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RESEARCH PAPER

Paddy cum fish farming in India: An innovative approach to utilize water logged resources in sustainable way

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Abstract : India is abode of 11.6 M ha waterlogged area across the country which is a major potential resource for diversified agriculture practices such as integrated paddy-cum-fish farming (PCF). Water logging conditions in various topography and terrain is a major constraint to design paddy cum fish farming system and to utilize these resources. To overcome these constraint there are need of proper design of paddy fields in accordance to their terrain and topography. Proper design of paddy field could encourage farmers to adopt this system to explore available resources with maximum sustainability.

Key Words : PCF

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INTRODUCTION

India is endowed with numerous fresh and marine aquatic resources such as rivers, reservoirs, ditches, lakes, ponds, flood plains and sea, brackish water estuaries etc. Inland resources in India include 191024 km of rivers and canals, 1.2 million ha of floodplain lakes, 2.36 million ha of ponds and tanks and 3.54 million ha of reservoirs, The enormous river network of country provides huge water area for fisheries sector (Lakra, 2010) and during the rainy season, a lot of adjacent low lying area of these water resources get flooded and become water logged. Agricultural and allied discipline's interference in water logging area is challenging. Waterlogging is one of the major causes for land degradation and making it unproductive. According to Roy *et al.* (2018) India is abode of 11.6 M ha waterlogged area across the country which is a major potential resource for diversified agriculture practices such as integrated paddy-cum-fish farming (PCF). Presently India is a second largest producer of rice after China and total 118.43 MMT of rice production were recorded during 2019-20 from India (DACFW, 2020-21**)** and during the same period, total fish production from country was recorded 14.16 MMT and got 2nd rank worldwide in fish production (DAHD, 2020). PCF is a method of cultivating paddy as a primary crop coupled with suitable fish species in the same area. The production of fish in water logged paddy fields is almost as age-old practice as paddy cultivation itself and prevalent in many parts of the world including India.PCF can provide an additional supply of fish crop in locations where paddy fields remain

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waterlogged for 3 to 8 months of the year, therefore, farmers may be able to utilize same area for diversified activity to increase their income as well as able to produce diversified food item for self. Utilization of areas for PCF which,expose to flood and receive water from surface runoff during rainy or post rainy season for a longer period, makes water logging conditions also stay in undated even after the paddy is harvested, provide an alternate option for farmers to produce fish as diversified food item. In recent years, however, with the introduction of high-yielding hybrid paddy varieties in agriculture sector increases the use of insecticides, pesticides, weedicides and fungicides, all of which are highly hazardous to aquatic environment even in small quantity, has become widespread. As a result, fish farming is no longer compatible with paddy farming in areas where the latest high-yielding paddy varieties are prevalent among the farmers.

In many part of world, paddy cum- fish fields are prevalently found, including China, Bangladesh, Korea, Malaysia, Indonesia, Thailand, Philippines and India to utilize water logged resources areas in sustainable way (krishijagran.com). In India, raising fish with paddy is a traditional farming method under water logged areas, especially in North-East part of country where it is mostly practised in a traditional, basic manner.

Fish and rice is a very common and preferable food for many Indians, despite the fact that it is an agro-based country and numbers of various alternate food choices are available, therefore, in view of available unutilized water logged resource of India, the country has huge potential to increase production of rice and fish in welfare of many small and marginal farmers and become a source of livelihood for many necessitous. The agriculture industry has a significant impact on the country's future development whereas fisheries is the world's second most important socio-economic activity after agriculture and presently this sector have involvement of more than16 millions peoples of India for their livelihood(NFDB, 2020). Fishery, as one of the key sub-sectors of agriculture, which play a critical role in rural areas of country along with the agriculture activity for empowerments of poor in terms of sustenance, nutrition, employment, foreign exchange earnings and most significantly play important role to maintain socio-economic stability of families involved.

Site selection :

Site selection for PCF plays critical role in management practice point of view, when choosing a site (land) for integrated paddy-cum-fish farming, some parameters should be consider appropriately such as the chosen area (location) should get an average annual rainfall of 80 cm; lands with a uniform contour and good water retention capacity are considered good for site selection. The best location for rice and aquaculture production is a low-lying land with abundant of water that can be accessible at any time of the year. Seedlings of paddy are planted in fertile soil that is rich in organic manure, containing optimum amount of nitrogen and carbon along with good water retention capacity. In general, soils with a medium texture and loam with silty clay is preferable for PCF.

Low-lying regions with easy access to water, as well as fertile organic manure-rich soil with excellent water-holding ability, are the key parameters to observe prior the site selection for PCF.

Bundh/pond preparation :

Suitable time for preparation of PCF unit is February-March, by raising the robust embankment all the side around the selected area is first step of preparation. Robust embankments of PCF unit are allow the retention of water in selected site for longer duration; construction of bundh/embankment upto the desired depth prevent the lateral seepage and loss of water in dry months, facilitate water retention and protect cultured fish from escaping during floods. Due to the variations in paddy field's geographic and topographic location, the dykes should construct robust enough to compensate adverse conditions such as flood and dry conditions. The bamboo screen mats placed at the base of the bundhs is

Fig. 1 : Bundh/pond preparation

an aid to support the strengthening of built quality of embankment for longer duration.

Different design of paddy cum fish farming unit:

Design of PCF is important to prepare suitable layout plan at selected waterlogged area in minimum expenditure as well as in view of management practices to be applied during various growing stages of paddy and fish such as paddy transplantation, seed stocking, harvesting of paddy and fish. The design of paddy plot can be prepared in a variety of ways depending on the land contours and terrain.

