

MANAGEMENT OF POND PRODUCTIVITY FOR OPTIMUM FISH PRODUCTION IN TWO CONTRASTING AGRO-ECOLOGICAL REGIONS OF WEST BENGAL, INDIA

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All the blocks of Nadia and Purulia districts characterized by hot moist sub-humid and hot dry sub-humid agro-ecological regions, respectively were surveyed and physico-chemical characteristics of pond water and sediments were analysed. The parameters of interest were texture, pH, cation exchange capacity, N, P and K contents of pond sediments and pH, dissolved oxygen, carbon dioxide, hardness, alkalinity, available phosphorus and primary productivity of the pond water. Based on the sediment and pond water characteristics an improved fertilizer and manure management schedule as well as maps has been prepared for demonstration of composite fish culture. The fish species attained higher growth rates in the ponds of hot moist sub-humid agro-ecological regions (alluvial soils) in comparison to hot dry sub-humid agro-ecological regions (red & lateritic soils). The fish production in the experimental and control ponds of hot moist sub-humid agro-ecological regions were 5.18 and 3.09 tonnes/ha/yr respectively, as against 4.56 and 2.64 tonnes/ha/yr respectively in hot dry sub-humid agro-ecological regions, indicating efficacy of improved nutrient management practices and the suitability of alluvial soil over red and lateritic soil for higher fish production.

INTRODUCTION

Assessment of sediment and water resources in different agro-ecological regions is one of the important factors to determine the aquaculture productivity. Fertilization and manuring schedule suggested by Banerjee (1967) has yet been a base line for optimizing fish pond management. As a result of variation in sediment and water characteristics, the management of nutrients schedule drastically differs in the same agro-climatic condition as vast heterogeneity of productivity parameters are observed in different blocks. Without proper knowledge of such physico-chemical variation a general practice of nutrient management is followed, resulting low fish production. Moreover, excessive fertilization deteriorates pond productivity, which in terms affects sustainable production of fishes in long run (Ayyappan and Jena, 2001, 2003; Yadav, 2009). Study was undertaken for preparing improved aquaculture management schedule in order to

increase fish production on sustainable basis through mapping of sediment and water resources in these contrasting agro-ecological regions.

MATERIAL AND METHODS

Investigations were carried out covering eighty-six sites in seventeen blocks of Nadia district (hot moist sub-humid agro-ecological region) and one hundred and ten sites in twenty-one blocks of Purulia district (hot dry sub-humid agro-ecological region) through field survey. Selected physico-chemical parameters of pond water attributes like pH, dissolved oxygen, free CO₂, total alkalinity, total hardness, dissolved organic matter, phosphate-phosphorous and primary productivity and sediments attributes like, pH, texture, CEC, Available-N, P, K and organic carbon were analysed by the following standard methods (APHA, 1992; Jackson, 1964; Piper, 1966; Boyd, 1982). Based on the sediment and pond water characteristics an improved fertilizer and manure management schedule as well as maps up to block levels using GIS packages were prepared. Specific four representative soil sites, two from each district were selected for aquaculture experiments. Pond sediments characteristics of Nadia and Purulia district were classified into three groups. Accordingly, three different management levels are scheduled. The spatial distribution of management schedule is presented in Fig. 1 and Table 2.

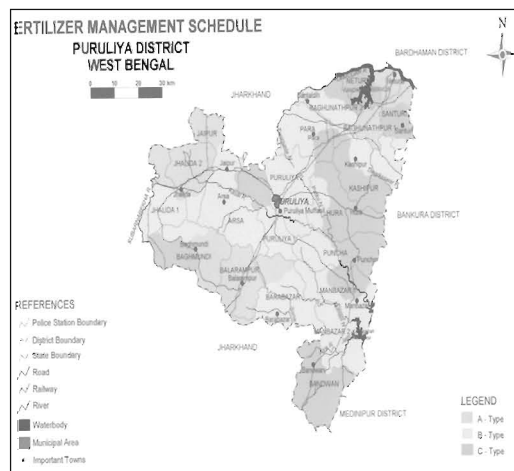


Fig. 1. Nutrient management schedule in hot dry agro-ecological region (Purulia), West Bengal

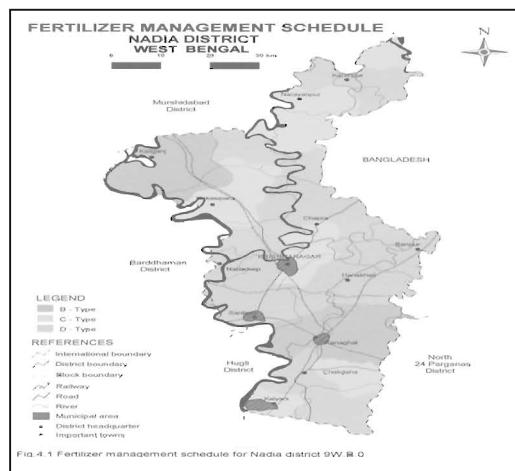


Fig. 2. Nutrient management schedule in hot moist agro-ecological region (Nadia), West Bengal

