REPORT ON A STUDY OF CONFINED-POND PRAWN FARMING IN CHILKA LAKE, ORISSA

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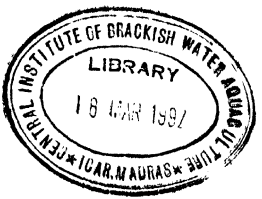

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DECEMBER, 1991

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1 INTRODUCTION

Orissa is endowed with a total estimated brackishwater area of 31,600 ha, of which 22,958 ha area (82% Government land) have so far been identified as suitable for development. These areas having no alternative economic use are found in the seven estuarine zones and Chilka lagoon spread over the four coastal districts of Balasore, Cuttack, Puri and Ganjam (Fig.1).

The Government of Orissa is the first State Government in the country which announced a leasing policy in 1981 for development of brackishwater aquaculture. According to this policy, 75% of the suitable areas shall be given on lease to the weaker sections of the society and the remaining 25% of the land requiring higher investment to entrepreneurs, companies, corporations etc. The Government has established district-level Brackishwater Fish Farmers Development Agencies (BFDAs) in the coastal districts between 1983-84 and 1989-90 under the Centrally Sponsored Scheme. Prawn culture in the State had its beginning in 1983-84 with the launching of the poverty alleviation scheme of "Economic Rehabilitation of the Rural Poor" (ERRP) in the Chilka Lake fringe area. By end of 1990, a total brackishwater area of 6151 ha has been brought under prawn culture in the State, benefiting 4741 beneficiaries/farmers (including 29.6% beneficiaries belonging to SC/ST). Of this, 1945 ha is under extensive pond culture and 4206 ha under tide-fed

"bherey" culture. The prawn culture development has been in 256 ha in Balasore, 2178 ha in Cuttack, 3101 ha in Puri and 617 ha in Ganjam districts.

Under the extensive prawn culture system practised in the State, the average production rates are 531 kg/ha/crop in the pond culture and 315 kg/ha/crop in the tide-fed bherey culture. The overall prawn production through aquaculture in the State during 1989-90 was 2900 tonnes (Mohanty 1991).

Realising the important developments taking place in brackishwater aquaculture in Orissa, the Central Institute of Brackishwater Aquaculture (CIBA) organised the Seminar on "Status and Prospects of Brackishwater Aquaculture in Orissa", on 14 October 1988 at Puri. The Seminar was inaugurated by Honourable Shri Sarat Chandra Panda, Minister of State for Commerce, Transport, Fisheries and Animal Husbandry, Government of Orissa. A total of 11 technical papers, including four papers from CIBA, were presented and discussed at the Seminar.

Amongst the Recommendations of the Seminar was a specific one on development of appropriate production technology for Chilka fringe ponds which stated as follows:

> "The Seminar noted that the Chilka fringe ponds represent a fragile ecosystem where production and productivity are low. The ecological conditions, nutrient turnover, energy cycle and factors limiting production may be carefully studied and optimum stocking rate, feed composition and feeding rate may be suggested to improve production and productivity of these ponds."

CIBA had initiated such a study earlier and the results presented and discussed at the First Indian Fisheries Forum at Mangalore, 4-8 December 1987 (Rajya-lakshmi et al , 1988). After the Puri Seminar, a more detailed study on the Chilka prawn culture system was taken up during 1988-89, the results of which are presented in this Report.

2. PRAWN FARMING IN CONFINED PONDS

The Chilka Lake is the largest brackishwater lake in India and is situated between latitudes 19^{0} 28' and 19^{0} 54' N and longitudes 85^{0} 65' and 85^{0} 35' E (Fig.1). Two branches of the Mahanadi river system, namely Daya and Bhargavi join the lake at the north-eastern end. The lake is shallow for most part in the northern sector and is comparatively deeper in the southern sector. The lake has monsoon water spread of 1165 sq.km and summer water spread of 906 sq km (Jhingran and Natarajan, 1966). The exposed fringe areas of the lake have been converted into confined ponds for prawn culture (Fig.2).

The State is promoting prawn farming under different schemes such as Brackishwater Fish Farmers Development Agency (BFDA), Economic Rehabilitation of the Rural Poor (ERRP) with full subsidy, Integrated Rural Development Programme (IRDP) with DRDA subsidy, Self Employment Programme with BFDA subsidy, Area Development Approach Programme (ADAP) with full subsidy etc.

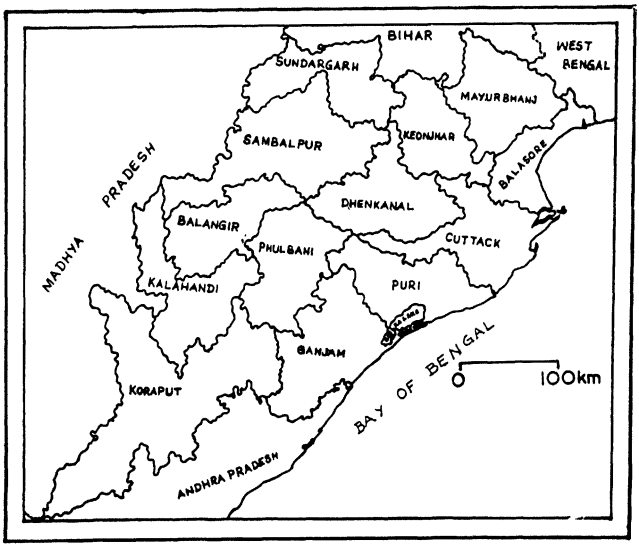

Fig.1 - Map of Orissa State showing
the districts and location of Chilka Lake

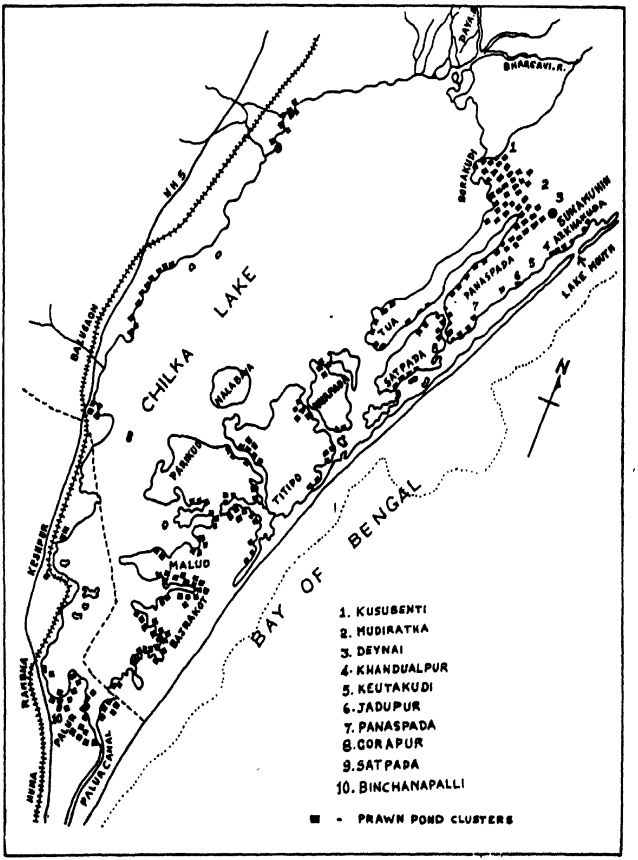

Fig.2 - Map showing the location of confined -pond prawn culture of Chilka Lake

The prawn farming in the Chilka Lake fringe area of Puri and Ganjam Districts is a very unique system. Ponds, 0.2 - 0.5 ha water spread area each, have been dug in the exposed area of the Lake. There are no canals to supply or drain water to/from the ponds. The ponds depend entirely on rain water collected in situ, which becomes brackish by mixing with the salt contained in the saline soil. Once the monsoon is over, the pond water slowly evaporates and the ponds become totally dry in summer. For these reasons, the system is described as confined ponds or rain-fed ponds or sky-fed ponds. Between July (monsoon) and April (summer), two crops of tiger prawn Penaeus monodon are taken under normal conditions, depending on availability of seed for stocking. In some cases only one crop is taken under adverse situation. The area received the minimum annual rainfall of 738.00 mm in 1987 and maximum of 1967.50 mm in 1980 (Table-1).

Pond preparation

The activities related to prawn culture commence from the onset of the south-west monsoon. Pond preparation for the monsoon crop begins in April-May. During this time most of the ponds are dry or partially dry. The pond bottom is raked and turned by the farmers. With the first rains, the ponds get water to about 15 cm depth. Liming is then done @ 200 - 250 kg/ha. Three to seven days after liming, organic fertilizer mainly raw cowdung is brought and spread in the pond bottom at the rate ranging from 1500 - 2000 kg/ha. Some farmers use inorganic fertilizers like urea and superphosphate in a single instalment in the beginning. Urea and superphosphate are applied @ 25 to 500 kg/ha. However, manuring and fertilization are not followed in all the ponds.

Stocking

When the ponds have received at least 50 cm or more of water stocking is done with juveniles of P. monodon. The seed is obtained from different sources, namely wild seed collected from Chilka Lake or from Paradip (Mahanadi estuary), Rushikulya estuary and Palur canal and also from hatchery. The size of the seed varied from 20 mm to 50 mm. Stocking is not done on one day because the seed supply from wild collection is unpredictable. Stocking is completed in about 6-12 days and there are instances that in some ponds stocking is prolonged commencing June and ending in August. This continuous stocking affects growth and production so also survival. None of the farmers stock the ponds with seed in a uniform phase or in a uniform size. Also the seed do not come from a single source.

During the second crop, stocking is done as for the first crop, commencing from October-November. In some ponds where high salinity status is experienced during second crop, farmers stock P. indicus as supplementary species. Many farmers do not operate the winter crop since water availability at the end of the season is a problem. If stocking is done, it is always understocked. In fact there is no fixed timing of stocking for the second crop. The stocking rate varies widely from 10,000 to 25,000 seed/ha.

Depth of pond water

During normal monsoon, the ponds have 100-120 cm of water by August. As the culture progresses, the water level slowly and steadily comes down coinciding with the steady reduction in the water level and water spread of the lake. Water level during the stocking phase of the second crop will be 80-100 cm and by the end of this crop in March, 95% of the ponds dry up.

Supplementary feeding

Feeding of the stock generally starts after 15 days of stocking if the seed stocked is small but starts immediately when prawn juveniles are stocked. The feeding is done with snail Pila meat (95%) and in some cases fresh-water mussel meat is used. The snail is crushed using a pounder and meat with shell is heaped in a earthern pot or some times in the pond bottom itself. The food is well accepted by the prawns.

Pila used is generally of the medium size and the meat yield is around 38%. One kerosene tin full of shell of Pila costs Rs 5-8. On an average the snails used for feeding per day varied from 20-30 kg/ha during the first 15-30 days and 50-60 kg/ha during the rest of the culture periods. Some of the farmers use groundnut oil cake also but in majority of cases feeding is inadequate resulting in low growth and low production.

Culture duration

The duration of each culture generally extends 3 to 4 months. The monsoon crop (first crop) begins in June/July and ends in September/October. The winter crop (second crop) starts during October/November and ends by February/ March.

Harvesting

Harvesting is done with trap called 'Dhaudi'. This is a continuous operation extending upto two weeks or more. Prawns of 25 g or above are harvested and the smaller ones are returned to the ponds. Harvesting of the first crop

can be 90% only since the pond retains water and there is every chance that some large sized ones may still remain. During February/March the water level decreases and eventually the ponds get dried. Here 100% retrieval of the stock is possible.

Production

The production ranged 100-750 kg/ha/crop. It was comparatively higher in monsoon crop than winter crop.

Marketing

The prawns are sold at the pond site itself. Marketing is not a problem since all size groups and even small quantities can be sold. Prawn collectors visit the pond clusters regularly on bicycle, purchase from the farmers directly and then sell to prawn processing plants.

3. DESCRIPTION OF THE STUDY AREA

The confined pond systems in the fringe areas of the Chilka Lake falls under the following three schemes:

1. Economic Rehabilitation of the Rural Poor (ERRP)
2. Area Development Approach Programme (ADAP)
3. Brackishwater Fish Farmers Development Agency (BFDA)

The unit size of ERRP ponds is 0.2 ha. The ponds are constructed on the Government land and allotted to the poorest of the poor. A total area of 111.60 ha has been brought under culture between 1983 and 1988.

