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Adoption of carps based polyculture system and status of fish productivity in eastern Uttar Pradesh, India

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Abstract
The present study was conducted during 2016-17 to assess the adoption of aquaculture practices and status of fish productivity in the Eastern Uttar Pradesh, India. The total number of 51 fish farmers of eight different districts was selected for studying various pond management practices. It was found that annual average fish production in Eastern Uttar Pradesh significantly varies from 1570 to 2873 kg/ha/year based on different management practice and different combination of species. The highest annual average fish production was obtained 2873 kg/ha/year from the ponds in which combination six fish species (group c) were cultured together and fed with mustard oil cake, rice bran, grasses along with regular pond management practices including organic and inorganic fertilization. The education level of the owners of the fish farms was varied from graduate to illiterate and maximum owners (35.3 %) had educated only up to school level. There were 66.7 % fish farm owners having 6 to 10 members in their family.

Keywords: Aquaculture, Eastern Uttar Pradesh, education, fish production, pond management

Introduction
In recent years aquaculture is assuming increasing importance around the globe. In India, Aquaculture is rapidly growing with annual growth rate of over 7% [1]. The transformation of aquaculture from traditional to commercial scale has led to an increase in fish production from 0.75 MT in 1950-51 to 12.59 MT [2]. The national mean production level from ponds has gone up from about 0.6 t/ha/year in 1974 to 3.0 t/ha/year at present and several farmers are even demonstrating higher production levels of 8 – 12 t/ha/year [3]. India are bestowed with 3.15 million ha of reservoirs, 2.36 million ha of ponds and tanks as well as 0.19 million ha of rivers and canals. The state, Uttar Pradesh has vast inland aquatic resources which include rivers and rivulets, reservoirs, irrigation canals and floodplain wetland. The successful induced breeding and development of polyculture and composite fish culture technology led to the increased fish productivity. At present growth rate of aquaculture sector is has reported an annual growth rate over to 7% [1] and India is second largest fish producing country in the world [4]. Freshwater aquaculture contributes over 85% to the total aquaculture production.
Besides meeting the nutritional requirement of fish eating population, the fisheries sector is also providing employment over 14.5 million people in the country. The fish culture systems adopted in the country varies greatly depending on the availability of inputs and as well as on the investment capabilities of the farmers. In polyculture system the combination of surface, column, and bottom inhabiting fish species, compatible in nature are recommended in order to utilize the natural food and space available in the different ecological niches of pond. Based on the intensity of inputs the fish farming is categorized as extensive, semi-intensive, intensive systems. In eastern Uttar Pradesh, semi-intensive carp poly-culture production system with low inputs and outputs are being extensively practiced. Consequently, the current work was undertaken to study the status of fish productivity, to study the extent of adoption of carp poly-culture and also to study the factors affecting fish production in terms of farm inputs.

Materials and methods
For the study, a pre-survey activity which included reconnaissance survey and preparation of the sampling frame was conducted.

Farmers were selected using stratified random sampling based on semi-intensive farming of the eight districts in eastern Uttar Pradesh. A total of 51 farmers were interviewed at their houses/farm sites. In the interviews, farmers were asked about fish production system, management practices like pre-stocking, stocking and post-stocking pond management, inputs provided to the fish ponds, productivity, farming constraints, education level and family members of the farm owners. Later, the data from questionnaire were coded and entered into a database system using Microsoft Excel software. The statistical analysis software *i.e.* SPSS was used to analyze the data.

Results

The data was collected from 51 fish farmers of eight districts *i.e*. Ambedkar Nagar, Ayodhya (formerly Faizabad), Deoria, Gorakhpur, Kushinagar, Maharajganj, Siddharth Nagar and Sultanpur in Eastern Uttar Pradesh and estimated the annual fish production. In the study, various pond management practices including fish species combinations, feed ingredients, level of fertilizer application and texture of pond soil was studied. Based on different management practice, the findings revealed annual average fish production in Eastern Uttar Pradesh was restricted to 2146 kg/ha/year. The highest annual average fish production was recorded as 2350 kg/ha/year from Ambedkar Nagar and lowest of 1900 kg/ha/year from Gorakhpur. Moreover, fish production in the studied region ranged from 1570 – 2873 kg/ha/year (Fig 1).