The experiments were conducted at four farmers' ponds at Kalyani and Chakdah (Table 1; schedule B) in Nadia district and Joypur and Hura (Table 2, Schedule B) in Purulia district following this improved schedule of nutrient management. The

experimental and control ponds were stocked with advanced fingerlings of Indian major carps and exotic carps. Catla (*Catla catla*) and silver carp (*Hypophthalmichthys molitrix*), rohu (*Labeo rohita*), mrigal (*Cirrhinus mrigala*) and bata (*Labeo bata*) in the ratio of 3:1:3:2:1 were stocked at density of 6000 fingerling/ha/year (80-90 mm/8-10 g) in both experimental and control ponds. Supplementary feeding comprising mustard oil cake and rice bran at 1:1 ratio by weight was provided daily @ 6% of biomass per day up to three months, @ 2% from the fourth month to eighth month and @ 1.5% from ninth month onwards till the harvest.

Table 1. Nutrient management schedule in composite fish culture in Nadia district, West Bengal

Schedule	Physico-chemical status of sediment and water	Requirements of fertilizer & manures (kg/ha/yr)	Name of the Block
A	pH (soil): 6.1-6.5 Organic carbon (soil): <0.5% Available P (soil): <10 kg/ha Available N (soil): 178-400 kg/ha Hardness (water): 42-100 mg/l	Urea 200-250; SSP 300-350; cowdung 10,000-12,000; lime: 550-600	Kaliganj and Ranaghat-I&II
B	pH (soil): 6.6-7.5 Organic carbon (soil): 0.5-0.75% Available P (soil): 0-25 kg/ha Available N (soil): 400-560 kg/ha Hardness (water): 100-150 mg/l	Urea 150-200; SSP 250-300; cowdung: 8,000-10,000; lime: 400-450	Kalyani subdivision, east part of Chakdah and Krishnanagar-I, west part of Chapra, middle part of Nakasipara, Tehata-I, south part of Karimpur-II and north part of Karimpur-I
C	pH (soil): 7.6-8.4 Organic carbon (soil): 0.76-2.21% Available P (soil): 26-35 kg/ha Available N (soil): 561-743 kg/ha Hardness (water): 150-208 mg/l	Urea 100-150; SSP 200-250; cowdung 5,000-8,000; lime 250-300	Haringhata, west part of Chakdah, Shantipur, Krishnanagar-II, Nawadip, west part of Krishnanagar-I, Hanskhali, Krishnananj, north-east part of Chapra, Tehata-II, south part of Tehata-I & Karimpur-I, north part of Karimpur-II.

Table 2. Nutrient management schedule in composite fish culture in Purulia district, West Bengal

Schedule	Physico-chemical Status	Requirements of fertilizer & manures kg/ha/yr	Block Name
A	pH: 5.2-5.5 Organic carbon (soil) : <0.5% Available P (soil): 3-10 kg/ha Available N (soil): 79-280 kg/ha Hardness (water): 14-50 mg/l	Urea 250-300; SSP 350-400; cowdung 12,000-14,000; lime 700-750	North part of Jhalda-I&II and Joypur, Balarampur, south-west part of Bagmundi, south part of Raghunathpur-I and east part of Neturia
B	pH: 5.6-6.5 Organic carbon (soil): 0.5-1.0% Available P (soil): 10-20 kg/ha Available N (soil): 280-400 kg/ha Hardness (water): 50-100 mg/l	Urea 200-250; SSP 300-350; cowdung 10,000-12,000; lime 550-600	Manbazar-II, west-south part of Manbazar-I, Barabazar, west part of Hura and Puncha, Purulia-II, Arsa, south part of Purulia-I, Jhalda-I&II, east part of Joypur and Para, west-south part of Raghunathpur-II, north part of Kashipur
C	pH: 6.6-7.3 Organic carbon (soil):1.0-3.32% Available P (soil): 20-23 kg/ha Available N (soil): 401-725 kg/ha Hardness (water): 100-143 mg/l	Urea 150-200; SSP 250-300; cowdung 8,000-10,000; lime 400 450	West-south part of Bagmundi, Bandwan, north part of Purulia-I and Manbazar-I, east part of Punchha, Hura and Para, west-south part of Kashipur, west part of Neturia and Santuri