The unit size of the ADAP ponds is 0.5 ha. The ponds are constructed on the Government land and allotted to the marginal farmers. 15.5 ha area was developed under this scheme between 1983 and 1988.

The unit size of BFDA scheme ponds varies as the ponds are constructed on the land owned by the farmers themselves. Under this category, the ponds were developed by converting some of the paddy fields adjoining to the lake. A total area of 1275.20 ha has been developed under the scheme during the years from 1983-84 to 1988-89.

Selection of pond clusters

Ponds under ERRP, ADAP and BFDA Schemes for this study were selected from different clusters from Puri and Ganjam districts. The north-eastern fringe area of the Chilka Lake falling under Brahmagiri and Krishnaprasad Blocks of Puri district have a large number of ponds under prawn culture. Ponds from the following clusters were selected:

Puri District: (1) Kusubenti (2) Mudiratha (3) Deynai (4) Khandualpur (5) Keutakudi (6) Jadupur (7) Panaspada (8) Gorapur and (9) Satpada.

While Kusubenti cluster of ponds is nearer to the outfall of Bhargavi and Daya rivers on the north-eastern end of the lake, Satpada is the point of origin of the outer channel of the lake. At Satpada the tidal influence is felt and generally salinity is higher at this point of the lake.

Ganjam District: (1) Binchanapalli at the southern end of the western side of the lake, and (2) Haripur in the fringe area of the Gopalpur backwaters.

Description of the pond clusters

The fringe area of the lake gets exposed 6-8 months during the post-monsoon and summer period and the lake water recedes considerably from the shoreline in certain areas. Brief description of each cluster is given below:

Puri District:

Puri District is divided into 3 blocks, namely Brahmagiri, Krishna Prasad and Chilka. In the present study cluster ponds from Brahmagiri and Krishna Prasad blocks were selected.

Brahmagiri block: Kusubenti cluster is situated near to outfall of the Bhargavi river. This cluster has 56 ponds under ERRP scheme. The ponds were constructed inside the lake bed, 500 metres from the shoreline and a ring dyke protects it from flood water inundation. Two ponds from this cluster were selected for the study.

Mudiratha cluster has 37 ADAP ponds constructed on the lake bed protected with an outer ring dyke. On the opposite side of these ponds adjacent to the protection embankment of the lake the existing paddy fields are gradually converted into BFDA ponds. Two ponds from ADAP Scheme and one from BFDA Scheme were selected for observations from this cluster.

Deynai cluster has 16 ADAP ponds. These ponds constructed on the lake bed are protected by ring dyke.

Outside to the lake protection embankment, on the opposite side of ADAP cluster, the BFDA ponds are located. Two ponds from ADAP scheme and three ponds from BFDA scheme were selected for observations.

Khandualpur cluster has 145 ERRP ponds. This cluster is well protected from the lake water by a ring dyke. From this cluster 10 ponds were studied.

Krishna Prasad block: Keutakudi cluster has 32 nursery ponds of 0.02 ha each in area. The ponds are located 0.5 km away from the outer embankment. This cluster is owned by the Department of Fisheries, Government of Orissa for nursery rearing of prawns. One pond was studied from this cluster.

Jadupur cluster has 30 ERRP ponds. Since construction of all the ponds has not been completed, the outer protective dyke is incomplete in this cluster. Three ponds from this cluster were selected.

Panaspada cluster has 39 ERRP ponds. From this cluster, five ponds were studied.

Gorapur cluster has 7 ERRP ponds located on the southern part of the Daohikhia canal which connects the lake body with the outer channel. Two ponds were selected for observations.

Satpada cluster on the left side of the outer canal, paddy fields protected from the lake by embankment are converted into ponds under BFDA scheme. Two ponds from this cluster were studied.

Ganjam District

Ganjam District is divided into three blocks, namely Ganjam block, Chatrapur block and Khallikot block. Ponds from first two blocks were selected for studies.

Ganjam block: Binchanapalli cluster is located on the south-western fringe area of the lake. In all 158 ERRP ponds are constructed here in the lake bed. The absence of proper outer protective dyke causes inundation of the ponds during flood season. Two ponds from this cluster were studied.

Chatrapur block: Haripur cluster has 31 ponds under ERRP scheme located on the western side of the Gopalpur port road adjacent to the backwaters. This cluster is protected by a ring dyke. Two ponds were selected for observation.

4. MATERIALS AND METHODS

The study area, pond clusters and number of ponds sampled have already been given in the preceding section. The serial numbers of ponds in different clusters selected for the study are as per records of BFDA and are given in Table-2.

Following the annual prawn culture cycle, three seasons were considered for this study. The first sampling was done in November, 1988 representing the beginning of winter crop. The second sampling in March, 1989 representing the beginning of summer conditions (drying of ponds),

and the third sampling in August 1989 representing the beginning of the monsoon crop.

Soil and water samples were collected from the ponds, preserved, transported and analysed either at the Puri Research Centre or at the headquarters of the Institute at Madras.

Soil samples were obtained from three depth layers, namely 0-10 cm, 10-20 cm and 20-37 cm, using a core sampler. The samples were analysed pond-wise and layer-wise. The physico-chemical parameters of soil analysed were: (i) texture, (ii) soil temperature, (iii) redox potential, (iv) soil pH, (v) electrical conductivity (E.C.) (vi) organic carbon, (vii) calcium carbonate ($CaCO_3$), (viii) available nitrogen, (ix) available phosphorus and (x) iron. Available nitrogen was estimated by the method of Subbiah and Asija (1956), soil texture and $CaCO_3$ by the methods of Piper (1966) and the other parameters by the methods of Jackson (1967). The values for the three depth layers in each pond were pooled, averaged and expressed as a single value. For each cluster the minimum and maximum of these values obtained from different ponds are expressed as the range in the Tables. Further, an average for the whole cluster was worked out from the above values and given in parenthesis in the Tables.

Surface and bottom water samples were analysed for the following parameters: (i) depth, (ii) temperature, (iii) pH, (iv) dissolved oxygen, (v) total alkalinity, (vi) calcium, (vii) magnesium, (viii) salinity, (ix) nitrate, (x) phosphate and (xi) iron. Standard analytical procedures were followed (APHA, 1971; Strickland and Parsons, 1972). Following the same procedure as for soil

values, average values for each pond, range of values for different ponds in the cluster, and the cluster average for water quality parameters are expressed in the Tables.

Information regarding culture methods was recorded through discussions with the farmers and data on prawn production were obtained from the BFDA officials.

5. OBSERVATIONS

1. Kusubenti cluster

(a) Soil characteristics (Table-3):

The soils are clayey in nature with clay percentage of 49.49. The distribution of clay was uniform in the depth profile. The pH of soil was alkaline in reaction with pH range from 7.8 to 8.7. There was not much difference in the pH value in the soil profile of the ponds. The $CaCO_3$ content of soil ranged from 0.97 to 1.72%. In depth profile, it ranged from 1.80 to 1.50% in ERRP 9 and 2.00 to 1.25% in ERRP 22. The electrical conductivity varied between 2.79 and 5.98 mmhos/cm in culture periods, however, there was an increase in its value (19.83 - 28.25 mmhos/cm) during summer period. The pond soil showed low redox potential (Eh) ranging from -56 to -135 mV in the surface layer (0-10 cm), however, Eh (+) value (+ 10 mV) was noticed at the bottom in the pond ERRP 9. The organic carbon ranged from 0.17 to 0.64% with

maximum value during summerperiod. Available nitrogen and phosphorus ranged from 11.47 to 24.43 and 2.71 to 4.98 mg/100 soil respectively. Organic carbon, available nitrogen and phosphorus content of the soil were found to decrease from surface to bottom. The iron ranged from 0.73 to 83%. No change in iron content was noted from surface to bottom.

The $CaCO_3$, organic carbon, available nitrogen and phosphorus were low in general. Iron content of soil was high.

(b) Water characteristics (Table-4):

During the two cropping seasons, the pH of water ranged from 6.9 to 9.2 indicating neutral to alkaline in nature with low pH value during monsoon (August) period. The dissolved oxygen varied from 6.0 to 8.0 ppm. There was a great variation in total alkalinity which ranged from 24.0 to 62.0 ppm. Calcium and magnesium content of water ranged from 75.8 to 152.6 and 154.6 to 317.5 ppm respectively. Water salinity varied from 6.0 to 14.5 ppt. All parameters showed low values during monsoon season. Nitrate and phosphate ranged from 0.032 to 0.050 and 0.005 to 0.008 ppm respectively. The concentration of iron in water ranged from 0.31 to 0.42 ppm with an average of 0.36 ppm.

In general, total alkalinity, salinity, nitrate, phosphate were low, however, the concentration of iron was high in pond water.

(c) Production data (Table-5):

In these two ponds, stocking density was tried in the range of 15000-20000 Nos/ha in Ist crop and production

obtained was 412.5 - 425.0 kg/ha with an average of 418.75 kg/ha. There was no second crop during the period.

2. Mudiratha cluster

(a) Soil characteristics (Table-6):

The soils are clayey in nature with 41.68% clay. It was observed that sand percentage was slightly more towards the deper layers of the soil profile. When the mechanical composition of two clusters (Kusubenti) and Mudiratha) are compared, a vast different is noticed. Kusubenti ponds soil has 29.97% sand, 21.03% silt and 49.49 clay whereas Mudiratha ponds soil with 41.47% sand, 16.56% silt and 41.68% clay. The pH of soil was always alkaline in reaction with pH range from 6.9 to 8.2. There was not much difference in pH value at different segment of the soil profile. The $CaCO_3$ content of soil was low and it ranged from 0.38 to 1.97%. The electrical conductivity of soil ranged from 5.10 to 12.95 mmhos/cm during culture periods, however, an increase in its value (30.50 - 44.75 mmhos/cm) was noticed during summer month. Pond sediments showed low redox potential (Eh) which ranged from -26 to -160 mV in the surface layer. Besides negative Eh in some ponds, (+) Eh value ranging from +100 to +120 mV was also noticed at the surface layer of the other ponds. In some ponds, the (+) Eh was noticed at lower depth (20-37 cm) which ranged from +35 to +125 mV. Reducing condition of soil was noticed high during winter than monsoon season . The organic carbon, available nitrogen and available phosphorus ranged from 0.18 to 0.63%, 8.67 to 23.65 and 1.76 to 7.91 mg/100 g soil respectively. Organic carbon, available nitrogen and phosphorus content of soil were found to decrease from surface to bottom in the depth profile. The total iron content of soil ranged from 0.85 to 1.24%. In

ADAP 13 pond, iron was found to increase at lower depths. It was 1.23% at surface and 1.26% at the bottom layer. There was not much change in iron content in depth profile of the remaining two ponds.

The $CaCO_3$, organic carbon, available nitrogen, available phosphorus were low in general, however, iron content of soil was high.

(b) Water characteristics (Table-7):

The pH of water was always alkaline with pH range of 7.8 to 8.9. The water was well oxygenated with dissolved oxygen (range 5.2 to 7.6 ppm). Total alkalinity was quite low in water and it ranged from 26.0 to 58.0 ppm. Calcium and magnesium ranged from 98.0 to 141.6 and 198.7 to 268.0 ppm respectively. Water salinity varied between 7.0 and 13.0 ppt. The salinity in BFDA pond was less (7.0 and 8.0 ppt) than ADAP ponds (11.0 - 13.0 ppt) Nitrate and phosphate ranged from 0.038 to 0.055 and 0.003 to 0.013 ppm respectively. The concentration of iron in water ranged from 0.46 to 0.77 ppm with an average of 0.60 ppm. The values of pH, total alkalinity, Calcium and salinity were low during monsoon period.

In general, the total alkalinity, salinity, nitrate and phosphate were low, however, the concentration of iron was high in pond water.

(c) Production data (Table-8):

In first crop, the stocking density ranged from 8000 to 14920 nos/ha and in second crop 5000 to 8000 nos/ha. The production ranged from 160-350 kg/ha in first crop and 83-242 kg/ha in the second crop with an annual yield of

408.33 kg/ha.

