

## **Production of Fish Varieties in Paddy Fields Simultaneously (The Case Study in Iran)**

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**ABSTRACT:** At present, agriculture systems must be programmed to achieve economic and sustainable crop production. Fish farming in the paddy fields taking the potential facilities available in the paddy fields is straight forward and low-cost. Four species of warm-water fish (common carp, grass carp, silver carp, and bighead) are of production potential in Northern Iran paddy fields. These 4 species of fish interrelated to each other (synergy). Fish farming in paddy fields is a sustainable, low cost activity to produce high value protein and minerals. This kind of combined production optimizes the resource consumption through complementary usage of land and water irrigation. Across the field, integrated rice and fish farming decrease the fertilizer, insecticides and herbicide consumption. On this basis, a positive environmental aspect is that economic loss threshold for pesticides and herbicides consumption increase to the higher levels. Also, higher yield of the rice plant is followed and provides more net interest for the farmer compared to rice monoculture through increase yield of rice and selling the fish.

**Keywords:** rice-fish farming, benefits, sustainable agriculture, fish production, rice paddy

### **INTRODUCTION**

In the sustainable agriculture, the system must be planned based on a resource management strategy to achieve economic, sustainable production. Meanwhile; there must be preservation of environment and guaranteeing the high quality of the environment. To realize the objective such as preservation of the environment and natural resources, improvement of food quality and improvement of socio-economic structure, alternative management must be used. So that in addition to decrease of heavy costs burdened on rural societies, society's health and preservation of the environment is also helped (Noorhosseini-Niyaki, 2010). Fish farming is an easy and low cost activity taking the potential facilities available in the paddy field, and if it is performed in a systematic and technical way, in addition to the production of significant amounts of fish in the paddy field, it is followed by positive and beneficial effects. Some studies have been performed on the benefits of this kind of culture in developed countries among them, international development research center of Canada, Sweden, America and Denmark could be noted. Where, about 2 million dollars have been invested in the research on rice and fish farming in Bangladesh, India, Indonesia, Thailand, Vietnam, Malaysia, Philippine and China (Momen-Nia, 2002). Also, data of integrated rice and fish farming in Iran has been noted in the table 1. Results of all of them indicate that integrated rice and fish farming provides countless economic, social and environmental benefits. This combined culturing system is among new technologies and sustainable system where it is possible to decrease the consumption of herbicides and pesticides compared to rice monoculture fields (Frei and Becker, 2005; Kathiresan, 2007; Salehi and Momen-Nia, 2006; Noorhosseini-Niyaki and Radjabi, 2010) and it also decreases the need to use chemical fertilizers (Frei and Becker, 2005; Salehi and Momen-Nia, 2006; Noorhosseini-Niyaki and Allahyari, 2010). Promoting integrated rice and fish farming and aquaculture; double usage of agricultural water resource and consumption of aquatic organisms in addition to greater availability of healthy, useful protein for villagers through fish production are followed by benefits such as double, optimum, economic usage of paddy fields (Hosseini-

Kheshtmasjedi, 2008), where it is possible to simultaneously harvest fish and rice from the paddy field without providing excess fertilizer, food and water and rice yield will also significantly increase. Fish farming in the paddy fields leads to the productivity of the field soil (Bakhshzad-Mahmoudi, 1997; Frei and Becker, 2005) and is followed by greater yield of the rice (Frei and Becker, 2005; Yong et al., 2006; Das *et al.*, 2010) and provides greater interest for the farmer compared to rice monoculture fields through increase yield of the rice (Saikia and Das, 2008). Grass carp, feeding on plants such as Azolla improves is the rice growth. These plants prevent oxygen exchange between the water and the air and also use the water minerals. When these plants die, they will deposit on the bed and make the field bed muddy. In addition, fish limit excessive expansion of Azolla in the paddy fields by feeding on Azolla and other weeds (Noorhosseini-Niyaki, 2011). In the present study, introduction of warm water fish with sustainable production potential in paddy fields is presented.

