Fertilization, soil and water quality management in small-scale ponds:

Fertilization requirements and soil properties

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Since most of the potential areas for inland aquaculture have already been explored in India, additional production can only be achieved through successful manipulation of available resources that influence the productivity of various aquaculture systems. One of the main ways this is achieved is through maintenance of adequate levels of nutrients in the pond environment. Pond management in fish culture is mainly concerned with fertilization requirements and strategies; and with good management of pond soil and water quality.

Fertilization requirements of fish ponds

The natural productivity of a fish culture system depends largely on the availability of natural food organisms and on favorable environmental conditions for the fish.

Phytoplankton, the floating microscopic plants that give water its green color, are the first step in the food chain of fish ponds. Other organisms also feed on them and multiply, increasing the availability of natural food for fish stocked in the pond. In addition to carbon dioxide ($C0_{2)}$, water and sunlight for carbohydrate synthesis, phytoplankton need mineral elements including nitrogen, phosphorus, potassium, calcium, sulfur, iron, manganese, copper and zinc for their growth and nutrition. To promote phytoplankton growth and maintain the optimum natural productivity of ponds, the water must contain adequate amounts of these nutrients. Managing the pond soil and water effectively can therefore help provide an adequate amount of natural food for stocked fishes, promoting the healthy growth of fry and fingerlings.

Pond soil plays an important role in regulating the concentration of nutrients in the pond water. Knowledge of the nature and properties of pond soil can help a farmer to develop efficient management practices that will boost production. The most important chemical properties of bottom soil influencing the nutrient management practices of ponds are as follows:

Properties of pond soils

Soil reaction (pH)

The pH of soil is one of the most important factors for maintaining pond productivity since it controls most of the chemical reactions in the pond environment. Near neutral to slightly alkaline soil pH (7 and a little above) is considered to be ideal for fish production. If the pH is too low (strongly acidic) this can reduce the availability of key nutrients in the water and lower pond fertility.

Organic carbon content

Organic carbon acts as a source of energy for bacteria and other microbes that release nutrients through various biochemical processes. Pond soils with less than 0.5% organic carbon are considered unproductive while those in the range of 0.5-1.5% and 1.5-2.5% to have medium and high productivity respectively. Organic carbon content of more than 2.5% may not be suitable for fish production, since it may lead to an excessive bloom of microbes and oxygen depletion in the water.

Carbon to nitrogen ratio

The carbon to nitrogen (C:N) ratio of soil influences the activity of soil microbes to a great extent. This in turn affects the rate of release of nutrients from decomposing organic matter. The rate of breakdown (mineralization) is very fast, moderately fast and slow at C:N in the range of less than 10, 10-20 and more than 20 respectively. In general, soil C:N ratios between 10-15 are considered favorable for aquaculture and a ratio of 20:1 or narrower gives good results.

General nutrient status

Nitrogen, phosphorus and potassium are the major nutrients required by phytoplankton. Inorganic fertilizers can be applied to provide these nutrients. The appropriate dosage depends on the amount of individual nutrients present in the pond soil in an available form. Generally, relatively small amounts of potassium are needed in fish ponds. However, newly constructed ponds or those situated on poor soils may need potassium application. The single most critical nutrient for the maintenance of pond productivity is the available phosphorus content of pond soil and water. Pond soils with 30 ppm, 30-60 ppm, 60-120 ppm and more than 120 ppm available phosphate (P2O5) are considered to have poor, average, good and high productivity respectively. Ponds with less than 250 ppm available soil nitrogen are considered to have

low productivity while concentrations in the range 250-500 ppm and above 500 ppm are considered to be medium and highly productive respectively.

Fertilization schedule of nursery ponds

Nursery ponds

The natural productivity of nurseries is often unsatisfactory due to a deficiency of one or more of the nutrient elements in soil and water, which may be caused by other environmental conditions. Correction of deficiencies by application of manures or fertilizers containing these nutrients in suitable form and in optimal amount is necessary to accelerate biological production and enhance productivity. Accordingly, small shallow ponds are preferred for nurseries for easy management and manipulation of environmental conditions.

Use of organic manures

Both organic manures and chemical fertilizers are widely used for improving the productivity of nurseries. Cow dung is the most widely used organic manure in many areas and is typically applied at a rate of 5,000-15,000 kg/ha in one installment well in advance of stocking with spawn, preferably at least a fortnight prior. The amount is reduced to 5,000 kg/ha when mohua oil cake is used as a fish toxicant in shallow nursery ponds. Sometimes, to hasten the process of decomposition of added manures, nurseries are limed ($CaCO_3$) at a rate of 250-350 kg /ha after the application of manure. Sometimes spaced manuring with cow dung at a rate of 10,000kg/ha 15 days prior to stocking followed by subsequent application of 5,000 kg/ha seven days after stocking has been practiced for sustainable production of zooplankton in nurseries. When more than one crop is raised, nurseries may be manured with cow dung at 5,500 kg/ha immediately after the removal of the first crop. Besides the cow dung, a combination of mustard oil cake, cow dung and poultry manure in the ratio of 6:3:1 at 1,100 ppm have been successfully used for the culture of zooplankton for carp spawn.