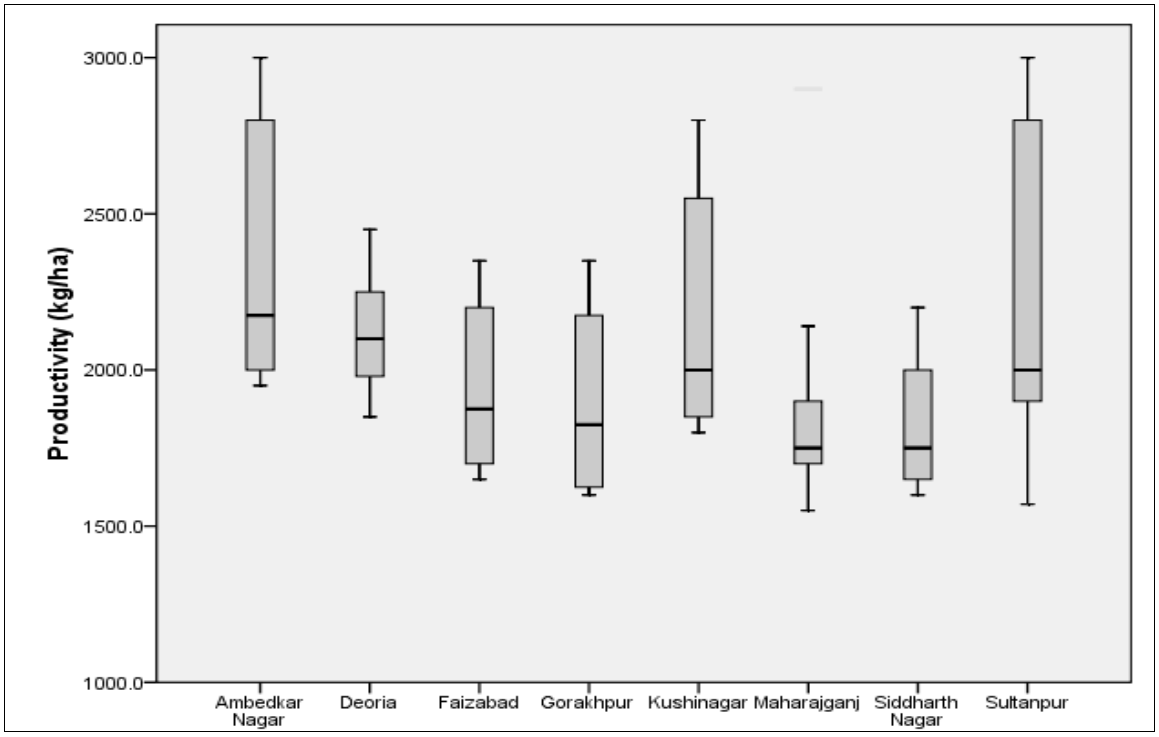

Fig 1: Production from different districts of Eastern Uttar Pradesh

The statistical analysis indicated that there were no statistically significant differences ($p>0.05$) in the mean fish production among the different districts under study. The study also revealed that the most widely adopted groups of fish species for aquaculture in Eastern Uttar Pradesh were group (a) *Catla catla*, *Labeo rohita*, *Cirrhinus mrigala* (b) *C. catla*, *L. rohita*, *C. mrigala*, *Hypophthalmichthys molitrix*, *Cyprinus carpio* and (c) *C. catla*, *L. rohita*, *C. mrigala*, *H. molitrix*, *Ctenopharyngodon idella*, *C. carpio*. The annual average fish production based on different combination of species cultured was recorded as 1868, 2140 and 2375 kg/ha/year from group a, group b and group c, respectively (Fig 2). The multiple comparison of mean productivity using LSD function of ANOVA indicated statistically significant difference ($p<0.05$) among the mean productivity of different groups of species.