3. Deynai cluster

(a) Soil characteristics (Tables 9A and 9B):

Four ponds are sandy clay (Ponds BFDA 2, 3 and ADAP 1, 5) and one pond (BFDA 4) is clayey in nature. The percentage of clay was found slightly less in this cluster (particularly in BFDA ponds) when it is compared to Mudiratha ponds. However, the percentage of sand was higher in this cluster. In general, the percentage of sand was found to increase slightly at the lower layers of the depth profile. The pH of soil was alkaline in reaction with pH range from 6.9 to 8.7. There was not much difference in pH value at different segments of the soil depth profile. The $CaCO_3$ content of soil was low and it ranged from 0.62 to 2.25%. During culture periods, the E.C varied between 2.50 and 15.75 mmhos/cm, however, it increased in its value (22.67 - 38.27 mmhos/cm) in summer periods. Low E.C. value was always noticed in BFDA ponds than ADAP ponds. It varied from 3.22 to 4.44 in BFDA ponds and from 7.44 to 11.20 mmhos/cm in ADAP ponds during culture periods. Negative redox potential (Eh) was noticed in the ponds of this cluster. The Eh ranged from -15 to -150 mV in the water-soil phase. High reducing condition of the soil was observed in winter than monsoon. In some ponds, Eh (+) value was noticed at the lower depth. The organic carbon ranged from 0.20 to 0.76% and was low. Available nitrogen and available phosphorus ranged from 9.59 to 23.83 and 0.88 to 4.23 mg/100 g soil respectively. The content of organic carbon, available nitrogen,

phosphorus were found to decrease at the lower depths. Iron content of soil was high and ranged from 0.68 to 1.28%. Its concentration was almost same at all the depths of the ponds with exception of ADAP 1 and BFDA 4. It was 0.93% and 0.95% in ADAP 1 and 1.28% and 1.29% in BFDA 4 at surface and bottom layers respectively.

In general, $CaCO_3$, organic carbon, available nitrogen and phosphorus were low. Iron content of soil was high.

(b) Water characteristics (Tables 10A and 10B):

In two cropping seasons, it is evident from the tables (10A and 10B) that water pH was alkaline and well oxygenated. In BFDA ponds, the total alkalinity, calcium, magnesium, salinity, nitrate, phosphate and iron ranged from 40.0 - 76.0 ppm, 55.2 - 109.4 ppm, 113.2 - 253.6 ppm, 3.5 - 8.0 ppt, 0.025 - 0.046 ppm, 0.007 - 001 ppm and 0.54 - 1.10 ppm respectively but in ADAP ponds, the above parameters ranged from 36.0 - 62.0 ppm, 45.6 - 151.6 ppm, 327.6 - 491.2 ppm, 12.0 - 14.0 ppt, 0.025 - 0.040 ppm, 0.003 - 0.009 ppm and 0.52 - 0.60 ppm respectively. It is interesting to note that water salinity was very low in BFDA ponds i.e. 4.2 ppt in monsoon and 5.3 ppt during winter whereas it was high in ADAP ponds i.e. 12.5 ppt in monsoon and 13.5 ppt during winter. The values of pH, D.O., total alkalinity, calcium and salinity and nitrate were low during monsoon as compared to winter.

In general, total alkalinity, salinity (BFDA ponds), nitrate and phosphate content were low but iron was high in pond water.

(c) Production data (Table-11):

The production details of P. monodon in BFDA and ADAP ponds of Deynai cluster are presented in Table-11. It is

seen from the above table that BFDA ponds of 0.2 ha has given production of 237.50 kg/ha in Ist crop and 200.0 kg/ha in the second crop whereas ADAP ponds of 0.5 ha has given 129.0 - 200.0 kg/ha in Ist crop and 78.20 kg/ha in the second crop. The annual production of P. monodon in BFDA ponds was 437.50 kg/ha and in ADAP ponds 242.70 kg/ha.

4. Khandualpur cluster

(a) Soil characteristics (Table-12):

In this cluster, out of the ten ponds, seven ponds are sandy clay and three ponds clayey in texture. It was observed that sand was more and clay content was less at lower depths of the soil profile. The pH of soil was acidic to alkaline in reaction with pH range 6.9 to 9.4 in pond ERRP 31, 32, 33, 34, 25 and 54 whereas 5.6 to 7.0 in pond ERRP 2, 3, 4 and 26. The differences in pH value was much pronounced in the soil profile of the ponds. The pH value of soil was found to decline from surface to bottom and the values respectively were 7.8 and 7.7 in ERRP 31, 6.9 and 6.8 in ERRP 32, 8.2 and 6.8 in ERRP 33, 7.4 and 6.9 in 34, 7.1 and 6.9 in EERP 25 and 7.6 and 6.8 in ERRP 54 showing alkaline reaction at surface and slightly acidic at the bottom. On the other hand, the pH values were 6.6 and 6.3 in ERRP 2, 5.6 and 5.5 in ERRP 3, 7.1 and 5.3 in ERRP 4 and 7.6 and 4.9 in ERRP 26 indicating strong acidic reaction particularly at the lower depths. Out of the three seasons studied, the soil pH decreased during the monsoon (August) period.

The calcium carbonate ($CaCO_3$) content of the soil was low ranging from nil to 2.0%. In depth profile (surface to bottom), it ranged from 2.00 to 1.82% in ERRP 31, 1.25 to 1.00% in ERRP 32, 2.50 to 1.18% in ERRP 33, 1.88 to 1.75% in ERRP 34, 1.25 to 0.80% in ERRP 25 and 1.37 to 0.73% in

ERRP 54. On the other hand, $CaCO_3$ was absent in ERRP 3 and it was only found in the surface layers in ERRP 2 (1.0%), ERRP 4 (0.7%) and ERRP 26 (1.25%).

The electrical conductivity (EC) of the soil ranged from 3.00 to 25.93 mmhos/cm in general. However, in the depth profile (surface and bottom), the E.C. value ranged between 13.00 and 9.80, 10.00 and 5.55, 8.50 and 6.25, 8.25 and 6.00, 31.50 and 22.80, 11.25 and 9.25 mmhos/cm in ERRP 31, 32, 33, 34, 25 and 54 respectively. In the acidic ponds, the E.C. ranged between 18.75 and 14.35, 9.50 and 8.60, 18.25 and 5.90 and 19.50 and 18.40 mmhos/cm in ERRP 2, 3, 4 and 26 respectivelv.

The pond sediments showed low redox potential (Eh) ranging from -48 to -160 mV in the surface layers (0-10 cm). In some ponds Eh(+) value was noticed at the bottom. The surface and bottom Eh values were -71 and +10 mV in ERRP 31, -132 and +20 mV in ERRP 34, -68 and +19 mV in ERRP 4 are the typical examples. High reducing condition of the soil was observed in winter season.

The organic carbon content of the soil was low ranging from 0.17 to 0.66% in general in the ponds and it was found to decrease from surface to bottom. During the two culture periods, there was not much difference in organic carbon content of the soil. Available nitrogen was low ranging from 11.37 to 23.83 mg/100 g soil in these ponds. It was found to decrease from surface to bottom and its content in the soil during the two cropping season did not vary much. Available phosphorus ranged from 1.62 to 6.34 mg/100 g soil but most of the ponds were low for this nutrient. It was found to decrease from surface to bottom. The total iron content of the soil was high ranging from 0.90 to 1.85%. It was 0.98% in ERRP 31, 0.90% in ERRP 32,

1.60% in ERRP 33, 1.23% in ERRP 34, 1.03% in ERRP 4, 1.59% in ERRP 25 and 1.18% in ERRP 54. No difference in the iron content of the surface and bottom was observed in the above ponds. However, in the three remaining ponds the surface and bottom soils showed difference in iron content and it was found to increase at the lower depths. The total iron in the surface and bottom soils were 1.80 and 1.88% in ERRP 2, 1.84 and 1.87% in ERRP 3 and 0.82 and 1.02% in ERRP 26.

In general, $CaCO_3$, organic carbon, available nitrogen and phosphorus were low, however, the iron content in soil was high.

(b) Water characteristics (Table-13):

The dissolved oxygen varied from 4.0 to 8.4 ppm in all the ponds except ponds ERRP 2 and 3 where it ranged from 12.0 to 14.4 ppm. The water always showed alkaline reaction with pH range of 7.6 to 9.3 in both the cropping seasons. The total alkalinity in the ponds ranged from 22.0 to 60.0 ppm. The concentration of calcium and magnesium ranged from 22.0 to 157.0 and 79.0 to 318.4 ppm respectively. All the ponds showed low saline conditions during the culture seasons. The salinity of water ranged from 5.0 to 10.0 ppt being low in monsoon season. The concentration of the dissolved nutrients like nitrate and phosphate ranged from 0.020 to 0.050 ppm and 0.004 to 0.012 ppm respectively. The pond water contained high concentration of iron and it ranged from 0.92 to 2.68 ppm with an average of 1.78 ppm. In most of the ponds, the iron concentration was observed above 1.8 ppm.

In general, the total alkalinity, salinity, nitrate and phosphate were low, however, the concentration of iron in water was high.

(c) Production data (Table-14):

The production details of P. monodon in ponds of Khandualpur cluster are given in Table-14. The stocking density tried were @ 7500 - 15000 in first crop and @ 5000 - 10000 nos/ha in the second crop. This has given an yield of 100.0 - 295.0 (average 217.50 kg/ha) and 72.5 - 187.5 (average 142.0 kg/ha) in first and second crop respectively The annual yield obtained was 359.0 kg/ha.

5. Keutakudi cluster

(a) Soil characteristics (Table-15):

The soil is sandy clay being 56.50, 11.23 and 32.27% of sand, silt and clay respectively in Keutakudi cluster pond where nursery rearing was done. It was observed that sand content showed an increase while the clay content of soil decreased with the depth of the soil profile. It was further observed that sand content increased and clay content decreased in this cluster as compared to other clusters described previously. The pH of the soil was acidic to alkaline in reaction with pH range from 6.6 to 8.0. pH of 5.8 was noticed at lower depth. The $CaCO_3$ ranged from 0.24 to 0.77%. The electrical conductivity varied between 4.37 and 5.75 mmhos/cm during the two culture periods, however, it increased to 48.98 mmhos/cm in summer period. Low redox potential (Eh) was noticed in the pond sediments which ranged from -70 to -165 mV, however, during August, an Eh (+) 110 mV was noted in soil-water phase. Reducing condition of the sediments was noticed high during winter season. Organic carbon, available nitrogen and phosphorus ranged from 0.14 to 0.29%,

10.78 to 15.33 mg/100 g and 1.39 to 1.55 mg/100 g soil respectively and the values of these parameters were found to decrease at the lower depths. The content of iron in soil was 1.45% and there was no change in its value in the depth profile.

The $CaCO_3$, organic carbon, available nitrogen and phosphorus were low in general, however, the concentration of iron in soil was high.

(b) Water characteristics (Table-16):

This cluster was sampled for water characteristics during monsoon season only. The water depth of the column was 150 cm. The values of other parameters were: water temperature 34°C, pH 6.6, dissolved oxygen 7.5 ppm, total alkalinity 14.0 ppm, calcium 125.6 ppm, magnesium 271.6 ppm, salinity 10.0 ppt, nitrate 0.032 ppm and phosphate 0.011 ppm. The concentration of iron in water was 0.96 ppm. The value of total alkalinity was very low and pH of water was acidic.

In general, total alkalinity, salinity, nitrate and phosphate were low, however, the concentration of iron in water was high.

6. Jadupur cluster

(a). Soil characteristics (Table-17):

The soils are sandy clay laom in texture. It was interesting to observe that percentage of sand increased and clay percentage decreased tremendously in this cluster as compared to the other clusters described previously. The pH of the soil was found to be highly acidic in reaction in general with pH range from 4.1 to 6.2. Only on

one occasion the pH of soil was near to neutral (pH 7.4). The pH values were 4.1 and 4.1 in ERRP 5, 4.2 and 4.1 in ERRP 6, and 4.9 and 4.9 in ERRP 7 at surface and bottom layers respectively. However, in March, the pH of surface soil was extremely low (pH 3.8) in pond ERRP 5.

The calcium carbonate content of soil was very low. Most of the time, it was absent in the profile. It was nil in pond ERRP 5 but ranged from 0.0 to 0.17% in ERRP 6 and 0.0 to 0.23% in ERRP 7.

Electrical conductivity ranged from 7.50 to 10.25 mmhos/cm in the culture period but it increased (42.0 to 66.5 mmhos/cm) during the summer period. However, there was a general trend of salts to be accummulated at the surface layers.