RESULTS AND DISCUSSION

Water characteristics

In Nadia district the pond water, in general, showed neutral to slightly alkaline in reaction (pH 6.7-8.4). A wide variation in dissolved oxygen contents ranging 1.2-11.6 mg/l were recorded during the study. Low content of dissolved oxygen (<5 mg/l) was recorded in the northern part of the district covering blocks of Chapra, Nakasipara, Kaliganj, Tehata-I&II and Karimpur-I&II. Ponds of these blocks were utilized for jute retting resulting higher organic load in the sediment and pond water as well, resulting lower dissolved oxygen concentration and thereby providing an unfavourable

environment for fish growth. Yearly removal of excessive organic load, restriction of organic manuring and subsequent higher application of inorganic nitrogenous fertilizer, and introduction of stress tolerant fish species were some of the measures suggested for increasing fish production in these sites. Total alkalinity of pond water showed wide variation (48-200 mg/l) and also the same for total hardness (42-208 mg/l). Dissolved organic matter was at optimum level (4-8 mg/l) and found favourable for fish growth. The concentration of phosphate-phosphorus showed an optimum range (0.03-0.2 mg/l). Slightly higher concentration of phosphorus (>0.2 mg/l) was recorded at Kaliganj and Nakasipara blocks, attributed to decomposition of organic matter of jute retted ponds. Wide variations in primary productivity were observed among the ponds, might be due to the variation of nutrients status of sediment. Net primary productivity (NPP) of the major area of the district showed optimum levels of NPP (800-1500 mgC/m³/hr), whereas medium range of NPP (500-800 mgC/m³/hr) was observed in the blocks of Hanskhali and Kalyani subdivision and east part of Kaliganj.

pH of pond water of Purulia district was slightly acidic to neutral in reaction (6.2-7.6). Dissolved oxygen content of pond water of the district was found to be conducive for fish growth, ranges in between 5-10 mg/l. Western part of Manbazar-II, east part of Santuri, Purulia-II and Jhalda-II blocks recorded low dissolved oxygen levels, might be due to use of municipal sewage. Total alkalinity ranged from 40-120 mg/l in major area of the district. Total hardness of pond water was low to medium levels (14-144 mg/l). Optimum level of total hardness was found in major area of the district. Concentration of dissolved organic matter was at optimal ranges (4-8 mg/l), which are favourable for fish growth. Concentration of phosphate-phosphorus in pond water was found to be very low to medium level (0.02-0.07 mg/l). Low level of phosphorus were recorded in the pond water of Bagmundi, Joypur, Arsa, Balarampur, Barabazar, Jhalda-I&II, Bandwan, Manbazar-I&II, Pancha, Purulia-I, Para, Raghunathpur-I&II, Santuri and eastern part of Hura and Kashipur blocks, whereas west part of Jhalda-I&II, Kashipur and Hura, south-east part of Barabazar, south and north part of Purulia-I&II and Neturia blocks recorded very low levels (<0.05 mg/l), attributed to its fixation by Aluminium, Iron and Calcium ions present in pond water and sediments. NPP of pond water was found to be at low level (<500 mgC/m³/hr), might be due to the poor nutrient status of bottom sediment, indicating the need of organic manure and phosphatic fertilizer application at higher doses for maintaining productivity.

Soil characteristics

Physico-chemical properties of the pond sediment are greatly influenced by the sediment texture. Clayey pond sediment absorbs important nutrient while sandy pond sediment allows nutrients for leaching. Major area of the Nadia district were medium to fine in texture varying from sandy clay (sc), silty clay (sic) and clay (c). Pond sediments were observed slightly acidic to slightly alkaline in reaction (pH 6.1-8.4) which indicated

to be in productive range. Organic carbon varied from 0.2-2.21%, with medium range (0.75%) observed in major areas of the district. Cation exchange capacity (CEC) depends mainly on amount of clay, organic carbon and base saturation and other factors (Anon, 1982). While major parts of Nadia district exhibited low in CEC (<19.0), eastern part of Karimpur-I, Nakasipara, Tehata-I and Chapra showed medium level, indicating moderate level of availability of bases like Ca^{2+} , Mg^{2+} , Na^+ , K^+ , Fe^{2+} , Mn^{2+} , Cu^{2+} and Zn^{2+} . Available nitrogen varies from 178-743 kg/ha. Available phosphate-phosphorus which is the most important macronutrient for pond productivity, varied from 7-35 kg/ha. Majority of the area showed medium phosphorus level, ranging 10-25 kg/ha. Available potassium of the pond sediment varied from 65-340 kg/ha.