Moreover, it was noted that fish farmers of different locations supplied different feeds and fertilizers during the culture period to foster the fish productivity. The most widely used feed ingredients and fertilizer were mustard oil cake, rice bran, grasses, raw cow dung and urea. Farmers use these feed ingredients and fertilizers either in combinations or in isolation to get increased fish production. Usually, there were four different kinds of feeding and manuring practices observed to be followed in Eastern Uttar Pradesh *viz.* (a) mustard oil cake + dung, (b) mustard oil cake + rice bran + dung, (c) mustard oil cake + rice bran + grasses + urea + dung and (d) dung alone. The analysis revealed that annual average fish production irrespective of different combination of species was obtained highest i.e. 2662 kg/ha/year when combination of mustard oil cake + rice bran + grasses + dung + urea was applied in ponds by following regular pond management practice. Whereas, only dung manure based fish farming resulted in lowest annual average fish production i.e. 1585 kg/ha/year. The ANOVA resulted in statistically significant difference in the mean fish production when different feed ingredients and fertilizers were applied to the fish ponds.

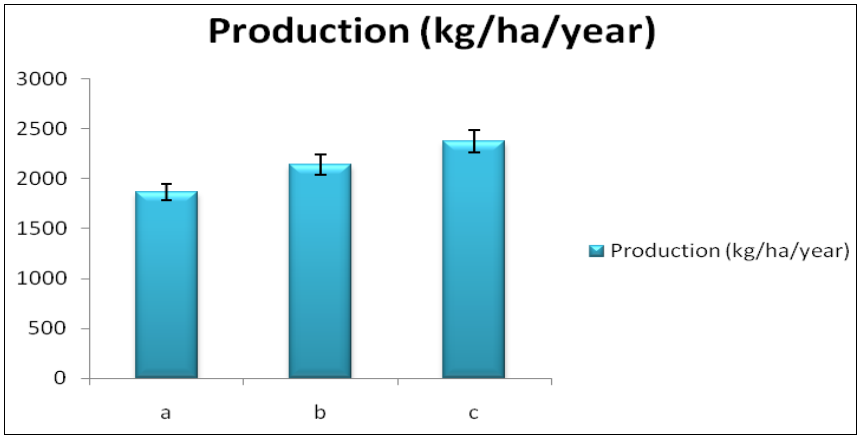

Fig 2: Fish production based on different species combination

Pond management includes pre-stocking, stocking and post-stocking management steps which play vital role in success of aqua farming. In the current study pre-stocking, stocking and post-stocking management practices were followed by farmers on regular basis. In such case, the farmers were getting their ponds dried off and plough it to eradicate aquatic weeds, insects, predatory and weed fishes. Moreover, the supplementary feeds were also provided along with the fertilizers on regular basis. Further, they were using $KMnO_4$, salt, CIFAX, alum, lime and turmeric powder time to time to prevent any possible outbreak of fish disease. In occasional pond management, the management practices were followed only when it was essentially required. In third case, farmers were not following any pond management practices except merely stocking fish and manuring by dung for fish growth. The analysis revealed annual average fish productivity were highest in the ponds wherein 'regular' basis management practices were adopted followed by 'occasional' and lowest from the ponds in which no management practices adopted (Table 1). The multiple comparison of mean fish productivity differences using LSD function of ANOVA have also indicated statistically significant difference among the different level of management practices adopted ($p<0.05$). Moreover, univariate general linear model function was used to assess the fish productivity by considering fish production as dependent variable whereas group of species cultured, feed ingredients and fertilizers and pond management practices kept together as fixed factors. The result of the study revealed that the highest annual average fish production i.e. 2873 kg/ha/year was obtained from the ponds in which combination of six fish species *viz*., *C. catla*, *L. rohita*, *C. mrigala*, *H. molitrix*, *C. idella* and *C. carpio* were cultured together and fed with mustard oil cake, rice bran, grasses; along with organic and inorganic fertilization and regular pond management practices followed by the fish farmers (Table 1). The lowest annual average fish production was recorded from the ponds wherein three Indian major carps, silver carp and common carp were stocked together for culture, but, no supplementary feeding and pond management practices followed, except dung manuring. In such ponds, the fish production was restricted to 1570 kg/ha/year (Table 1).