It was observed that Eh (+) values were noticed in the sediments which ranged from +80 to +90 mV in the culture period, however, very high Eh (+) values were recorded during the summer period and it ranged from + 140 to + 315 mV in the surface layers.

Organic carbon, available nitrogen and phosphorus ranged from 0.11 to 0.37%, 10.00 to 16.42 and 3.48 to 4.75 mg/100 g soil respectively and their values were found to decrease at the lower depths. The total iron ranged from 0.60 to 1.30% in general. There was no difference in iron content at different segments of the soil depth profile.

The $CaCO_3$, organic carbon, available nitrogen and phosphorus were low, however, iron in soil was high.

(b) Water characteristics (Table-18):

This cluster was sampled for water for physico-chemical analysis during monsoon season only. The water was always alkaline in reaction with pH range from 7.3 to 7.9 (average 7.6 ppm). The dissolved oxygen varied between 5.1 and 5.6 ppm. The total alkalinity and salinity ranged from 24.0 to 36.0 ppm and 15.0 to 16.0 ppt respectively. Nitrate was in the range of 0.020 to 0.023 ppm and phosphate 0.011 to 0.012 ppm. The concentration of iron in water varied between 0.96 and 1.80 ppm with an average of 1.46 ppm.

In general, total alkalinity, salinity, nitrate and phosphate were low, however, the concentration of iron in water was high.

(c) Production data (Table-19):

The details of production of P. monodon in the cluster are given in Table-19. The stocking density tried were @ 5000-7500 kg/ha. The yield varied from 110.0 - 175.0 kg/ha. The annual yield was 146.66 kg/ha.

It is suggested that remaining ponds of the cluster should be thoroughly investigated to have full fact of the ponds ecosystems.

7. Panaspada cluster

(a) Soil characteristics (Table-20):

The pond soil are of different texture ranging from clayey (ERRP 2), sandy clay (ERRP 3 and 29) and sandy clay loam (ERRP 4 and 5). Sand percentage was higher towards the lower layers without much appreciable change in clay

contents. The ponds contained clay ranging from 24.60 to 47.30% with an average of 35.88%. The pH of the pond soils varied between 6.4 and 8.0 in the surface layer, however, at deeper layers of the profile, the pH of soil was recorded to be acidic in reaction. The pH of soil at surface and bottom layers were 7.3 and 6.5 in ERRP 2, 6.7 and 6.4 in ERRP 3, 6.6 and 6.1 in ERRP 4, 6.6 and 6.2 in ERRP 5 and 7.3 and 6.5 in ERRP 29 respectively indicating more acidic characteristics at the lower layers.

The calcium carbonate contents of the soil was low and it ranged from nil to 1.08%. It was 0.90 to 1.25% in pond ERRP 2, 0.45 to 0.90% in ERRP 3, 0.05 to 0.75% in ERRP 4, 0.00 to 0.70% in ERRP 5 and 0.39 to 1.00% in ERRP 29. The contents of $CaCO_3$ in soil was low at lower depths.

The elctrical conductivity of soil ranged from 7.75 to 10.08 mmhos/cm during culture period, however, it increased (27.23 to 79.08 mmhos/cm) in summer months. There was a general trend for salts to be accummulated at the surface and decrease at the lower depths of the soil profile.

The ponds showed low redox potential (Eh) in the soil-water phase. It ranged from -40 to -135 mV. Eh (+) values were also noticed in some ponds which ranged from +140 to + 170 mV.

The organic carbon, available nitrogen and available phosphorus values were in the range of 0.12 to 0.68%, 11.00 to 25.50 mg/100 g and 2.87 to 5.42 mg/100 g soil respectively. These parameters values were found to decrease at the lower depths. The total iron was in the range of 0.60

to 1.19% in the pond soils, however, its value was same at all the depths of the soil profile of the respective pond.

The $CaCO_3$, organic carbon, available nitrogen and phosphorus were low, however, iron was high in the soil.

(b) Water characteristics (Table-21):

Ponds were studied during monsoon season only and physico-chemical characteristics of water are given in Table-21. The pH of water was acidic to alkaline in reaction with pH range of 6.4 to 8.6. The low pH was noticed in ponds ERRP 4 and ERRP 5. The dissolved oxygen ranged from 5.2 to 8.6 ppm. The total alkalinity was very low ranging from 8.0 to 24.0 ppm with exception to pond ERRP 3 where alkalinity was 50.0 ppm. The salinity of water was low and it ranged from 7.0 to 11.2 ppt in all the ponds with exception in pond ERRP 29, where salinity of water was 16.0 ppt. The nitrate ranged from 0.020 to 0.030 ppm and phosphate 0.004 to 0.011 ppm. The concentration of iron was high and it ranged from 0.52 to 1.68 ppm with an average of 1.20 ppm.

In general, total alkalinity, salinity, nitrate and phosphate were low, however, the concentration of iron in water was high.

(c) Production data (Table-22):

The production data of P. monodon in this cluster are given in Table-22. The stocking density tried were 5000-7500 nos/ha in first crop and 2500-5000 nos/ha in second crop. The yield obtained was 174.0 kg/ha and 85.62 kg/ha in first and second crop respectively. The annual yield was 259.62 kg/ha. Besides low stocking density in second

crop, the prawns were allowed to remain in acidic water with pH of 6.4 for a long time and resulted in reddish colour of prawn which were seen dying during the visit of CIBA scientists. There is a need to study other ponds of the cluster to understand ecosystems.

8. Gorapur cluster

(a) Soil characteristics (Table-23):

The texture of the soil is sandy clay with sand 50.90%, silt 8.42% and clay 40.68%. An increase in sand content and decrease in clay content was noticed towards the lower layers. The pH of soil ranged from 6.6 to 7.2 and was found to decrease at the lower depths of the soil profile. It was 7.1 and 6.8 in pond ERRP 7 and 6.9 and 6.0 in ERRP 2 at surface and bottom layers respectively. The calcium carbonate content of the soil was low and ranged from 0.17 to 0.71%. The electrical conductivity ranged from 1.83 to 2.08 mmhos/cm during culture period but increased (62.82 to 71.33 mmhos/cm) in summer months. The pond showed Eh(+) value which ranged from +70 to +160 mV, however, on one occasion, Eh -90 mV was recorded. Organic carbon ranged from 0.12 to 0.55%. Available nitrogen and phosphorus ranged from 15.47 to 22.33 mg/100 g and 2.29 to 4.87 mg/100 g soil respectively. The value of all these parameters were found to decrease at the lower depths. Total iron ranged from 0.84 to 0.95% and in depth profile, the value was same at all the segments studied.

In general $CaCO_3$, organic carbon, available nitrogen and phosphorus were low but the iron content of the soil was high.

(b) Water characteristics (Table-24):

The water sampling was done during monsoon season only and data are given in Table-24. A wide variation in pH of water was observed which varied between 6.8 and 9.4. The dissolved oxygen ranged from 5.2 to 8.5 ppm. The total alkalinity also showed wide variation amongst the ponds. It was 16.0 ppm in pond ERRP 2 whereas 100.0 ppm in pond ERRP 1. The salinity of water varied between 2.3 and 11.0 ppt. The pond ERRP 1 showed almost the nature of fresh-water with salinity value of 2.3 ppt. Nitrate ranged from 0.022 to 0.022 ppm and phosphate 0.007 to 0.008 ppm. The concentration of iron was high and ranged between 0.97 and 1.53 ppm with an average of 1.25 ppm.

Total alkalinity (ERRP 2), salinity (ERRP 1), phosphate and nitrate were low, however, the concentration of iron was high in both the ponds.

(c) Production data (Table-25):

The stocking density of P. monodon tried were 3000-5000 nos/ha in first crop and 2500-2500 nos/ha in the second crop. The yield obtained was 125.0 and 62.50 kg/ha in first and second crop respectively. The annual yield was 187.50 kg/ha. There is need to study more ponds of this cluster in detail to understand the behaviour of soil and water to increase the production.

9. Satpada cluster

(a) Soil characteristics (Table-26):

The soil of one pond (BFDA 1) is sandy clay and second pond (BFDA 2) sandy clay loam in texture. The

percentage of sand is higher at deeper layers of the soil profile. The pH of the soil was alkaline in reaction with pH range from 7.1 to 7.7. There was not much difference in the pH value between surface and bottom layers. The content of $CaCO_3$ in soil ranged from 0.25 to 1.24%. Electrical conductivity ranged from 5.10 to 9.67 mmhos/cm during the culture season, however, it increased (58.79 - 62.58 mmhos/cm) in summer months and salts accummulation was at the surface layers only. The ponds did not show much reducing condition. Redox potential (Eh) ranged from -30 to -47 mV and +160 to +170 mV in the water-soil phase during August and March respectively. The organic carbon, available nitrogen and phosphorus ranged from 0.15 to 0.34%, 13.00 to 17.50 and 1.95 to 3.09 mg/100 g respectively. The values of these three parameters decreased at the lower depths. The total iron content of soil ranged from 0.54 to 0.55%, however, there was no change in the values of iron at different segments of the soil profile.

The $CaCO_3$, organic carbon, available nitrogen and phosphorus were low in general.

(b) Water characteristics (Table-27):

The ponds water were studied during monsoon season only. The pH of water was alkaline in reaction with pH value of 7.6 to 8.4. The dissolved oxygen ranged from 5.0 to 5.0 ppm. Total alkalinity varied between 40.0 and 55.0 ppm. Calcium and magnesium ranged from 87.2 to 116.0 ppm and 209.4 to 484.0 ppm respectively. Water salinity ranged from 11.0 to 17.0 ppt. Nitrate ranged from 0.036 to 0.037 ppm and phosphate 0.006 to 0.010 ppm. The concentration of iron in water ranged from 0.31 to 0.38 ppm.

In general, the total alkalinity, nitrate and phosphate were low in pond water.

(c) Production data (Table-28):

The production details of P. monodon in the cluster are given in Table-28. The stocking density tried were 13936 nos/ha and 14080 nos/ha which yielded 395.2 and 294.4 kg/ha of prawns respectively with an annual yield of 689.6 kg/ha.

10. Binchanapalli cluster

(a) Soil characteristics (Table-29):

The soil of the ponds are clayey in texture. The pH of the soil was always alkaline with pH values from 7.8 to 8.9. The calcium carbonate content of soil was observed high (3.83 to 4.85%) during November in both the ponds but was low (0.50%) in March. Electrical conductivity ranged from 6.00 to 6.30 mmhos/cm during the culture period but it increased (18.00 to 42.75 mmhos/cm) in summer month. These ponds showed redox potential ranging from -18 to -85 mV in the water-soil phase. Organic carbon, available nitrogen and phosphorus ranged from 0.12 to 0.53%, 9.80 to 13.12 and 2.03 to 3.35 mg/100 g soil respectively and its values were low at lower depths. The total iron was in the range 0.85 to 0.87% in the pond soils.

The organic carbon, available nitrogen and phosphorus were low in general, however, iron content in the soil was high.

11. Haripur cluster

(a) Soil characteristics (Table-30):

The soil of pond ERRP 2 is clayey and ERRP 18 sandy clay. Alkaline pH of soil was always observed in these ponds which ranged from 7.5 to 8.8. Here also, like Binchanapalli ponds, the $CaCO_3$ content of soil was high (3.81 to 3.91%) during November, however, a decrease in its value (1.80 to 2.00%) was noticed in March. The electrical conductivity ranged from 6.53 to 6.65 mmhos/cm during culture season but its value increased (20.25 to 23.50 mmhos/cm) in March. These ponds showed low redox potential which ranged from -164 to -170 mV in soil-water phase. The organic carbon ranged from 0.36 to 0.72%. Available nitrogen and phosphorus ranged from 11.76 to 21.35 and 1.66 to 2.50 mg/100 g soil respectively. The values of organic carbon, available nitrogen and phosphorus were low at the bottom of the soil profile. The total iron ranged from 0.60 to 0.84% with an average of 0.72%.

In general, organic carbon was low in the ponds. Available nitrogen and phosphorus were also low. The iron content of soil was high.