The pond sediment texture of Purulia district was dominated by sandy clay loam to clay loam. Pond sediments were acidic to neutral in reaction (pH 5.2 to 7.2). Organic carbon in pond sediments varies from 0.20 to 3.32%. Major part of the district recorded lower CEC (< 19.0 cmol). Available nitrogen in pond sediment ranged from 79-725 kg/ha, while available phosphorous recorded low to medium concentration of 3-23 kg/ha. Available potassium ranged from 65 to 419 kg/ha.

Purulia districts under hot dry sub-humid agro-ecological region show that the pond sediments of these districts were usually light in texture, poor organic carbon, low in water holding capacity, acidic to neutral in reaction and low N, P & K status. Such pond sediments exhibit low productivity level for fish growth. As the soils under this agro-ecological region was developed on granite-gneiss parent materials dominated by Kaolinitic mineralogy (low charge mineral) have great influence on the nutrient fixation, especially N (NH_4^+ form) reservoir in the pond sediments which affect the productivity of the ponds (Anon, 1982).

Fish growth and production

Results showed that all the fish species attained higher growth (Figs. 3&4) in ponds of hot moist sub-humid agro-ecological regions of Nadia district i.e., Kalyani and Chakdah (alluvial soils) in comparison to hot dry sub-humid agro-ecological regions of Purulia district i.e., Joypur and Hura (red & lateritic soils). The average fish productions in experimental and control ponds of hot moist sub-humid agro-ecological regions were recorded 5.18 and 3.09 tones/ha/yr, respectively as against 4.56 and 2.64 tones/ha/yr, respectively in experimental and control ponds of hot dry sub-humid agro-ecological regions. Among the six carp species silver carp showed maximum growth followed by catla, rohu, mrigal and bata. The registered growth of silver carp in experimental ponds of Chakdah, Kalyani, Joypur, Hura were 40.1 cm/1570 g, 38.9 cm/1550 g, 38.0 cm/1457 g, 36.6 cm/1440 g, respectively as against 34.3 cm/1147 g, 34.0 cm/1128 g, 33.4 cm/1110 g, 33.2 cm/1087 g in control ponds (Figs. 3&4). The corresponding growth values in catla in the experimental and control ponds were 32.2 cm/1128 g, 28.2 cm/1070 g, 38.4 cm/1267 g

and 30.3 cm/114 g, and 31.4 cm/943 g, 30.1 cm/893 g, 30.8 cm/923 g and 30.1 cm/846 g, respectively. The growth trends were observed to be almost similar for the other fish species.

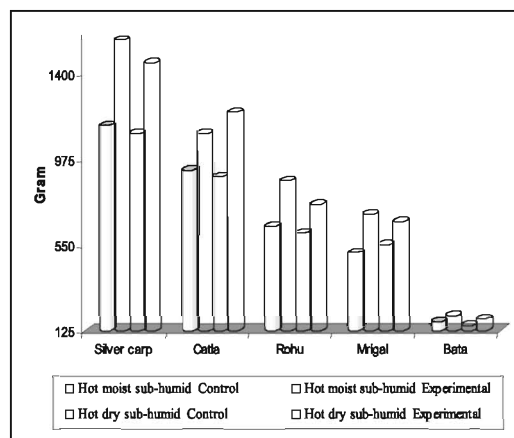


Fig. 3. Fish growth in weight in two agro-ecological regions (Nadia and Purulia) of West Bengal

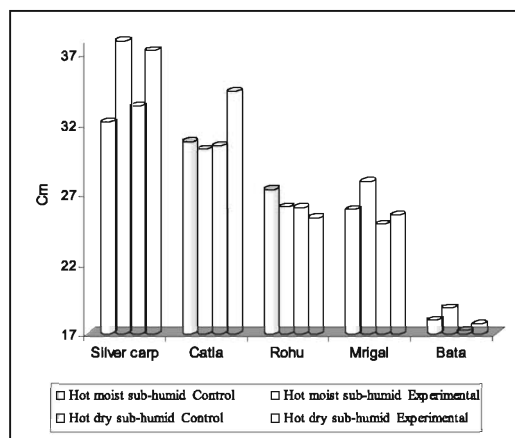


Fig. 4. Fish growth in length in two agro-ecological regions (Nadia and Purulia) of West Bengal

Results of higher fish production in experimental ponds over control following improved nutrient management measures arising from pond sediment, water and primary productivity in two contrasting agro-ecological regions ensured that better management, rather than general fertilizer management procedures, would increase fish production. Therefore, GIS aided maps can be an important tool for boosting the aquaculture productivity in these districts. Production in ponds of hot moist agro-ecological region, in general, were higher in comparison to hot dry agro-ecological (red and lateritic) region both in experimental and control due to inherent higher nutrient status and availability of water. The study suggest that even with low level of nutrient management the ponds with alluvial soil can yield higher fish production than those in red and laterite regions even with better management measures.

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