The education level of the owners of the fish farms was verified to be graduate, intermediate, high school, school level and illiterate as 9.8 %, 11.8 %, 15.7 %, 35.3 % and 27.5 %. It was noted that all the owners of the fish farms were male in the studied region. Moreover, the 6 to 10 members were recorded in the family of 66.7% fish farm owners while 16 to 25 family members were observed in 4.0% and rest owners having less than 6 members in their family.

Table 1: Annual average fish production based on combination of species cultured, feed & fertilizers applied and pond management practices adopted

Species combination	Feeds and Fertilizers	Management	Production* (kg/ha/year)
Group a. (Catla, Rohu & Mrigal)	MOC+Dung	Not any	1720.0±62.3
	MOC+RB+Dung	Occasional	2050.0±56.9
	MOC+RB+Grasses+Urea+Dung	Occasional	2100.0±139.4
	Dung	Not any	1600.0±69.7
Group b. (Catla, Rohu, Mrigal, Silver carp & Common carp)	MOC+Dung	Occasional	1953.7±69.7
	MOC+RB+Dung	Regular	2633.3±80.5
		Occasional	2095.0±69.7
	MOC+RB+ Grasses+Urea+Dung	Regular	2450.0±139.4
	Dung	Not any	1570.0±139.4
Group c. (Catla, Rohu, Mrigal, Silver Carp, Grass carp & Common carp)	MOC+Dung	Occasional	2250.0±139.4
		Not any	1750.0±98.6
	MOC+RB+Dung	Regular	2800.0±139.4
	MOC+RB+ Grasses+Urea+Dung	Regular	2873.0±52.7
		Occasional	2200.0±139.4

*Mean±SD

Discussion

In India, fish is important source of animal protein albeit the proportion of fish in the diet of countrymen is significantly less [5]. In the scenario of stagnating capture fishery resources and rapidly growing population aquaculture has an important role to play in ensuring food and nutritional security around

the globe. To meet the demand of animal protein, efforts are being diverted towards achieving sustainable aquaculture production being evident from the fact that aquaculture is the fastest growing animal food producing sector, growing at the rate of 7.0 % annually. Bulk of carp production in the country is contributed by the three Indian major carps, namely *C. catla*, *L. rohita*, *C. mrigala* and Exotic carps namely *H. molitrix*, *C. idella* and *C. carpio* are the second most important cultured group of fishes [1].

In this study, it was observed that combination six species culture of IMC and Exotic carps leads to higher fish production. This was due to the proper utilization of all niches of the pond by the surface (*C. catla* and *H. molitrix*), column (*L. rohita* and *C. idella*) and the bottom (*C. mrigala* and *C. carpio*) feeder fishes. This helps in proper utilization of natural and supplementary feed utilization to the maximum extent. It is always advisable to the fish farmers to stock more than three species in pond to utilize the space and food available in optimum. This technology is being followed by the farmers and IMC contribute to around 80 % followed by exotic carps comprising Silver, Grass and Common carp as second highest group of the total freshwater fish production [6].