Table 1. Statistics of integrated rice-fish farming in North of Iran

Rank	Name of county	Number of rice-fish fields	Fields area (ha)
1	Astaneh Ashrafiyeh	84	83.8
2	Rasht	48	42.2
3	Soomeh sara	44	38.9
4	Lahidjan	42	30.7
5	Talesh	31	46.8
6	Masal	31	37.4
7	Fooman	21	20.5
8	Siyahkal	17	9.2
9	Rezvanshahr	17	7.7
10	Roodsar	14	8.1
11	Astara	12	24.6
12	Bandar Anzali	11	11.2
13	Shaft	11	6.2
14	Langrood	10	11.7
15	Roodbar	2	2.5
16	Amlash	2	1.5
Total		397	383

Source: Noorhosseini-Niyaki and Allahyari, 2012

### **Fish and its Environment**

All the organisms particularly fish depend partly on the condition of the environment where they live. Fish have lived in water for thousands of years and they have been accustomed to the environmental conditions. Fish have exceptional potential to habituate to the conditions. Therefore, everywhere from water surface of seas, rivers, gulfs, lagoons, warm waters of equator and cold waters of Polar Regions to mountainous warm water springs and in several thousand depths of oceans, fish life and are accustomed to its environment. In various different and strange conditions where fish live, it is not assumed that any representative of other vertebrate is able to live in. In addition to the fact that water is a suitable environment for fish to live, on the other hand, it provides food for them and on the other hand, most enemies and parasites which could destroy the fish generation are there. Fish life directly depends on the water. Water should have desirable conditions for life including temperature, oxygen, minerals, salinity for each specific fish according to their structure. In the combined culturing, due to specific ecologic conditions of the field, only certain species of fish can be cultured where most important limiting factors are low depth of water, water flowing leading to fail for early production, shadowing of rice plant followed by lowering of oxygen which is harmful for fish, lack of adequate space for fish movement and swimming, coverage of water surface by Azolla leading to obstruction of sun light, subsequently water temperature will decrease steadily and this has negative effect on fish farming (Bakhshzad-Mahmoudi, 1997).

### **Fish Cultured in Paddy Fields**

The Wide range of fish species is used in integrated rice-fish farming. The Most common species used in this technique are included common carp (*Cyprinus carpio* L.), Nile tilapia (*Oreochromis niloticus* L.), silver barb (*Barbonymus gonionotus*), *Carassius carassius*, *Hypophthalmichthys molitrix*, big head (*Arsitichthys nobilis*), grass carp (*Ctenopharyngodon idella*). In India, native species, *Catla Catla*, *Cirrhinus mrigala* and *Labeo rohita* are the common cultured fish in the paddy fields. Culturing of *Trichogaster pectoralis*, *Clarias macrocephalus* and *Channa striata* has been reported from various Asian countries. Shrimp production was also performed in the paddy fields on India, specifically *Macrobrachium rosenbergii* and also in Vietnam. Alternative culturing of rice and various shrimp species (such as *Metapenaeus spp*, *Penaeus monodon*) was operated in the Mekong delta, Vietnam. Little

empirical work was performed to evaluate which fish and crustacean species are more useful to optimize the fish and rice yield. It is possible to increase the yield, of a multiple culturing dish of the above mentioned aims exploitation of various foods (Frei and Becker, 2005). In the following, we will explain the most important species under the combined culturing with the rice.

### **Common Carp (*Cyprinus carpio*)**

Carp is the oldest species among the cultured species so far used by human. Carp prefer to live in warm waters with low speed and sandy or muddy bed, covers by Aquatic plants. This fish generally hides in deep parts of the river between the water plants. It preys during the day with much caution and during the night with great eagerness. Carp feeds on coast water aquatics such as nematodes, insect larva and small mollusks. Grown fish even feed on the larva of other fish and frog larva. Common carp tolerates against environmental factors and their changes such as temperature, pH, salinity, water dissolved oxygen, food shortage and most importantly, disease and internal and external parasites. This fish is principally omnivorous and in general it is benthivorous (feeding on benthos). In normal conditions, in the first year generally feeds on zooplankton and then feeds on phytoplankton or water suspended organisms. But gradually they feed on benthic organism. Fish older than 1 year mostly feed on benthos and in general invertebrates, mollusks and insect larva. Meanwhile, carp feeds on plant foods which produce fat in their bodies. According to the above mentioned points, the best fish for integrated rice-fish farming is common carp. Since, in the certain conditions of paddy field, in respect of limiting factor, this fish can grow easily. Common carp density in the combined culturing could be in average 700 fish / ha<sup>1</sup>. But if there was low cost food available, this could be reached to 1000 fish / ha<sup>1</sup> (Noorhosseini-Niyaki and Safarzadeh-Vishekaei, 2009).