Inorganic fertilizers

Inorganic fertilizers containing a fixed percentage of individual nutrient elements or a combination of more than one element are also able to enhance the productivity of nurseries. A ratio of nitrogen : phosphorus ration (N:P) of 4:1 is considered most effective for increased production in nurseries. Weekly application of nitrogen : phosphorus: potassium mixture (N:P:K) in the ratio of 8:4:2 ppm is suitable for increased production of fish food organisms. Use of N:P:K in the ratio of 18:8:4 at 500 kg/ha after liming at 200 kg/ha is quite effective in enhancing the production of slightly acidic and unproductive soils used for nurseries.

Nitrogenous fertilizers containing different forms of nitrogen (amide, ammonium-cum-nitrate and ammonium) are suitable for management of nurseries. These three forms of fertilizers (e.g. urea, calcium ammonium nitrate and ammonium sulfate) are effective for slightly acidic to neutral, moderately acidic and alkaline soils respectively and a rate of 80 kg nitrogen/ha is most suitable for rearing of rohu spawn in nurseries.

Combining organic and inorganic fertilization

The combined use of both organic and inorganic fertilizers is another strategy for increased production of either fish food organisms or fry. The combination of mustard oil cake and 6:8:4 :N:P:K inorganic fertilizer on equivalent nutrient basis (at 12 kg nitrogen/ha) is suitable as compared to either organic to inorganic for nutrient management of nurseries. However, on an equivalent nutrient basis (N:P:K) organic manure (cow dung) is the most suitable fertilization strategy for management of carp nurseries compared to either inorganic fertilizer or combined use of organic and inorganic fertilizer.

Fertilization of rearing and stocking ponds

Acidic pond soils reduce microbial activity and the availability of nutrients in pond water and may render fertilization ineffective. Therefore, the application of lime is the first step of management for all stages of fish culture. Liming raises the soil pH to a desirable level (near neutral) and establishes a strong buffer system in the aquatic environment, improving the effectiveness of fertilization.

Liming stimulates the microbial decomposition of organic matter, supplies calcium to the pond, increases nitrate content in the pond and maintains sanitation in the pond environment. Generally, ground limestone is extensively used and spread over the dry bed or broadcast over the water surface in a single dose at least 15-20 days before stocking. On the basis of soil pH, the following dosages of lime are usually applied to ponds. Besides initial application, some compensatory applications of lime in the range of 100-200 kg/ha may also be made in the stocking pond from time to time to neutralize the acidity developed through application of acid-forming inorganic fertilizers and organic manures and also when fishes are diseased or distressed.

In India, organic manures are more commonly used than inorganic fertilizers. A variety of agricultural wastes, including cow dung, poultry droppings, pig manures and biogas slurry etc. can be used as organic manures. In rearing ponds, application of raw cow dung or biogas slurry is observed to give better results. Depending on the organic carbon content of pond soil in the rearing pond, application of raw cow dung or biogas slurry in the range of 3-7 or 5.5-12 t/ha respectively and addition of 2.5-5 t/ha/year of cow dung or 10-30 t/ha/year biogas slurry or 5-15 t/ha/year poultry droppings respectively in stocking ponds give good results. In rearing ponds, usually 50% of the total requirement is given 15-20 days prior to stocking of fry and the remaining in two equal monthly splits during rearing period. In stocking ponds, on the other hand, 20% of the total requirement is applied initially and the rest is given in equal monthly split. But if the ponds are treated with mohua oil cake to eradicate unwanted fishes, the initial application of the organic manure can be dispensed with in both the culture system.

The efficiency of nitrogen fertilizers in enhancing the productivity of ponds depends largely on their forms. The commonly used nitrogen fertilizers are

Shrimp pond maintenance. Photo: U Win Latt

urea, ammonium sulfate and calcium ammonium nitrate. Among these, urea is suitable for slightly acidic to neutral soil, ammonium sulfate for alkaline soil and calcium ammonium nitrate for acidic soil. Depending on the available nitrogen content of the pond soil, application of 50-70 kg nitrogen/ha (i.e. 108-152 kg urea/ha; 200-280 kg calcium ammonium nitrate/ha; 250-3 50 kg ammonium sulfate (ha) in rearing ponds and 75-150 kg/ha/year (i.e. 163-326 kg urea /ha/year; 300-600 kg calcium ammonium nitrate /ha/year; 375-750 kg ammonium sulfate/ha/year) in stocking ponds give good results. The fertilizer should be applied in equal monthly splits alternately with organic manure with a gap of about a fortnight.

Single Super Phosphate (SSP) is most commonly used as a phosphate fertilizer in fish ponds. Depending on the available phosphate content of pond soil, application of 25-50 kg phosphate (P2O5) /ha (i.e. 156-312 kg SSP/ha) and 40-75 kg P205/ha/year (i.e. 250-468 kg SSP/ha) in rearing and stocking ponds, respectively give good results. To get better utilization efficiency, phosphorus fertilizers should be applied in weekly intervals and the first installment should be given seven days after initial organic manuring.