It was also observed that the ponds with loamy beds were more productive than ponds with clayey beds. This is because the clay soils are rich in calcium and magnesium ions, phyllosilicate minerals that trap the water and the small clay particles binds nutrients to the soil bed that reduce the availability of nutrients for plankton production. Whereas, loamy soil are considered best for pond construction because they contain mixture of sand, silt and clay that provide varied nutrients for growth of fish food organisms. Inputs like dung and fertilizers were used to increase the pond productivity. The dung act as organic base whereas fertilizer act as chemical source of nutrients to further increase the available nutrients in pond water and soil. Rice bran and oil cakes were applied as fish feed in ponds and most common traditional fish feed use widely in India and almost in all tropical countries [7]. These organic material decompose releasing nitrogen and phosphorous into the water to increase the productivity. In this study when these above ingredients were applied in combination pond soil strongly adsorbs phosphorous, and the capacity of pond soil to adsorb phosphorous increases as a function of increasing clay content **[8]** and this adsorbed phosphorous remain highly insoluble [9-10]. Therefore, organic manures often are applied to the pond in tropical nations as a substitute for chemical fertilizers. These organic materials decompose to release nitrogen and phosphorous which is dissolved in water and enters in food chain. Feed are used in aquaculture to increase the aquatic animal production above that is possible with nitrogenous and phosphatic fertilizer and manures [11]. The production of natural fish food organisms can be increased by cyclic mineralization of organic manure, fertilizer application and unconsumed feed in addition to desired water quality. Besides fertilization farmers are using formulated, nutritionally balanced quality fish feed as per the life stage and species requirement. Now a days intensive fish and prawn culture are based on scientifically formulated, optimally processed nutritionally balanced fish feed [12]. In this study the fish farmers are not using the nutritionally balanced feed to harvest the fishes to the optimum potential of water body. Almost all the farmers were using conventional feed that is mustard oil cake and rice police.

Though, the state of Uttar Pradesh has vast inland aquatic resources, but, aquaculture is mainly done in un-drainable simple excavated multi-purpose ponds. It has been reported that out of the 1.61 lakh ha of community ponds only 70,000 ha are presently being used for aquaculture. With the current level of fish production, the state is able to provide fish at the rate of 5.88 kg per capita/year only to its 40 percent of fish eating population against the desired level of 15 kg/capita/year. The state requires producing about 1.5 million metric tonne of fish annually to provide fish at the desirable rate of 15 kg per capita/y for its 40 percent of fish eating population[13].

There is an immense scope for using the remaining community ponds after undertaking renovation and improvement. In spite of that, there are about 12,000 ha private ponds are under utilization with conventional culture technology with minimal level of input use. Also, there are massive water logged areas suitable for construction of fish culture ponds and farms by private sector. These are potential areas for aquaculture development by converting into fish ponds and farms.

The major constraints responsible for low productivity in the region were unavailability of quality fish seed, feed and technical education at time which leads to lower fish production [14]. The current findings revealed that annual average fish production in the eastern region of Uttar Pradesh can be enhanced to at least two folds by adopting modern scientific culture practices and bringing unutilized and underutilized aquatic resources under culture to bridge up the gap between demand and supply of fish in the state. The results indicated that fish productivity can be enhanced when combination of six fish species *viz. C. catla*, *L. rohita*, *C. mrigala*, *H. molitrix*, *C. idella* and *C. carpio* are cultured together and fed with mustard oil cake, rice bran, grasses followed by timely application of organic and inorganic fertilization. The species diversification is an effective tool for sustainable aquaculture with high production per unit area and one should think about it. In many states of Eastern Region, self-recruited and indigenous fishes (minor carps) fetch higher price and more consumer preference. Hence, by incorporation of minor carps like *Labeo bata*, *L. calbasu*, *L. gonius*, *Cirrhinus reba* as well as *Puntius sarana*, *P. gonionotus*, catfishes, prawn etc. in polyculture system the fish production can also be enhanced [15-16]. The use of stunted fingerlings in composite/polyculture fish culture systems will also help in getting the increased fish production [14].

Conclusion

Uttar Pradesh is enriched with vast inland freshwater resources and sustainable use of these water bodies will help to enhance the per unit area productivity. Though, with the advancement of time, land and water scarcity, climatic condition, and competition from other allied sectors are likely to increase the fish culture sector and needs to come up with proper strategy to meet the growing demand of fish. The systematic intensification and diversification of culture system along with improvement in the technical knowhow of fish farmers are the need of the day to tap the optimum production potential in the state. Adoption of new aquaculture technologies like Recirculatory Aquaculture System (RAS), Biofloc farming and Aquaponics with proper knowledge will help to enhance fish production and productivity. The study will help to understand the lacking grounds of fish farming in Eastern Uttar Pradesh and to formulate the developmental policies to enhance the fish production.

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