6. GENERAL REMARKS ON POND CONDITIONS

The salinity of soil and water of ponds in the outer fringe of the lake are mostly low as compared to those of other ponds lying proximal to the lake water. The salinity of soil increased considerably during summer (upto 79

mmhos/cm) with the total evaporation of pond water and decreased with the onset of monsoon (down to 2 mmhos/cm), when water level increases in the pond. However, water salinity always remained low in both the cropping seasons, in general.

Some ponds of Khandualpur, Jadupur, Panaspada and Gorapur are highly acidic (pH 3.4) particularly at lower depth of the soil profile. $CaCO_3$ contents in the soil was nil in such acidic condition. Ponds constructed on acidic soils are low productive.

Anaerobic environment developed under prolonged water logging condition of the ponds. This resulted in reducing condition of the pond sediments. Reducing condition was much noticed during winter season. Sometimes Eh (+) values were recorded at the surface as well as at the lower depths. In some ponds, reducing condition was noticed at the surface but it was positive at lower depths.

The pond soils were low in nitrogen and phosphorus. Its turnover in the soil-water phase was also low.

Iron content of soil was high in almost all the cluster ponds. Its concentration was also noticed high in the pond waters.

Total alkalinity of water was mostly low, indicating poor buffering capacity of pond-water ecosystem.

The above generalised conditions of the confined ponds in the Chilka Lake fringe show certain limitations which will restrict productivity upto certain levels only.

Remedial measures will be required to improve productivity, at the same time taking care to see that there is no environmental degradation.

7. SUGGESTIONS FOR IMPROVEMENT OF THE SYSTEM

Based on the results of the study presented and discussed in the preceding sections, certain suggestions are made here as remedial measures to improve the soil and water quality as well as productivity. The quantitative measures suggested are only indicative and will have to be carefully monitored so as to either increase or decrease the dosages as may be required under conditions of each pond.

Sludge accummulated at the bottom of pond may be removed immediately after the winter crop is harvested. Care should be taken not to remove the soil. Otherwise, the pond will loose salinity.

It is necessary to prevent erosion of the pond bunds, which leads to accumulation of iron compounds and reduction in pH of soil and water. Locally available appropriate materials may be fixed on the inner sides of the bunds to prevent soil erosion. Wooden materials, when used, may be conditioned in lime water overnight.

Development of reducing condition of bottom sediments is a common feature in the cluster ponds due to the

presence of large amount of iron compounds, metabolites etc. under anaerobic conditions. The pond bottom should be tilled and exposed to sunlight, and treated with lime during April-May at the time of pond preparation to create hygienic conditions.

Chilka ponds have two culture seasons and the following suggestions are made for pond preparation under dry conditions in summer (April-May):

Agricultural limestone ($CaCO_3$) in fine ground condition may be applied to dry ponds at the basal dose given in Table-31. The pond bottom may be ploughed upto a depth of 15 cm. Alternatively deep raking can be done. The ponds may be allowed to remain as such for about 2-3 weeks. Some moisture in the soil is necessary for proper reaction of lime with the soil and initially rainfall helps this process.

Note: Some ponds of Khandualpur cluster (Pond Nos.2, 3, 4 and 26), Jadupur cluster (pond No.5, 6 and 7), Panaspada cluster (pond No.3, 4, 5 and 29) and Gorapur cluster (pond No.2 and 7) require special treatment. The pond sediments are highly acidic particularly at lower depths (Please see text). Such ponds have high lime requirement (Table-31). The quantity of lime may be divided into 3 doses. These may be applied at weekly intervals and the acidic water at the end of each treatment may be pumped out. This will not only improve the buffering capacity of water but will keep water pH stable.

Combination of nitrogenous and phosphatic fertilizers along with organic manure is very useful in enhancing production of brackishwater ponds. After the lime treatment as above, when the soil is moist or water level in the ponds is low (less than 10 cm) decomposed dry cattle

manure, urea and single superphosphate as a basal dose at the rates given in Table-32 may be applied by spreading/ broadcasting over entire pond surface. This should be mixed with the soil. The organic manure so added will help not only to provide a steady source of different elements but also to improve some physico-chemical properties of the soils. Upon the application of urea as a fertilizer, most of NH_4^+ ions developed are absorbed by the soil exchange complex of the bottom mud within a few days and remain strongly bound there. The benthic algae which form the food organisms for the prawns in brackishwater ponds, derive the nutrient in this form.

The phosphatic fertilizer will form insoluble compounds when mixed with the soil. However, due to the prevailing waterlogged condition of pond, phosphates are liberated which will help the development of benthic algae.

The pond may be left as such till it gets filled up with rain water. When water level rises to 80-100 cm level, the ponds may be stocked with the required number of prawn seed.

During culture period, one month from stocking or as soon as indication of depletion of natural food i.e. plankton is noticed, repeated doses of inorganic fertilizers may be applied. The water can be fertilized with urea @ 20 kg/ha/month in split doses at fortnightly intervals and single superphosphate @ 20 kg/ha/month in split doses at weekly intervals. Both fertilizers should be dissolved in water separately and sprayed uniformly throughout the surface of the ponds.

After the harvest of the first crop, the pond water should be prepared for stocking of the seed for the second crop during November. At this stage, the water is limed with fine ground $CaCO_3$ @ 50 kg/ha and total alkalinity is recorded after a week. The stocking of prawn seed can be done when total alkalinity value of water exceeds 50 ppm approximately. Water showing less than 50 ppm alkalinity requires reliming.

It is observed that water level of ponds reduces during second crop. Due to this, the inorganic fertilizer doses can be reduced during culture period. Urea can be applied @ 10 kg/ha/month in split doses at fortnightly intervals and single superphosphate @ 10 kg/ha/month in split doses at weekly intervals.

> Note: If the water becomes darkish green or brownish, the fertilization of water will have to be stopped immediately.

The salinity and total hardness of water were observed to be low, in general, in the two cropping seasons. The possibility of getting higher saline ground water may be explored. If ground water of appropriate quality is available, the resource may be sparingly used for better water management in crisis situations.

During culture period, on some occasions the water pH and total alkalinity were observed to be low. These can be corrected by using lime ($CaCO_3$) to raise pH of water above 7.0 and total alkalinity around 50 ppm. Waters with low alkalinity are poorly buffered against the drastic pH changes and this may limit phytoplankton growth. Lime may increase the availability of CO_2 for photosynthesis.

The above suggestions relate to improving the quality of the pond culture environment and plankton productivity within the limitations posed by the ambient conditions of the system. With the above improvements and following the hitherto recommended stocking density of 25,000 PL 20-30 Penaeus monodon, production rates of 430-625 kg/ha in the first crop and 300-450 kg/ha in the second crop, averaging to 860 kg/ha/year (Mohanty, 1991) may be obtained. However, there are a lot of variations in practices, stocking density and production rates as seen during this study.

If the production rates are to be improved, it can be done through the following approaches:

(a) increase in stocking density.
(b) use of compounded feeds to supplement/replace snail meat.
(c) provide for circulation and aeration of water.
(d) maintain minimum water level during the second crop.

These measures may be adopted only when it can be assured that

(a) the system functions within the carrying capacity of pond environment.

(b) they do not cause degradation of the environment due to self-pollution problems.

(c) they lead to sustainable increased production over a period of time.

(d) the additional inputs are within the means and capabilities of the beneficiaries.

(e) supply of critical inputs such as seed and feed are readily available for the two crops.

(f) additional infrastructure facilities as required are created, and

(g) the improved system is economically viable and brings in profits commensurate with higher level of investment.

Given the small area of 0.2 ha and 0.5 ha of ponds under the beneficiary schemes and the static water conditions, the approach to achieve higher production rates should be a cautious one. The farmers at present are satisfied with the extensive level of prawn farming activity which gives them additional income. The larger ponds of 0.5 ha area and above under the ADAP/BFDA schemes may be more amenable for higher inputs, better management practices and higher production than at present. The smaller ponds of 0.2 ha area may respond adversely with higher inputs which may lead to self-pollution problems.

Our attempts at this point should be to ensure that

(i) Seed of P. monodon is made available to all the farmers in a given duration of time in required numbers (keeping the stocking density at the present recommended level of 25,000 - 30,000 PL-20-30/ha) from hatcheries.

(ii) Nurseries are constructed as a common facility in each cluster to rear and condition the hatchery seed before stocking the grow-out ponds.

(iii) Small-scale prawn feed preparation units are established at appropriate locations with ordinarily available grinding, sieving, mixing and pelletising units. Such feed units will utilise locally available

materials such as trash fish (fishmeal), shrimp head waste (shrimp meal), groundnut cake, rice polish, broken wheat and bone meal and the mix could be fortified with poultry grade vitamin and mineral mix. Such feeds can be used besides fresh snail and mussel meat and this will bring the pressure on snail population down.

(iv) Some additional water source will become necessary to tide over pond drying and also to mitigate pollution due to metabolite accumulation and plankton blooms. Canals/borewells could be considered for the purpose.

(v) The cluster of larger ponds (0.5 ha and above) may take in slightly higher stocking densities of 30,000 - 35,000 PL/ha, provided aeration devices are installed.

(vi) By streamlining the inputs and introducing marginal improvements, a uniform sustainable production range of 800 - 1000 kg/ha/year could be expected to be achieved in the confined pond culture of tiger prawn in the Chilka Lake fringe area.

The present study has been conducted based on one-time sampling in the cluster ponds for each season. The data have helped in a better understanding of the physico-chemical parameters of the culture ponds. However, a more critical study is required to understand the changes that take place in the ponds in an annual cycle on a continuous basis with accurate data on pond and crop conditions. Improvements in inputs and management practices should be tested and closely monitored for impact on pond ecology and production.

ACKNOWLEDGEMENTS

Our grateful thanks are due to Shri P.Mohapatra, the then Director of Fisheries, Government of Orissa, Cuttack, for his interest and support during the investigations. Shri S.K.Mohanty and Shri Utkal Das, Chief Executive Officers of BFDA, Puri made it possible for us to cover the confined-pond clusters in different blocks in the districts of Puri and Ganjam, with the help and co-operation of the BFDA field officers and other staff. We wish to express our sincere thanks to them all.

The staff members of this Institute at Puri Research Centre extended all help and assistance in the collection and handling of the samples and the assistance is acknowledged.

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TABLE-1 Average rainfall (in mm) for Sunamuhin, Puri District

Month	1980	198	1982	1983	1984	1985	1986	1987	1988	1989
January	-	4.0	2.50	-	-	5.0	13.0	40.0	-	-
February	-	13.0	83.05	88.75	-	27.0	27.2	-	-	-
March	-	62.75	15.00	92.50	-	-	-	-	-	-
April	-	44.75	-	11.75	12.50	6.0	30.00	13.00	52.0	-
May	-	125.00	-	52.50	51.50	30.0	19.00	43.00	76.00	81.00
June	288.75	141.25	212.50	77.25	221.50	117.25	137.00	20.00	122.00	391.00
July	440.00	104.25	139.25	205.25	451.75	4.50	237.50	131.00	271.00	189.00
August	504.50	511.75	289.75	184.50	241.50	522.50	173.00	84.0	146.00	372.00
September	420.25	371.50	197.55	171.00	132.25	316.25	170.00	109.0	387.00	105.00
October	300.25	2.50	28.50	140.25	43.50	212.50	188.50	126.00	61.00	-
November	-	-	8.75	2.00	-	-	326.50	172.0	-	-
December	13.75	21.25	-	12.50	-	-	6.00	-	-	-
Total	1967.50	1405.00	977.30	1038.50	1154.50	1241.00	1327.70	738.00	1015.00	1138.00

TABLE-2. Details of prawn pond clusters in the Chilka fringe area investigated during 1988-89.