Muriate of potash (potassium chloride, KCl) and sulfate of potash (potassium sulfate, K2S04) are commonly used as potassium fertilizers in fish ponds. Application of 10-20 kg K20/ha (i.e. 16-32 kg KCl/ha or 20-40 kg K2S04/ha) and 25-40 kg K20/ha/year (i.e. 41-66 kg KCl/ha or 52-83 kg K2S04/ha/year) in rearing and stocking ponds, respectively give good results. The fertilizer should be applied in equal monthly splits.

Application of manure and fertilizer should be suspended if thick green or blue green blooms of algae develop in the pond in order to avoid depletion of oxygen.

Careful use of organic manures and chemical fertilizers in combination is a sound strategy. Occasional development of un-hygenic conditions in the pond may be avoided by using pre-decomposed organic manure. Use of excessive amounts of raw organic manure can result in excessive blooms of microbes during aerobic breakdown of large amount of raw organic manure, and may also caused oxygen depletion.

An understanding of chemical and biological conditions of pond soil and water through regular monitoring systems and adoption of efficient and careful management practices will lead to enhanced production of fish food organisms and thereby increase the growth and survival of fish.

Growth enhancement of carp and prawn through dietary sodium chloride

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intestine and hepatopancreas of the treated fish as well as prawn (Table 2). The type of diet is known to influence the activity of digestive enzymes[15]). Increased digestive enzyme activity coupled with higher nutrient digestibility might have been responsible for better utilization of nutrients from salt incorporated diets.

Our results suggest that dietary inclusion of salt can be beneficial.

References

1. De Silva, S.S. and Aderson. T.A. 1995. Fish Nutrition in Aquaculture. Chapman & Hall. London. 319 p.
2. Matty. A.J. 1988. Growth promotion. In: M.M. Joseph (ed.) The First Indian Fisheries Forum Proceedings. Asian Fisheries Society, Indian Branch. Mangalore, India. p 13-15.
3. Veerina, S.S., Nandeesha. M.C., Rao, K.G. and De Silva, S.S. 1993. Status and technology of Indian major carp farming in Andhra Pradesh, India. Asian Fisheries Society. Indian Branch, Mangalore. 30 pp.
4. Yakupitiage, A. 1993. On-farm feed preparation and feeding strategies for carps and tilapias. In: M.B. New. A.G.J. Tacon and I. Csavas (eds.) Farm-made Aquafeeds. Proceedings of the FAO/AADCP Regional expert consultation on farm-made Aquafeeds. FAO-RAPA/AADCP. Bangkok. Thailand. p. 87-100.
5. Ogino. C. and. Kaniizono, M 1975. Mineral requirements in fish. I. Effects of dietary salt mixture level on growth, Mortality and body composition in rainbow trout and carp. Bull. Jap. Soc. Sci. Fish. 41: 429-434.
6. Murray, M.W. and Andrews, J.W. 1979. Channel catfish: the absence of an effect of dietary salt on growth. Prog. Fish Cult. 41:155-156.
7. Gatlin. D.M. Mackenzie. D.S. Craig. S.R. and Neill W.H. 1992. Effects of dietary sodium chloride on red drum juveniles in waters of various salinities. Prog. Fish Cult. 54: 220-227.
8. Varghese, T.J., Devaraj, K.V. Shantharam. B. and Shettv. H.P.C. 1976. Growth response of common carp. *Cyprinus carpio* var. Communis to protein rich pelleted feed. Proceedings of the Symposium on Development and Utilisation of Indian Fishery Resources. Colombo (Sii Lanka). FAQ Regional Office for Asia and the Far East, Bangkok, Thailand. 408 pp.
9. Duncan, D.B. 1955. Multiple range and multiple F-tests. Biometrics 11: 1-42.
10. Arai, S., Nose. T. and Kawatsu H. 1974. Effect of minerals supplemented to the fish mealdict on growth of eel Anguilla japonica. Tansuika Suisan Kenkvusho Kenkvu Hokoku 24: 95-100.
11. Holsapple, D.R. 1990. The effect of dietary sodium chloride on red drum (*Sciaenops oceliatus*) in fresh and brackish water. Master's Thesis. Texas A and M University, College Station.
12. MacLeod. M.G. 1978, Relationship between dietary sodium chloride, food intake and food conversion in the rainbow trout. J. Fish Biol. 13: 73-79.
13. Salman. N.A. and Eddy. F.B. 1988. Effect of dietary sodium chloride on growth, food intake and conversion efficiency in rainbow trout, Salino gairdneri (Richardson). Aquaculture 70:131-144.
14. Tacon, A.G.J., Knox, D. and Cowey, C. B. 1984. Effect of different dietary levels of salt mixtures on growth and body composition in carp. Bull. Jap. Soc. Sci. Fish. 50: 12 17-1222
15. Bazaz, M.M. and Keshavanath. P. 1993. Effect of feeding different levels of sardine oil on growth, muscle composition and digestive enzyme activities of mahseer, Tor khudree. Aquaculture 115: 111-119.