.66	39.50	0.2346
C	62	,, ,,	21.63 ± 4.90	61.75	28.33	0.2318

*Shrimps were introduced on the 5th day.

TABLE 3. *Comparison of the growth of* P. indicus *in various treatments using 't' test*

Treatments	d.f. (n–2)	Calculated	Significance level 0.05	0.02	inference
FR and FF	542	4.43	1.960	2.576	S
FR and FD	325	4.44	1.960	2.576	S
FR and C	258	3.13	1.960	2.576	S
FF and FD	689	16.51	1.960	2.576	S
FF and C	622	12.94	1.960	2.576	S
FD and C	405	1.42	1.960	2.576	N.S.

Shrimp growth and survival
(Tables 2, 3; Fig. 4)

Shrimp growth and survival rate were found highest in FF pools (26.47 ± 3.85 mm; 75.70%) with the lowest in control (21.63 ± 4.90 mm; 28.33%). Between FR and FD pools, it is noticeable that despite the better growth in FR pools, survival rate was comparatively less, while in FD pools, though the average growth was only 20.94 ± 4.77 mm the survival rate was moderate (39.5%). Average final shrimp weight in FR, FF, FD and C pools was 144.0, 120.03, 92.67 and 61.75 mg respectively.

A comparison of the various treatments using 't' test (Table 3) indicates that there is significant difference in the final average length of shrimp between FR and FF (t = 4.43), FR and FD (t = 4.44), FR and C (t = 3.13), FF and FD (t = 16.51) and FF and C (t = 12.94). However, growth in FD and C pools was found to be not significant (t = 1.42).

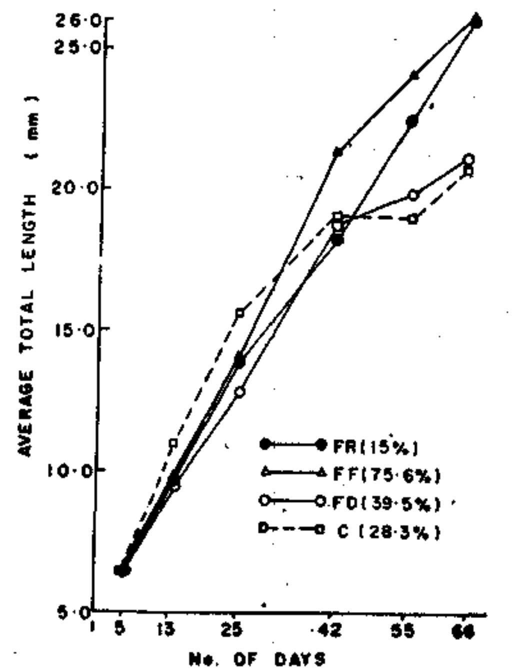

FIG. 4. Weekly shrimp growth in various treatments (Figures given in parantheses indicate percentage of survival in each treatment).

DISCUSSION

The role of nitrogen as primary limiting nutrient in marine environment has been much discussed (Thomas, 1966; Collier, 1970; Vince and Valiela, 1973). Though the postulated N:P ratio of phytoplankton is 10:1 (Ryther and Dunstan, 1971), investigations by Mc Allister *et al.* (1961) as quoted by Vince and Valiela (1973) have shown that under favourable condition and rapid growth phytoplankton may absorb more phosphate than the ratio predicts. As such with the 'average' sea water containing available phosphorus to the tune of only 2.3 mg at/m^3, compared to 34.5 mg at/m^3 of nitrogen (Redfield *et al.* 1963), phosphate can become the limiting factor followed by nitrogen (Collier, 1970). In the present study, though a comparison on the role of nitrogen and phosphorus as limiting factors was not possible, it was apparant that addition of phosphate fertilizer had tremendous effect on chlorophyll-a production in FF and FR pools on the 42nd day, after the 2nd fertilizer application.

Nevertheless, the 1st treatment of fertilizer did not appear to have immediate effect on chlorophyll-a concentration though it was found dissolved in water and declining subsequently (Fig. 2). Observing similar condition in his investigations, Einsele (1941) as quoted by Hepher (1958) has suggested that phosphorus is probably absorbed by the phytoplankton in an 'active' physiological way. According to this view, the absorbed phosphate does not form a part of the organic matter building the cells, but is stored in the cells for future use. It is also postulated that phosphate added as nutrient can also be absorbed by the mud (Hepher, 1958). This view is substantiated in the present case, where sediment phosphate in FR and FF pools showed a sharp increase between the 5th and 13th day of administering the first treatment of fertilizer (Fig. 2). Thus it may be surmised that the phosphate nutrient added initially is either stored by the phytoplankton and/or is absorbed by the mud, thereby not reflecting immediately in the chlorophyll-a concentration.

Earlier studies on the food habits of *P. indicus* showed that the post larvae (5–10 mm) feed mainly on zooplankton including rotifers, copepods, copepodites, very small worms and larval stages of various aquatic invertebrates, while juveniles (11–25 mm) and adults (26 mm and above) prefer organic detritus and a variety of small animals (Gopalakrishnan, 1952; James, 1978). In this experiment, the post larvae reached the juvenile stage by the 13th day. A corroboration of the zooplankton population with the shrimp growth showed that during the post larval stage, they were subsisting mainly on ciliates and tintinnids which were found declining from the 5th to 13th day (Fig. 3). And after the 13th day, with the emergence of juvenile stage possessing, a detritus feeding habit, the zooplankton including copepods and rotifers would have contributed towards the formation of detritus, the latter being rated higher than either phytoplankton or zooplankton for their nutritive value (Kumari *et al.,* 1978). A large quantity of organic material produced during the sudden plankton spurts could also have been utilised as available energy towards the formation of detritus. And according to Tucker *et al.* (1979), the frequent addition of nutrients from metabolic waste and uneaten feed also enhances plankton production. Apparently, the active growth of shrimp in the present case in the FF pools compared to FR, FD and C pools, suggests the probable role played by fertilizer and feed added, in the formation of plankton and their conversion into detritus, on which prawns are believed to subsist.

A scrutiny of the data on shrimp growth among various treatments highlights certain noteworthy features. Significant differences in the growth pattern of shrimp in FF pools with either FR, FD or C pools were discernible. Likewise in the FR pools, growth of test animals was markedly different from that of FD and C pools. In the control pools, growth rate was found to be significantly different from FR and FF pools, while no difference was noticed with that of FD.

A parallel observation on the survival rate in the various treatments (Table 2) indicates that the FR pools with higher growth rate had the minimum survival rate (15%). Similarly, the FD pools, with a slightly lower growth had a moderate survival rate (39.5%). Though survival rate in culture system is inversely related with stocking density (Chamberlein *et al.,* 1981), in the present study with uniform stocking rate, the reasons for varying survival in different treatments may be attributed to factors like stress due to handling. As such, with the high and moderate survival rates in FF, FD and C pools, the lower survival rate noticed in the FR pools may perhaps be due to mortality occurred in the course of the experiment, with the resultant active growth of the remaining stock.

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