S.No.	Name of cluster	Scheme	Area of pond (ha)	S.No. of ponds sampled
1.	Kusubenti	ERRP	0.2	9, 22
2.	Mudiratha	ADAP	0.5	13, 16
	Mudiratha	BFDA	0.4	1
3.	Deynai	BFDA	0.16	2, 3, 4
			0.18	
	Deynai	ADAP	0.5	1, 5
4.	Khandualpur	ERRP	0.2	2, 3, 4, 25, 26, 31, 32, 33, 34, 54
5.	Keutakudi	(Nursery pond)	-	-
6.	Jadupur	ERRP	0.2	5, 6, 7
7.	Gorapur	ERRP	0.2	2, 7
8.	Panaspada	ERRP	0.2	2, 3, 4, 5, 29
9.	Satpada	BFDA	0.24	1
		"	0.39	2
10.	Binchanapalli	ERRP	0.2	2, 18
11.	Haripur	ERRP	0.2	2, 18

Note: Ponds in S.No.1-5 were sampled during Nov.88, Mar.89 and Aug.89; S.No.6-10 during Mar.89 and Aug.89; and S.No.11 during Nov.88 and Mar.89

Table-3. Kusubenti - Soil characteristics of ponds

PARAMETERS	SEASONS		
	WINTER (Nov. 1988)	SUMMER (March, 1989)	MONSOON (August, 1989)
Sand %	27.43 - 32.51 (29.97)	-	-
Silt %	19.24 - 22.83 (21.03)	-	-
Clay %	44.66 - 54.33 (49.49)	-	-
Temperature (^{o}C)	25.3 - 25.3 (25.3)	31.8 - 34.4 (33.1)	29.1 - 30.5 (29.8)
Eh (mV)	-56 to -110 (-83)	-106 to -135 (-120)	-90 to -130 (-110)
pH	8.3 - 8.7 (8.5)	7.8 - 8.0 (7.9)	7.9 - 8.5 (8.2)
E.C. (mmhos/cm)	4.28 - 5.98 (5.13)	19.83 - 28.25 (24.04)	2.79 - 2.95 (2.87)
Org. Carbon (%)	0.17 - 0.25 (0.21)	0.19 - 0.64 (0.41)	0.30 - 0.38 (0.34)
$CaCO_3$(%)	1.60 - 1.72 (1.66)	0.97 - 1.10 (1.03)	1.03 - 1.49 (1.26)
Av. Nitrogen (mg/100 g)	11.47 - 11.76 (11.66)	14.32 - 24.43 (19.37)	17.25 - 17.37 (17.31)
Av. phosphorus (mg/100 g)	2.71 - 3.00 (2.85)	2.75 - 5.17 (3.96)	3.50 - 4.98 (4.24)
Fe (%)	---	0.73 - 0.83 (0.78)	---

TABLE-4. Kusubenti - Water characteristics of pond

PARAMETERS	SEASONS		
	WINTER (Nov. 1988)	SUMMER (March, 1989)	MONSOON (Aug. 1989)
Depth (cm)	60.0 - 65.0 (62.5)	-- (17.0)	69.0 - 79.0 (74.0)
Temperature (^{o}C)	25.0 - 25.0 (25.0)	-- (35.0)	32.0 - 32.0 (32.0)
pH	8.2 - 9.2 (8.7)	-- (8.5)	6.9 - 6.9 (6.9)
D.O. (ppm)	6.2 - 8.0 (7.1)	-- (10.0)	6.0 - 6.3 (6.1)
Total alkalinity (ppm)	46.7 - 62.0 (54.3)	-- (22.0)	24.0 - 50.0 (37.0)
Ca^{++} (ppm)	142.1 - 152.6 (147.3)	-- (238.1)	75.8 - 77.6 (76.7)
Mg^{++}(ppm)	301.7 - 317.5 (309.6)	-- (549.2)	154.6 - 169.5 (162.0)
Salinity (ppt)	7.0 - 14.5 (10.7)	-- (22.0)	6.0 - 11.0 (8.5)
$NO\bar{3}$ - N (ppm)	0.045 - 0.050 (0.047)	-- (0.030)	0.032 - 0.047 (0.039)
PO_4 (ppm)	0.005 - 0.006 (0.005)	-- (0.004)	0.008 - 0.008 (0.008)
Fe^{+++}(ppm)	--	--	0.31 - 0.42 (0.36)

TABLE-5. Kusubenti - P. monodon culture production data

	I Crop
No. of seed stocked	3000 - 4000
Stocking density (No./ha)	15,000 - 20,000
Quantity harvested (kg)	82.5 - 85.0
Yield (kg/ha)	412.5 - 425.0
Average production (kg/ha)	418.75

Note: There was no second crop in the ponds.

TABLE-6. Mudiratha - Soil characteristics of ponds

PARAMETERS	SEASONS		
	WINTER (Nov.1988)	SUMMER (Mar.1989)	MONSOON (Aug.1989)
Sand %	40.17 - 42.78 (41.47)	--	--
Silt %	13.90 - 19.23 (16.56)	--	--
Clay %	39.16 - 44.20 (41.68)	--	--
Temperature (^{o}C)	25.9 - 26.5 (26.2)	24.6 - 28.3 (27.0)	30.5 - 33.5 (32.1)
Eh (mV)	-55 to -160 (-107)	-26 to -110 (-69)	+100 to -125 (+32)
pH	7.5 - 8.2 (7.97)	6.9 - 7.5 (7.27)	7.4 - 7.9 (7.63)
E.C. (mmhos/cm)	5.10 - 7.75 (6.44)	30.50 - 44.75 (39.83)	6.63 - 12.95 (9.45)
Org. Carbon (%)	0.28 - 0.63 (0.41)	0.41 - 0.52 (0.46)	0.18 - 0.29 (0.24)
$CaCO_3$ (%)	1.29 - 1.97 (1.67)	0.38 - 1.20 (0.74)	0.93 - 1.04 (0.97)
Av. Nitrogen (mg/100 g)	8.67 - 20.80 (13.93)	15.90 - 23.65 (19.77)	8.67 - 16.42 (12.03)
Av. Phosphorus (mg/100 g)	1.76 - 7.91 (4.06)	2.28 - 3.42 (2.80)	2.83 - 4.61 (3.61)
Fe (%)	--	0.85 - 1.24 (0.99)	--

TABLE-7. Mudiratha - Water characteristics of ponds

PARAMETERS	SEASONS		
	WINTER (Nov. 1988)	SUMMER (Mar. 1989)	MONSOON (Aug. 1989)
Depth (cm)	60.0 - 65.0 (62.3)	--	60.0 - 90.0 (76.7)
Temperature (^{o}C)	24.9 - 25.0 (25.0)	--	31.0 - 33.0 (32.0)
pH	8.4 - 8.9 (8.6)	--	7.8 - 8.2 (8.0)
D.O. (ppm)	5.2 - 7.2 (6.2)	--	5.4 - 7.6 (6.6)
Total alkalinity (ppm)	36.0 - 58.0 (46.0)	--	26.0 - 48.0 (38.0)
Ca^{++} (ppm)	124.8 - 129.6 (127.2)	--	98.0 - 141.6 (113.2)
Mg^{++} (ppm)	198.7 - 217.1 (207.9)	--	205.0 - 268.0 (240.0)
Salinity (ppt)	8.0 - 13.0 (11.2)	--	7.0 - 13.0 (10.3)
$NO\bar{3}$ -N (ppm)	0.038 - 0.055 (0.046)	--	0.038 - 0.046 (0.042)
PO_4^{---} (ppm)	0.003 - 0.004 (0.003)	--	0.008 - 0.013 (0.011)
Fe^{+++} (ppm)	--	--	0.46 - 0.77 (0.60)

TABLE-8. Mudiratha - P. monodon culture production data

	Ist crop	IInd crop
No. of seed stocked	4000 - 7460	2500 - 4000
Stocking density (nos/ha)	8000 - 14920	5000 - 8000
Quantity harvested (kg)	80.0 - 175.0	41.5 - 121.0
Yield (kg/ha)	160.0 - 350.0 (247.50)	83.0 - 242.0 (160.83)
Annual yield (kg/ha)	408.33	

TABLE-9A. Deynai - Soil characteristics of ERRP ponds

PARAMETERS	SEASONS		
	WINTER (Nov. 1988)	SUMMER (Mar. 1989)	MONSOON (Aug. 1989)
Sand %	34.77 - 50.50 (45.05)	--	--
Silt %	11.46 - 23.37 (15.73)	--	--
Clay %	37.13 - 41.87 (39.22)	--	--
Temperature (^{o}C)	-- (26.8)	29.3 - 32.0 (30.65)	30.0 - 30.5 (30.23)
Eh (mV)	-- (-140)	+95 to -90 (-27)	-15 to -138 (-58)
pH	7.7 - 8.0 (7.8)	6.9 - 7.3 (7.1)	7.4 - 7.5 (7.47)
E.C. (mmhos/cm)	2.50 - 3.75 (3.22)	22.67 - 29.92 (27.04)	2.58 - 5.63 (4.44)
Org. Carbon (%)	0.30 - 0.75 (0.50)	0.38 - 0.76 (0.55)	0.47 - 0.53 (0.48)
$CaCO_3$ (%)	1.00 - 2.25 (1.60)	0.62 - 0.73 (0.69)	0.79 - 1.72 (1.23)
Av. Nitrogen (mg/100 g)	9.59 - 18.75 (14.53)	15.42 - 22.17 (18.36)	14.17 - 22.0 (17.19)
Av. Phosphorus (mg/100 g)	0.88 - 4.23 (2.86)	1.45 - 2.82 (2.16)	1.22 - 4.03 (2.29)
Fe (%)	--	0.68 - 1.28 (0.92)	--

TABLE-9B. Deynai - Soil characteristics of ADAP ponds

PARAMETERS	SEASONS		
	WINTER (Nov. 1988)	SUMMER (Mar. 1989)	MONSOON (Aug. 1989)
Sand %	43.67 - 46.67 (45.17)	--	--
Silt %	12.00 - 14.53 (13.26)	--	--
Clay %	41.33 - 41.80 (41.56)	--	--
Temperature (^{o}C)	-- (27.7)	28.0 - 30.9 (29.45)	32.7 - 33.0 (32.85)
Eh (mV)	-- (-150)	-94 to -106 (-100)	-85 to -86 (-85)
pH	7.2 - 8.7 (7.95)	6.9 - 6.9 (6.9)	7.7 - 8.1 (7.9)
E.C.	6.66 - 15.75 (11.20)	32.35 - 38.27 (35.31)	3.03 - 11.85 (7.44)
Org. Carbon (%)	0.20 - 0.54 (0.37)	0.53 - 0.56 (0.54)	0.23 - 0.57 (0.40)
$CaCO_3$ (%)	1.53 - 2.25 (1.89)	0.67 - 0.92 (0.77)	1.22 - 1.38 (1.30)
Av. Nitrogen (mg/100 g)	19.04 - 19.90 (19.51)	23.42 - 23.83 (23.62)	16.67 - 20.50 (18.58)
Av. Phosphorus (mg/100 g)	2.45 - 3.33 (2.89)	1.98 - 2.67 (2.32)	1.92 - 2.03 (1.97)
Fe (%)	--	0.87 - 0.94 (0.90)	--

TABLE-10A. Deynai - Water characteristics of ERRP ponds

PARAMETERS	SEASONS		
	WINTER (Nov. 1988)	SUMMER (Mar. 1989)	MONSOON (Aug. 1989)
Depth (cm)	73.0 - 75.0 (74.0)	--	65.0 - 80 (71.7)
Temperature (^{o}C)	27.9 - 28.0 (27.9)	--	30.0 - 31.0 (30.7)
pH	8.4 - 8.4 (8.4)	--	7.6 - 8.5 (8.0)
D.O. (ppm)	5.2 - 8.0 (7.1)	--	5.2 - 5.6 (5.5)
Total alkalinity (ppm)	40.0 - 76.0 (56.0)	--	50.0 - 52.0 (50.9)
Ca^{++} (ppm)	-- (109.4)	--	55.2 - 93.6 (71.2)
Mg^{++} (ppm)	-- (194.4)	--	113.2 - 253.6 (163.0)
Salinity (ppt)	4.0 - 8.0 (5.3)	--	3.5 - 5.0 (4.2)
$NO\bar{3}$ (ppm)	-- (0.041)	--	0.025 - 0.046 (0.038)
PO_4^{---} (ppm)	-- (0.005)	--	0.007 - 0.015 (0.001)
Fe^{+++} (ppm)	--	--	0.54 - 1.10 (0.75)