Peripheral trench design (three side trench type):

The paddy producing area could be created or selected in the center position of plot, with a moderate height to provide desired exposure for water and drought according to various stages of paddy while cultivation. One side that is not converted in to trench, allow the convenient movement of agriculture implements into the paddy field. In this design, slope of paddy field is toward perimeter trenches this allow convenient drainage of water and harvesting of paddy as well as fish (Fig. 2).

Central trench design :

Fig. 2 : Peripheral trench design

The paddy-growing area is on the periphery, with a little incline towards the centre into a central trench which harvest water from drainage as well as of rain towards the center *i.e.* area for fish rearing (Fig.3).

One side lateral trench design :

Digging of trench takes place only one side of the plot which have maximum depth or slope *i.e.* area for fish rearing. It facilitates preparation of selected site into PCF unit in minimum expenditure (Fig.4).

Fig. 3 : Central trench design

Two side lateral trench design

Fig. 4 : Vegetable-paddy based fish farming unit

Digging of trench takes place in two lateral side of plot and unit has facility of entry of agriculture implements from two sides. It also facilitates preparation of selected site into PCF unit in minimum expenditure and allows the supply of water to neighbour agriculture field in both side *i.e.* unit could be act as rain water harvesting component to facilitates other agriculture activities of farmers.

Suitable rice varieties:

Rice verities which is to be select for transplanting in PCF should have strong roots, and high tolerance capacity against the water logging conditions and drought. Details of common suitable varieties of paddy for PCF in different water logging conditions are listed below.

Cultivable species of fishes:

Table 1 : Varieties of paddy for PCF in different water logging conditions

Conditions	Variety	Seed sowing rate (kg/ha)	Time of sowing/Transplantation	Crop maturity/Ripening time	Production (quintal/ha)
Shallow water logged area (30-40cm)	Cross-116	40-45	Nursery-Mid June Transplantation-Mid July	2nd Week of November	35-40
	Type-100	„	„	,,	30-35
	Mahsoori (Lambi)	30-35	„	,,	35-40
Medium water logged area	Jallahari	„	„	,,	40-45
Deep water logged area (50-100cm)	Chakia-59	75-80	May-June	1st Week of December	25-30
	Jalpriya	Direct sowing transplantation 35-40	„	,,	35-40
Flooded water logged area (120cm)	Jalmagn	75-80 Direct sowing	From 15 April to 15 May	1st Week of December	25-30
	Jalnidhi	„	„	,,	30-35
	Madhukar	75-80 Direct sowing	May-June	1st Week of December	30-35
	Flood tolerance	„	„	,,	35-40
	Swarna Sub-1	30-35 (Transplantation)	„	,,	55-60

Source: Kisan Diary, 2020, ANDUA & T, Kumarganj, Ayodhya

According to Coche (1967). The following traits must be present in fish species farmed in rice fields:

– Fish species must be able to survive in shallow and warm water.

– Fish species must be able to with stand low dissolved oxygen levels.

– Fish species must be able to endure a lot of turbidity and aquatic vegetations.

– They must have fast growth to attain marketable size.

Indian major carps (Catla, Rohu, Mrigala), Exotic carps (Silver carp, Common carp), Tilapia, Channa species are suitable fish species for PCF.

Advantages of paddy cum fish farming :

In general, stocking of fish in paddy fields improves soil fertility and productivity, primarily in three ways:

Decomposition of dead fish and fish faeces provide additional nutrients to soil and water which improve overall productivity of PCF system, movement of fish in paddy field leads disturbance of the soil-water interface, which results in the release of arrested nutrients of soil into the water and brings it to top soil and allowing nutrients to be absorbed more easily by the roots of paddy field. Fish graze on photosynthetic aquatic biomass and other components of PCF system (Cagaman, 1995). Furthermore, bottom feeders fishes are recognised for bringing mineral and organic particles into suspension from the sediments through their feeding activity. This results in increased water turbidity in the rice fields (Vromant *et al.*, 2004), increase soil aeration and oxygen supply in rice fields (Heckman, 1979) and ensure availability of phosphorous for both component of unit from the sediment (Breukeuat *et al.*, 1994).

Fish culture in paddy fields may convert material and energy into fish production, speed up rice growth, and boost solar energy fixation, increasing overall PCF field output (Mohanty, 2003). Paddy fields are protected by rice plants from avian predation.

In a rice field, fish can convert insoluble organic forms of nitrogen such as algae in rice field into soluble nitrogen by feeding over it and increase soil fertility. Fish cultivation in rice fields improves the quantity of nitrogen in the soil and the amount of nitrogen absorbed by rice plants, allowing more nitrogen to reach the rice grains and thus improve rice quality.

After harvesting of rice, the roots and residual sections of rice in the form of straw offer organic matter and promote microorganism growth along with nutrient supplementation to water after decomposition of it rice straw contains 9-13% cellulite, 1.5-3 % potassium and 30-40 % cellulose which enrich the soil by adding inorganic carbon into it.

Limitations in paddy cum fish farming:

Transplantation of paddy seedlings should be done at least one month prior to fish fingerlings stocking in PCF unit. Some fishes are able to uproot the seedlings

of paddy such as common carp and tilapia, if plants didn't get proper time to strengthen. In certain time when any parasitic or any other microbial disease occurs in paddy it is difficult to use agrochemicals for control because minute amount of these chemicals may hazardous to fishes. Water level of PCF unit may be fluctuated drastically if supply of water is totally depends on fortune of rain water though these limitations can be overcome by the applications of judicious management practices.

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