Figure 1. Common Carp (*Cyprinus carpio*)

### **Grass Carp (*Ctenopharyngodon idella*)**

Grass carp 's body is elongated and flat laterally, coloration of dorsal part is dark, lateral parts are light colored and abdomen is white. This fish is generally herbivorous and its major food is water plants and also feeds on terrestrial higher plants such as clover, alfalfa etc. as its substitute food and achieve adequate growth. In early life to 2-3 centimeters height, it feeds on 200 plankton and then on phytoplankton. Subsequently, it turns in feeding on small, higher plants such as Azolla, etc. Food consumption rate in 24 hours in desirable conditions is about 40 % of body weight and the ratio of conversion of food to the flesh, depending on the kind of grass feeding on, is 1 to 20 up to 1 to 30 or sometimes more. Feeding initiation for this fish is in 10-12 °c. Lower than this temperature, feeding stops. The Best water temperature for nourishment of this fish is 20-30 °c. In Iran, among cultured carps, white grass carp is of great fame and desirability due to its great similarity to Caspian kutum. Grass carp is another fish capable to grow in combined culturing. According to the fact that in recent years, growth of Azolla in water resources, ponds, water dams, lagoons had significantly expanded and paddy fields were over showed by Azolla, huge occurred on it. Thus, for biologic fighting against Azolla in paddy fields it is possible to use grass carp to feed this plant, thus decrease it in paddy fields and on the other hand, the fish itself will grow. on average, it is possible to release 100-120 grass carp/ha<sup>1</sup>. In the absence of Azolla, grass carp can feed on the weeds in the field and on the lower leaf of rice plant. If fodder is poured in to the field (pond), fish density may be raised up to 200 fish /ha<sup>1</sup>. Since confidence between grass carp and rice plant is only 2-3 months and since rice plant grow simultaneous to the growth of grass carp, there will not be a particular problem in respect of grass carp feeding on the rice stalk. Particularly fish are fed by fodder or Azolla. But if grass carp are deprived of food in the field, they may rush to the lower stalks of rice plant and eat them, consequently rice that will be injured (Noorhosseini-Niyaki and Safarzadeh-Vishekaei, 2009).

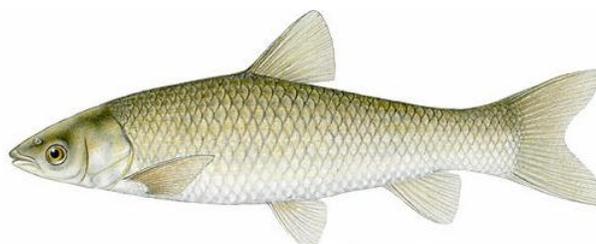


Figure 2. Grass Carp (*Ctenopharyngodon idella*):

**Silver Carp** (*Hypophthalmichthys molitrix*)

Silver carp is a warm water fish feeding on phytoplankton of fresh waters, thus, inner blades of branchial arc in this fish is elongated and fitted for filtering the phytoplankton present in the water. Silver carp has a relatively round and flat head. The eyes of this fish are in the lower part of the head and lower parts of the eyes are placed relatively opposite to the mouth corners. Lateral line begins from the end of branchial cover and ends of the tail axis. Coloration of this silver fish is darker in dorsal part and upper head, but it is silver in the corners and abdomen. It has greatest number among 4 major species of fish. Since, taking its nutrition, it is more economical and lower cost compared to other cultured species. But in paddy fields, due to lack of flow water and shadowing by the rice plant on the water surface, early production is small, thus the growth of this fish is low. But in paddy fields, due to lack of flow water and shadowing by rice plant on the water surface, early production is small, thus the growth of this fish is low. But if we could supply the paddy field water from a fish farming field where fertilizing is perfumed and its early production is raised, it is possible to culture this fish and 100-150 fish / ha<sup>1</sup> could be released and cultured in the paddy field. This fish will grow at the same rate as in fish ponds (Noorhosseini-Niyaki and Safarzadeh-Vishekaei, 2009).

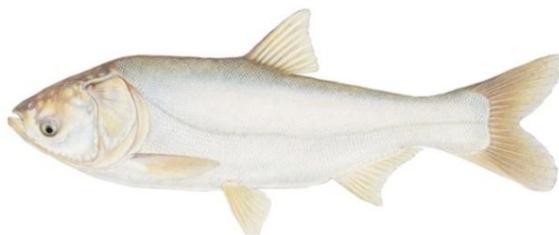


Figure 3. Silver Carp (*Hypophthalmichthys molitrix*)

**Big head** (*Hypophthalmichthys nobilis*)

The Heads of these fish are big, thus they are called bighead they are considered as herbivorous fish. But their major food is mostly zooplankton present in the water. Its body is covered with small, dark scales. Septa of branchial arc are relatively elongated and developed to filter and trap all zooplankton present in the water. If there is food abundance, its growth is great. If silver carp culturing conditions is provided, this kind of fish also could be cultured where 30-40 fish/ha<sup>1</sup> could be released (Noorhosseini-Niyaki and Safarzadeh-Vishekaei, 2009).