TABLE-10B. Deynai - Water characteristics of ADAP ponds

PARAMETERS	SEASONS		
	WINTER (Nov. 1988)	SUMMER (Mar. 1989)	MONSOON (Aug. 1989)
Depth (cm)	110.0 - 120.0 (115.0)	39.0 - 58.0 (48.5)	78.0 - 100.0 (89.0)
Temperature (^{o}C)	34.5 - 35.0 (34.7)	30.5 - 35.5 (33.0)	33.0 - 33.5 (33.2)
pH	8.4 - 8.5 (8.4)	8.2 - 8.7 (8.4)	7.8 - 8.1 (7.9)
D.O (ppm)	6.0 - 6.8 (6.4)	8.4 - 11.0 (9.7)	5.6 - 5.6 (5.6)
Total alkalinity (ppm)	40.8 - 50.0 (45.4)	116.0 - 150.0 (133.0)	36.0 - 62.0 (49.0)
Ca^{++} (ppm)	-- (151.6)	295.7 - 305.3 (300.5)	45.6 - 128.8 (87.2)
Mg^{++} (ppm)	-- (327.6)	781.4 - 925.4 (853.4)	379.2 - 491.2 (435.2)
Salinity (ppt)	13.0 - 14.0 (13.5)	25.4 - 30.7 (28.0)	12.0 - 13.0 (12.5)
$NO\bar{3}$ (ppm)	-- (0.040)	0.017 - 0.019 (0.018)	0.025 - 0.029 (0.027)
PO_4^{---} (ppm)	-- (0.003)	0.002 - 0.006 (0.004)	0.008 - 0.009 (0.008)
Fe^{+++} (ppm)	--	--	0.52 - 0.60 (0.56)

TABLE 11. Deynai - P. monodon culture production data

	ERRP	ADAP
Ist crop		
No. of seed stocked	1000 - 3000	4000 - 4000
Stocking density (nos/ha)	6250 - 18750	8000 - 8000
Quantity harvested (kg)	31.0 - 45.0	64.5 - 100.0
Yield (kg/ha)	193.75 - 281.25	129.00-200.00
	(237.50)	(164.50)
IInd crop		
No. of seed stocked	1500 - 2300	1000 - 4500
Stocking density (nos/ha)	9375 - 12780	2000 - 9000
Quantity harvested (kg)	30.0 - 34.0	5.0 - 73.2
Yield (kg/ha)	187.50- 212.50	10.00 - 146.40
	(200.00)	(78.20)
Annual yield (kg/ha)	437.50	242.70

TABLE-12. Khandualpur - Soil characteristics of ponds

PARAMETERS	SEASONS		
	WINTER (Nov. 1988)	SUMMER (Mar. 1989)	MONSOON (Aug. 1989)
Sand %	34.60 - 59.00 (48.01)	--	--
Silt %	4.50 - 16.10 (8.88)	--	--
Clay %	35.70 - 50.10 (43.16)	--	--
Temperature (^{o}C)	27.0 - 27.7 (27.3)	29.7 - 34.0 (30.9)	29.0 - 32.3 (30.7)
Eh (mV)	-151 to -160 (-156)	--	-48 to -142 (-98)
pH	7.1 - 9.4 (8.3)	6.2 - 7.9 (7.2)	5.6 - 7.6 (6.8)
E.C. (mmhos/cm)	3.00 - 7.80 (4.89)	7.08 - 19.92 (12.57)	6.78 - 25.93 (12.78)
Org. Carbon (%)	0.42 - 0.51 (0.46)	0.43 - 1.32 (0.75)	0.17 - 0.66 (0.44)
$CaCO_3$ (%)	1.75 - 2.00 (1.87)	0.28 - 1.08 (0.61)	0.00 - 1.94 (0.86)
Av. Nitrogen (mg/100 g)	15.35 - 18.47 (17.01)	17.67 - 35.08 (24.45)	11.37 - 23.83 (19.04)
Av. Phosphorus (mg/100 g)	1.62 - 2.22 (1.91)	1.38 - 7.62 (4.03)	1.73 - 12.98 (5.20)
Fe (%)	--	0.90 - 1.85 (1.3)	--

TABLE-13. Khandualpur - Water characteristics of ponds

PARAMETERS	SEASONS		
	WINTER (Nov. 1988)	SUMMER (Mar. 1989)	MONSOON (Aug. 1989)
Depth (cm)	65.0 - 82.0 (74.0)	35.0 - 50.0 (40.2)	57.0 - 92.0 (75.9)
Temperature (^{o}C)	28.0 - 29.0 (28.3)	36.0 - 38.0 (37.0)	30.0 - 34.0 (31.7)
pH	7.7 - 8.4 (8.2)	6.2 - 8.8 (7.9)	7.6 - 9.3 (8.6)
D.O. (ppm)	6.0 - 7.6 (7.1)	5.2 - 7.2 (5.8)	4.0 - 14.4 (7.3)
Total alkalinity (ppm)	22.0 - 60.0 (37.0)	16.0 - 208.0 (103.5)	36.0 - 60.0 (46.9)
Ca^{++} (ppm)	86.4 - 103.6 (95.0)	142.1 - 273.3 (196.5)	22.0 - 157.6 (85.7)
Mg^{++} (ppm)	203.6 - 210.6 (207.1)	329.6 - 561.8 (446.6)	79.0 - 318.4 (184.1)
Salinity (ppt)	10.0 - 10.0 (10.0)	13.0 - 19.0 (15.2)	5.0 - 9.0 (6.5)
$NO\bar{3}$ (ppm)	0.050 - 0.050 (0.50)	0.010 - 0.038 (0.025)	0.020 - 0.040 (0.026)
PO_4^{---} (ppm)	0.004 - 0.004 (0.004)	0.002 - 0.008 (0.005)	0.006 - 0.012 (0.009)
Fe^{+++} (ppm)	--	--	0.92 - 2.68 (1.78)

TABLE-14. Khandualpur - P. monodon culture production data

	Ist crop	IInd crop
No. of seed stocked	1500 - 3000	1000 - 2000
Stocking density (nos/ha)	7500 - 15000	5000 - 10000
Quantity harvested (kg)	20.0 - 59.0	14.5 - 37.5
Yield (kg/ha)	100.0 - 295.0	72.5 - 187.5
	(217.50)	(142.00)
Annual yield (kg/ha)	359.50	

TABLE-15. Keutakudi - Soil characteristics of ponds

PARAMETERS	SEASONS		
	WINTER (Nov. 1988)	SUMMER (Mar. 1989)	MONSOON (Aug. 1989)
Sand %	-- (56.50	--	--
Silt %	-- (11.23)	--	--
Clay %	-- (32.27)	--	--
Temperature (^{o}C)	-- (24.6)	-- (31.6)	-- (31.3)
Eh (mV)	-- (-165)	-- (-70)	-- (+110)
pH	-- (8.0)	-- (7.2)	-- (6.6)
E.C. (mmhos/cm)	-- (4.37)	-- (48.98)	-- (5.75)
Org. Carbon (%)	-- (0.14)	-- (0.26)	-- (0.29)
$CaCO_3$ (%)	-- (0.77)	-- (0.33)	-- (0.24)
Av. Nitrogen (mg/100 g)	-- (10.78)	-- (15.33)	-- (13.83)
Av. Phosphorus (mg/100 g)	-- (1.39)	-- (1.55)	-- (1.54)
Fe (%)	--	-- (1.45)	--

TABLE-16. Keutakudi - Water characteristics of ponds

PARAMETERS	SEASONS		
	WINTER (Nov. 1988)	SUMMER (Mar. 1989)	MONSOON (Aug. 1989)
Depth (cm)	--	--	-- (150.0)
Temperature (^{o}C)	--	--	-- (34.0)
pH	--	--	-- (6.6)
D.O. (ppm)	--	--	-- (7.5)
Total alkalinity (ppm)	--	--	-- (14.0)
Ca^{++} (ppm)	--	--	-- (125.6)
Mg^{++} (ppm)	--	--	-- (271.6)
Salinity (ppt)	--	--	-- (10.0)
$NO\bar{3}$ (ppm)	--	--	-- (0.032)
PO_4^{---} (ppm)	--	--	-- (0.011)
Fe^{+++} (ppm)	--	--	-- (0.96)

TABLE-17. Jadupur - Soil characteristics of ponds

PARAMETERS	SEASONS		
	WINTER (Nov. 1988)	SUMMER (Mar. 1989)	MONSOON (Aug. 1989)
Sand %	61.60 - 63.83 (62.81)	--	--
Silt %	7.67 - 8.97 (8.38)	--	--
Clay %	28.50 - 29.43 (28.81)	--	--
Temperature (^{o}C)	--	26.5 - 27.1 (26.8)	29.2 - 29.9 (29.5)
Eh (mV)	--	+140 to +315 (+227)	+80 to +90 (+85)
pH	--	4.7 - 7.4 (6.05)	4.1 - 4.9 (4.5)
E.C. (mmhos/cm)	--	42.00 - 66.50 (54.25)	7.50 - 10.25 (8.87)
Org. Carbon (%)	--	0.18 - 0.37 (0.27)	0.11 - 0.21 (0.16)
$CaCO_3$ (%)	--	0.00 - 0.23 (0.11)	0.00 - 0.00 (0.00)
Av. Nitrogen (mg/100 g)	--	13.83 - 16.42 (15.12)	10.00 - 13.33 (11.66)
Av. Phosphorus (mg/100 g)	--	3.78 - 4.75 (4.26)	3.48 - 4.37 (3.92)
Fe (%)	--	0.60 - 1.30 (0.95)	--

TABLE-18. Jadupur - Water characteristics of ponds

PARAMETERS	SEASONS		
	WINTER (Nov. 1988)	SUMMER (Mar. 1989)	MONSOON (Aug. 1989)
Depth (cm)	--	--	85.0 - 90.0 (87.7)
Temperature (^{o}C)	--	--	33.7 - 34.0 (33.8)
pH	--	--	7.3 - 7.9 (7.6)
D.O. (ppm)	--	--	5.1 - 5.6 (5.4)
Total alkalinity (ppm)	--	--	24.0 - 36.0 (29.3)
Ca^{++} (ppm)	--	--	--
Mg^{++} (ppm)	--	--	--
Salinity (ppt)	--	--	15.0 - 16.0 (15.3)
$N\bar{O}_3$ - N (ppm)	--	--	0.020 - 0.023 (0.022)
PO_4^{---} (ppm)	--	--	0.011 - 0.012 (0.012)
Fe^{+++} (ppm)	--	--	0.96 - 1.80 (1.46)

TABLE-19. Jadupur - P. monodon culture production data

	Ist crop
No. of seed stocked	1000 - 1500
Stocking density (Nos/ha)	5000 -7500
Quantity harvested (kg)	22.0 - 35.0
Yield (kg/ha)	110.0 - 175.0 (146.66)
Annual yield (kg/ha)	146.66

Note: There was no second crop in the ponds.

TABLE-20. Panaspada - Soil characteristics of ponds

PARAMETERS	SEASONS		
	WINTER (Nov. 1988)	SUMMER (Mar. 1989)	MONSOON (Aug. 1989)
Sand %	44.20 - 66.90 (55.77)	--	--
Silt %	6.33 - 12.43 (8.35)	--	--
Clay %	24.60 - 47.30 (35.88)	--	--
Temperature (^{o}C)	--	25.7 - 28.4 (26.9)	30.7 - 32.4 (31.8)
Eh (mV)	--	+170 to -130 (+44)	-40 to -135 (-93)
pH	--	6.6 - 8.0 (7.1)	6.4 - 7.0 (6.7)
E.C. (mmhos/cm)	--	27.23 - 79.08 (45.23)	7.75 - 10.08 (9.16)
Org. Carbon (%)	--	0.23 - 0.41 (0.32)	0.12 - 0.68 (0.43)
$CaCO_3$ (%)	--	0.00 - 0.42 (0.24)	0.30 - 1.08 (0.64)
Av. Nitrogen (mg/100 g)	--	14.23 - 20.33 (17.12)	11.00 - 25.50 (18.19)
Av. Phosphorus (mg/100 g)	--	4.32 - 5.42 (4.93)	2.87 - 4.75 (4.02)
Fe (%)	--	0.60 - 1.19 (0.93)	--

TABLE-21. Panaspada - Water characteristics of ponds

PARAMETERS	SEASONS		
	WINTER (Nov. 1988)	SUMMER (Mar. 1989)	MONSOON (Aug. 1989)
Depth (cm)	--	--	74.0 - 81.0 (77.6)
Temperature (^{o}C)	--	--	33.0 - 34.0 (33.6)
pH	--	--	6.4 - 8.5 (7.4)
D.O. (ppm)	--	--	5.2 - 8.6 (6.8)
Total alkalinity (ppm)	--	--	8.0 - 24.0 (15.0)
Ca^{++} (ppm)	--	--	--
Mg^{++} (ppm)	--	--	--
Salinity (ppt)	--	--	7.0 - 11.2 (9.3)
$NO\bar{3}$ (ppm)	--	--	0.020 - 0.030 (0.024)
PO_4^{---} (ppm)	--	--	0.004 - 0.011 (0.007)
Fe^{+++} (ppm)	--	--	0.52 - 1.68 (1.20)

