Unlocking the Potential of Makhana-Based Aquatic Ecosystems for Propagation of Nutrient Dense Small Indigenous Fish in Flood Plain Wetlands of Eastern India

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A rapid increase is observed in people's awareness about the importance of diet in maintaining a healthy lifestyle. People are becoming more health conscious. Today food is not only considered as a source of nutrition but also an alternate for medicine, which has increased the demand for healthy and functional foods in the global market. Hence searching for new foods for diet having both superior nutritional quality and health-beneficial activity is the need of the hour. It is well known that fish, especially small nutrient dense indigenous fish like mola, puntius, chela, garai (channa), gaichi (eel) are rich source of calcium, iron, vitamins, minerals etc. to fight the problem of hidden hunger globally. In addition, there are numbers of small fish available in wetlands having ornamental value and a candidate species like colisa, danio, barbs, etc. for Indian aquarium industry.

Similarly, makhana or gorgon nut, *Euryale ferox* is a nutrient-rich aquatic crop that is commercially cultivated in India. Although *Euryale ferox* is distributed in many parts of the world their commercial cultivation is confined to some geographical regions such as China, India, and some other parts of South East Asia. Even in India, the majority of *Euryale ferox* cultivation is found in Bihar and North-Eastern India. Hence proper awareness and documentation of scientific evidence of the health-promoting effect of this plant are highly essential. Thus, this present article will be helpful in promoting the nutritional and health-beneficial properties of SIFs and makhana. Traditionally, fish is being culture with makhana in ponds of Bihar, especially, Darbhanga, Madhubani, Purnia and Katihar. Fish and makhana are mutually beneficial crops because the makhana crop's detritus creates organic matter that helps plankton growth, which is food for fish. This system of fish cum makhana culture is not only a source of income but also provide nutrition to people. Self-recruiting fish are hardy and breed in ponds having three to four peaks in a year without being any artificial agents. Once, these fish are stocked in the pond, a continuous supply of fish will be available for the locals. The ponds being used for culture of makhana, may be used for stocking these small fish. As a protocol of conventional composite fish culture, small native fish species are eradicated, leading to a drastic shift in the species composition and diversity in favour of carps at the cost of some of the prized native fish species like *A. mola* in the wetlands. However, the high nutritional value of such small fishes, when appear in the market, the demand is so high that it commands exorbitant price over the carps.

These fish although breed naturally in responsive to conducive conditions of the habitat but due to environmental degradation their propagation is dwindling. A high-priced food fish now calls for its conservation, propagation in temporary water resources, paddy fields, wetlands etc. to harness extra benefit from such resources by the farmers. The technology of propagation of these fish has not been worked out with makhana culture. However, there lies ample scope of standardizing techniques for habitat breeding and sympathetic breeding of such fish in shallow waters and other aquatic resources along with makhana and also to propagate it naturally. Other suitable attribute of these species is remarkably shorter period of 3-4 month required to achieve table size fish and self-recruiting ability of this fish in still or seasonal water bodies. Further, this fish appears to perform well in shallower water bodies and is euryphagus fluctuating between herbivorous to omnivorous feeding behaviour with reports of

phytoplankton belonging to both Chlorophyceae and mixophyceae phytoplankton in the gut. Some empirical observations have suggested that mola is a good consumer of zooplankton, especially rotifers. Makhana and fish are mutually beneficial crops as the debris of makhana crop form organic matter that act as source of nutrition for the plankton's growth and also provides ground for the growth of zooplanktons which in return acts as food for the fishes, whereas the fish not only adds to the income it also aids benefit by controlling the makhana pests. The faecal matter of the fish acts as an organic manure. The cost of makhana cum fish cultivation for 1acre land was studied in order to analyse it as a source of income enhancement for the small and marginal farmers of wetland areas. It was observed that makhana cum fish cultivation is a comparatively more profitable enterprise as it yielded a B:C ratio of 1.57 whereas a mono cultivation of makhana yielded a B:C ratio of 1.07. Integrated farming of makhana with fish results into diversification leading to risk reduction with income enhancement of small farmers. This integrated farming has positive socio-economic impact.

The Makhana plant followed a distinctive life cycle characterized by several stages, begins with seed germination, typically from December, marked by the emergence of small red-coloured leaves. As the season progresses into March and April, vegetative growth sets in, with the leaves transforming into vibrant green orbs, sizable in diameter, floating gracefully on the water's surface, and exhibiting a corrugated texture above and pink or deep purple hue beneath, supported by robust, porous, and prickly ribs. Following this phase, flowering and fruiting transpire from May to October/November, with violet-blue or dark pink blossoms adorning the plant, each yielding 15–20 fruits. The subsequent stage involves fruit bursting, where each fruit yields 15–45 seeds encapsulated within a thick sheath around the white edible kernel, which continues intermittently upon fruit maturation. Finally, the cycle concludes with seed sinking, occurring within 2–3 days after fruit bursting, as the seeds settle at the bottom of the pond, preparing for the regeneration of this aquatic crop.

The various stages of makhana cultivation in ponds and tanks considerably alter as well as disrupt the ecological conditions of the water body. The planktonic productivity of such ponds remains very meagre due to shaded surface imparted by *Eurale ferox* leaves which mostly cover the entire surface of the pond. So that the air-breathing fishes, by virtue of the presence of accessory respiratory organs can thrive well in such adverse, low- oxygen environmental conditions. It is a common view that the air- breathing fishes in such ecologically disrupted ecosystem are probably made for each other by nature itself.

***Eurale ferox* cum fish culture has certain advantage and disadvantages:**

The main advantages are

- The most economical utilization of pond or wetland area, since the same pond would be used for the production of both *eurale ferox* and fish.
- Utilization of limited extra labour to take care of fish, since both *eurale ferox* and fish may be taken care at the same time.
- The quantity of supplemental of fish feeds, if it all given, will be comparatively less compared to feed given to the fish in general pond culture and the unused feed in pond *eurale ferox* increases the fertility of the pond by acting as organic manure.
- Fish eat harmful organisms, such as insect larvae and some other water insects, fresh water molluscs. The *eurale ferox* yield would increase due to reduced insect pest pressure and increased organic fertilization.
- The movement of fish would result in better aeration of the water and greater tillering of the euraleferox crop.

The disadvantages of the *Eurale ferox* cum fish culture are:

- If the fish are introduced to early, they may damage the young *Eurale ferox* plants.
- The huge sprawling leaves of *Eurale ferox* plant keep the water surface shaded from May to August. During this period sun-light will not penetrate inside the water surface due to which the grazing chain gets disrupted. As a result of this the dissolved oxygen content of water gets depleted which makes the environment unfavourable.

Union Budget 2025-26 announced the establishment of Makhana Board in Bihar under Agriculture as the first engine' for India's development journey. Board will be established to improve production, processing, value addition, and

marketing of makhana. Board will also provide handholding and training support to makhana farmers and will also work to ensure they receive the benefits of all relevant Government schemes. To optimize the aquatic resources available for makhana culture a pilot project on suitability of SIF culture with makhana need to be initiated to conserve and harvest those fishes which are well known for their high protein, high iron, high calcium and low-fat content and easy digestibility and such, suitable for nutritional security and alternate livelihood option for the country.

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