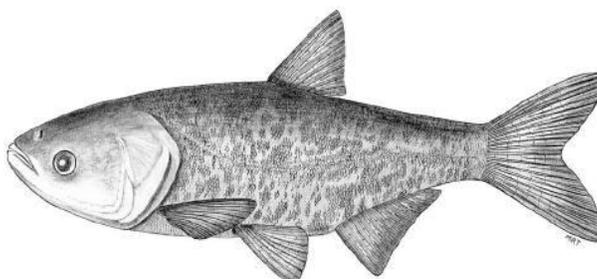


Figure 4. Big head (*Hypophthalmichthys nobilis*):

### **Fish Larva**

In paddy field, it is possible to culture developed fish larva and getting its weight to at least 50 g. When fish fry reached up to 3g, they will search for food. Since benthos and insect larva are abundant in the field, thus, it is advisable that precedence is given to carp larva, since this fish will grow with minimum manual feeding in paddy fish. As well, when harvesting the fish fry, they must be transferred to the sheltered ponds. Meanwhile they will trap in between, the rice stalks. They must hold in little water for a while. Carp fries can better tolerate these conditions compared to other species. In larva farming, it is necessary to enrich the pools be for larva introductions through spraying and fertilizer, and to provide the required food for feeding the larva. Pond periphery should be in closed by plastic covering, this way access of frogs, snakes and other insidious animals is prevented. In each hectare it is possible to release 15000-20000 developed larvae, 20% of which is developed larva, 20% of which is assigned to other species and the remaining is considered for carp larva. In the suitable, at least 50% of larva turns to the fries with 50 g weight (Bakhshzad-Mahmoudi, 1997).

### **BENEFITS OF FISH FARMING IN THE RICE FIELDS**

Fish farming in paddy fields preserves and improves the environmental conditions, decreases the biological contamination, environmental sustainability, increase the water productivity power, increase the oxygen exchange water and air, oxidation potential and soil recovery, as well, many social benefits are provided including social health benefits, it is role in decrease of poverty, its role in creating the motivation of farmers towards the sustainable agriculture. Fish farming in paddy fields decreases many of hazards and problems imposed on the health and social life of human societies (Noorhosseini-Niyaki and Mohammadi, 2010). In general, most important benefits and biological ecological effects of Fish farming in the paddy fields are controlling the weeds, efficient controlling of pests, preservation and raising the soil productivity, preservation and improving the environmental status, increasing the biological pollutions, sustainability of environment and social health benefits as well as effects of fish farming on the rice plant including its effect on the content of nitrogen, phosphorous, potassium, chlorophyll content, leaf area expansion, root grid activity and aggregation of dry matters in the rice plant. In general, it is demonstrated that fish farming in paddy fields recycles more nutrients and provides positive and useful effects on the biological cycle (Noorhosseini-Niyaki, 2011).

### **CONCLUSION AND RECOMMENDATION**

In general, 4 species of warm water fish (common carp, grass carp, silver carp and bighead) introduced in the present study. Have the production potential in northern Iran paddy fields. Since its food is naturally present in the field and it is a good biological fighter against rice pests. So it involves the greatest number of fish in the combined culturing. Grass carp also could grow well in the presence of in paddy fields or manual feeding. If field water is supplied from a fish pond (enriched by primitive production), silver carp and bighead could be cultivated. These 4 species of fish have interrelated relationship (synergy) and if they are cultured together, they grow better. Reviews of the present study indicate that fish farming in paddy fields is a sustainable and low cost activity to produce proteins with high value and minerals. This kind of combined production optimizes the resource consumption through complementary usage of land and water irrigation. In the field surface, integrated rice and fish farming decreases the consumption of fertilizer, insecticides and herbicides. On this basis, none of its positive environmental aspects are increasing the economic loss threshold for using pesticides and herbicides to the higher levels. Such that, biologic fighting against the pests and weeds by fish decreases the weeds and pest population in paddy fields leading to decrease or cease of chemical toxin consumption. Thus environmental contamination is prevented. As well, by decreasing the costs, economic burden of farmers will decrease. Integrated rice and fish farming lead to higher yields of the rice and produces greater net interest for farmer compared to the rice monoculture through increasing the yield of rice and selling the fish, in general, it can be concluded that fish farming in the paddy fields will decrease much of risks and problems imposed on the social health and life in human societies, and leads to environmental sustainability. According to the fact all above-mentioned benefits are among sustainable agriculture objectives, it is recommended that promoting fish farming in the paddy fields must be taken more attention and widespread research must be performed in this regard.

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