TABLE-22. Panaspada - P. monodon culture production data

	Ist crop	IInd crop
No. of seed stocked	1000 - 1500	500 - 1000
Stocking density (nos/ha)	5000 - 7500	2500 - 5000
Quantity harvested (kg)	22.5 - 44.5	11.00 - 22.50
Yield (kg/ha)	112.50 - 222.50	55.00 - 112.50
	(174.00)	(85.62)
Annual yield (kg/ha)	259.62	

TABLE-23. Gorapur - Soil characteristics of ponds

PARAMETERS	SEASONS		
	WINTER (Nov. 1988)	SUMMER (Mar. 1989)	MONSOON (Aug. 1989)
Sand %	50.13 - 51.67 (50.90)	--	--
Silt %	7.00 - 9.84 (8.42)	--	--
Clay %	40.03 - 41.33 (40.68)	--	--
Temperature (^{o}C)	--	28.2 - 28.4 (28.3)	31.2 - 31.8 (31.5)
Eh (mV)	--	+160 to - 90 (+35)	+70 to +90 (+80)
pH	--	6.6 - 7.2 (6.9)	6.6 - 6.8 (6.7)
E.C. (mmhos/cm)	--	62.82 - 71.33 (67 07)	1.83 - 2.08 (1 95)
Org. Carbon (%)	--	0.48 - 0.55 (0 51)	0.12 - 0.44 (0.28)
$CaCO_3$ (%)	--	0.17 - 0.50 (0.33)	0.48 - 0,71 (0.59)
Av. Nitrogen (mg/100 g)	--	21.00 - 22.33 (21.67)	15.47 - 19.83 (17.65)
Av. Phosphorus (mg/100 g)	--	3.29 - 4.87 (4.08)	2.29 - 4.72 (3.50)
Fe (%)	--	0.84 - 0.95 (0.89)	--

TABLE-24. Gorapur - Water characterisics of ponds

PARAMETERS	SEASONS		
	WINTER (Nov. 1988)	SUMMER (Mar. 1989)	MONSOON (Aug. 1989)
Depth (cm)	--	--	81.0 - 99.0 (90.0)
Temperature (^{o}C)	--	--	32.0 - 32.0 (32.0)
pH	--	--	6:8 - 9.4 (8.1)
D.O. (ppm)	--	--	5.2 - 8.5 (6.8)
Total alka-linity (ppm)	--	--	16.0 - 100.0 (58.0)
Ca^{++} (ppm)	--	--	--
Mg^{++} (ppm)	--	--	--
Salinity (ppt)	--	--	2.3 - 11.0 (6.6)
$NO\bar{3}$ (ppm)	--	--	0.022 - 0.022 (0.022)
PO_4^{---} (ppm)	--	--	0.007 - 0.008 (0.007)
Fe^{+++} (ppm)	--	--	0.97 - 1.53 (1.25)

TABLE-25. Gorapur - P. monodon culture production data

	Ist crop	IInd crop
No. of seed stocked	600 - 1000	500 - 500
Stocking density (nos/ha)	3000 - 5000	2500 - 2500
Quantity harvested (kg)	18.5 - 31.5	12.5 - 12.5
Yield (kg/ha)	92.5 - 157.5	62.5 - 62.5
	(125.00)	(62.50)
Annual yield (kg/ha)	187.50	

TABLE-26. Satpada - Soil characteristics of ponds

PARAMETERS	SEASONS		
	WINTER (Nov. 1988)	SUMMER (Mar. 1989)	MONSOON (Aug. 1989)
Sand %	54.50 - 59.83 (57.16)	--	--
Silt %	9.83 - 11.67 (10.75)	--	--
Clay %	28.50 - 35.67 (32.08)	--	--
Temperature (^{o}C)	--	28.1 - 28.3 (28.2)	29.6 - 30.9 (30.2)
Eh (mV)	--	+160 to +170 (+165)	-30 to -47 (-38.5)
pH	--	7.1 - 7.7 (7.4)	7.3 - 7.4 (7.3)
E.C. (mmhos/cm)	--	58.79 - 62.58 (60.68)	5.10 - 9.67 (7.38)
Org. Carbon (%)	--	0.24 - 0.34 (0.29)	0.15 - 0.22 (0.18)
$CaCO_3$ (%)	--	0.25 - 0.94 (0.59)	1.10 - 1.24 (1.17)
Av. Nitrogen	--	17.12 - 17.50 (17.31)	13.00 - 13.67 (13.33)
Av. Phosphorus (mg/100 g)	--	2.54 - 3.09 (2.81)	1.95 - 2.37 (2.16)
Fe (%)	--	0.54 - 0.55 (0.54)	-- --

TABLE-27. Satpada - Water characteristics of ponds

PARAMETERS	SEASONS		
	WINTER (Nov. 1988)	SUMMER (Mar. 1989)	MONSOON (Aug. 1989)
Depth (cm)	--	--	60.0 - 76.0 (68.0)
Temperature (^{o}C)	--	--	31.0 - 31.0 (31.0)
pH	--	--	7.6 - 8.4 (8.0)
D.O. (ppm)	--	--	5.0 - 5.0 (5.0)
Total alkalinity (ppm)	--	--	40.0 - 55.0 (47.5)
Ca^{++} (ppm)	--	--	87.2 - 116.0 (101.6)
Mg^{++} (ppm)	--	--	209.4 - 484.0 (346.7)
Salinity (ppt)	--	--	11.0 - 17.0 (14.0)
$NO\bar{3}$ (ppm)	--	--	0.036 - 0.037 (0.036)
PO_4^{---} (ppm)	--	--	0.006 - 0.011 (0.005)
Fe^{+++} (ppm)	--	--	0.31 - 0.38 (0.34)

TABLE-28: Satpada- P. monodon culture production data

	Ist crop	
	ERRP	ADAP
No. of seed stocked	3350	5500
Stocking density (Nos/ha)	13936	14080
Quantity harvested (kg)	95.0	115.0
Yield (kg/ha)	395.2	294.4
Annual yield (kg/ha)	395.2	294.4

Note: There was no second crop in the ponds

TABLE-29. Binchanapalli - Soil characteristics of ponds

PARAMETERS	SEASONS		
	WINTER (Nov. 1988)	SUMMER (Mar. 1989)	MONSOON (Aug. 1989)
Sand %	44.50 - 45.0 (44.75)	--	--
Silt %	6.20 - 13.00 (9.60)	--	--
Clay %	42.00 - 49.30 (45.65)		
Temperature (^{o}C)	25.0 - 25.2 (25.1)	--	--
Eh (mV)	-81 to -85 (-83)	--	--
pH	8.1 - 8.9 (8.5)	7.8 - 7.8 (7.8)	--
E.C. (mmhos/cm)	6.00 - 6.30 (6.15)	18.00 - 42.75 (30.37)	--
Org. Carbon (%)	0.32 - 0.53 (0.42)	0.12 - 0.21 (0.16)	--
$CaCO_3$ (%)	3.83 - 4.85 (4.34)	0.50 - 0.50 (0.50)	--
Av. Nitrogen (mg/100 g)	10.37 - 10.96 (10.67)	9.80 - 13.12 (11.46)	--
Av. Phosphorus (mg/100 g)	2.03 - 2.27 (2.15)	2.18 - 3.35 (2.76)	--
Fe (%)	0.85 - 0.87 (0.86)	--	--

TABLE-30. Haripur - Soil characteristics of ponds

PARAMETERS	SEASONS		
	WINTER (Nov. 1988)	SUMMER (Mar. 1989)	MONSOON (Aug. 1989)
Sand %	33.20 - 47.00 (40.10)	--	--
Silt %	16.17 - 19.80 (17.98)	--	--
Clay %	36.83 - 47.00 (41.91)	--	--
Temperature (^{o}C)	22.3 - 22.3 (22.3)	--	--
Eh (mV)	-164 to -170 (-167)	--	--
pH	8.7 - 8.8 (8.7)	7.5 - 7.6 (7.5)	--
E.C. (mmhos/cm)	6.53 - 6.65 (6.59)	20.25 - 23.50 (21.87)	--
Org. Carbon (%)	0.36 - 0.56 (0.46)	0.65 - 0.72 (0.68)	--
$CaCO_3$ (%)	3.81 - 3.91 (3.86)	1.80 - 2.00 (1.90)	--
Av. Nitrogen (mg/100 g)	11.76 - 14.48 (13.12)	19.50 - 21.35 (20.42)	--
Av. Phosphorus (mg/100 g)	1.66 - 2.43 (2.04)	2.35 - 2.50 (2.42)	--
Fe (%)	0.60 - 0.84 (0.72)	--	--

TABLE-31. Doses of lime (kg/ha) to be applied in ponds of cluster

Cluster name	Pond No.	Lime stone or Chuna* ($CaCO_3$)	Quick lime or burnt lime (CaO)
Kusubenti	ERRP 9	640	357
	22	615	343
Mudiratha	BFDA 1	620	346
	ADAP 13	790	441
	16	590	329
Deynai	BFDA 2	735	410
	3	730	407
	4	775	432
	ADAP 1	775	432
	5	600	335
Khandualpur	ERRP 31	1000	558
	32	1000	558
	33	1000	558
	34	1000	558
	54	1000	558
	2	2240	1241
	3	4800	2681
	4	2240	1251
	25	1000	558
	26	2240	1251
Keutakudi	N pond	1100	614
Jadupur	ERRP 5	8640	4826
	6	8640	4826
	7	6480	3620
Panaspada	ERRP 2	1000	558
	3	1600	893
	4	1555	868
	5	1540	860
	29	1060	592

contd

(TABLE-31 contd...)

Cluster name	Pond No.	Lime stone or Chuna* ($CaCO_3$)	Quick lime or burnt lime (CaO)
Gorapur	ERRP 2	1475	824
	7	1600	893
Satpada	BFDA 1	500	279
	2	550	307
Binchanapalli	ERRP 2	500	279
	18	500	279
Haripur	ERRP 2	600	335
	18	675	377

*ecommendation of limestone ($CaCO_3$) is based on pure $CaCO_3$:hat will pass a 0-25 millimeter (mm) screen and considered to have calcium carbonate equivalency (CCE) of 1.00 (or 100%).

Note 1. Depending upon the availability of liming material any one of tnem as suggested may be used for liming the soil

2. Quicklime or unslaked lime or burnt lime or calcium oxide (CaO) must be used with care as it may raise the pH of water to levels that will kill prawn.

TABLE-32. Doses of cattle manure, urea and single superphosphate (kg/ha) to be applied in ponds of cluster

Cluster name	Pond No.	Cattle manure	Urea	Single super-phosphate
Kusubenti	ERRP 9	1250	65	42
	22	1510	70	49
Mudiratha	BFDA 1	1350	73	54
	13	1100	60	12
	16	1340	76	56
Deynai	BFDA 2	1100	70	37
	3	700	63	57
	4	1145	67	77
	ADAP 1	1315	61	63
	5	925	58	53
Khandualpur	ERRP 31	1100	61	69
	32	1060	67	43
	33	1000	50	50
	34	1000	62	51
	54	1080	63	26
	2	800	45	34
	3	810	45	--
	4	1000	57	14
	25	1135	68	14
	26	1240	59	14
Keutakudi	N. pond	1525	73	72
Jadupur	ERRP 5	1510	76	23
	6	1510	76	37
	7	1600	71	38
Panaspada	ERRP 2	900	54	23
	3	1090	61	18
	4	1400	58	39
	5	1700	75	27
	29	1245	63	18

contd.....

TABLE-32 contd....

Cluster name	Pond	No.	Cattle manure	Urea	Single super-phosphate
Gorapur	ERRP	2	1300	59	51
		7	1060	62	20
Satpada	BFDA	1	1700	70	57
		2	1700	70	56
Binchanapalli	ERRP	2	1240	76	53
		18	1535	80	60
Haripur	ERRP	2	1000	69	63
		18	800	64	58