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Efficiency of Integrated Rice, Fish and Duck Polyculture as Compared to Rice and Fish Culture in a Selective Area of Khulna District, Bangladesh

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Abstract: The study was conducted in Batyaghata sub-districts, Khulna, Bangladesh to observe how three different components of rice, duck and fish in a polyculture system are benefited from each other. The study was conducted in a land size of 0.087 ha, which was divided into two parts measuring 0.058 and 0.029 ha. In the larger part (0.058 ha) ducks and fishes were introduced along with rice. Rice and fishes were cultured in the rest of the land. Four fish species namely, Rohu (*Labeo rohita*), Catla (*Catla catla*), Mirror carp (*Cyprinus carpio*) and Nilotica (*Oreochromis niloticus*) were introduced in both parts of the land with a stocking density of 1800, 2700, 1500 and 2100 fry ha⁻¹ respectively. No additional feed was supplied for the fishes. Thirty ducks of Zending breed were allowed to graze in the larger part of the land. There were four male ducks and the rests were female. The ducks were allowed to graze during the daytime and they were confined in a house constructed on the corner of the land. The yield of rice was 690 kg ha⁻¹ where it was cultivated with ducks and fishes and 1450 kg ha⁻¹ where it was cultivated with fishes only. The possible reason of such unexpected results might be due to over grazing of ducks soon after the rice was transplanted. During the study period (3.5 months) the fish production was 1.23 and 0.91 t ha⁻¹ for rice-fish-duck polyculture and rice-fish culture systems respectively. The egg production percentage of ducks was 61.21. The analysis of variance in respect of culture systems showed that the growth performances of Rohu, Catla and Mirror carp were highly significant ($P < 0.001$). Therefore, the duck dropping was found very effective for better growth and development of fishes.

Key words: Integrated, rice, fish, duck, culture

INTRODUCTION

The economy of Bangladesh is predominantly based on agriculture sharing one-third of Gross Domestic Products (GDP) of which 24% is contributed by crop sector and the remaining portion is by non-crop agriculture such as fisheries, livestock and forestry^[1]. Bangladesh has been facing serious crisis to meet the increasing food and energy demand for her 147 million people. But there is a little scope to any horizontal expansion of agriculture because of increasing pressure of non-agricultural land use, rapid urbanization and parallel expansion of trade service sector. Ducks are usually kept under scavenging condition. In rice fields they fed themselves by foraging or by picking up the fallen rice after harvest, aquatic organisms like juvenile frogs, tadpoles, mollusks, aquatic weeds etc.

There are positive interrelations and many other merits in integration of fish with rice. In a lowland rice field in Orissa, India, under controlled (cement tank) and

uncontrolled (earthen tank) water situations the uptake of Fe (Iron) by rice was 2 times higher under rice-cum -fish culture than in rice alone. The uptake of N by rice recorded 10% increase when fish was reared in the field in association with rice^[2]. Weeds also can be controlled by herbivorous fishes such as *Tilapia rendilli*, *Puntius javanicus* etc when integrated with rice^[3]. These positive effects render increased productivity both of rice and fish^[4]. As a result the system could increase the farmers' income compared to monoculture of paddy^[5]. The rice-fish farming option gave a 100% increase in net returns compared to rice only^[6]. In a rice-fish farming system in the Luzhou region, China, the percentage of rice yield increased from 8.1 to 11.7 % and fish output rose from 0.3 to 2.25 t ha⁻¹^[7].

When ducks were introduced with rice-fish system that performed better than the rice-fish system^[8]. Both rice and fish yields increased to a considerable level due to higher plankton production, better nutrient uptake by paddy and pest control by the duck species^[9,10]. However,

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the yields depend upon many factors, like types of fish species, rice varieties, surrounding environmental conditions, duration of cultivation period, management status etc.^[8, 11]. Duck feeds, bedding materials and manure storage affect the nutrient release characteristics of duck manure in water. The good quality manure obtained from high-grade duck feed increased the yields of rice and fish^[9].

This study was undertaken to evaluate the combining efficiency of rice, fish and duck in a rice-fish-duck integrated system and to quantify the effects of different components on each other. A rice-fish system was compared with the rice-fish-duck system to evaluate the relative efficiency of two systems.

MATERIALS AND METHODS

The study was conducted in Batyaghata sub-district of Khulna district, Bangladesh. Most of the cultivable lands of the area was low lying and generally cultivated with transplanted local Aman rice. A farmer's field consisting an area of 0.087 ha was selected to conduct the study. Whole land area was well fenced to avoid damage from animal grazing. The study compared two different farming systems namely, rice-fish and rice-fish-duck systems. The total land area was divided into two plots. For rice-fish system, one-third of the area was allocated and the remaining two-third for the rice-fish-duck system. A popular local Aman rice variety (Zotai) was transplanted at the 1st September of 2000 with the seedling of around 40 days aged. A spacing of 25x20 cm was used for transplanting rice. No fertilizer was applied for the rice assuming that duck droppings will supply the necessary nutrients. No weeding practice was followed for rice cultivation considering the natural weeding by the fish species integrated.

Four fish species namely, Rohu (*Labeo rohita*), Catla (*Catla catla*), Mirror carp (*Cyprinus carpio*) and Nilotica (*Oreochromis niloticus*) were cultured for both the systems. These species were selected based on the depth of water, temperature variability and relative distribution and availability of feed in rice fields. The rates of fish fry were 2700, 1800, 1500 and 2100 fryha⁻¹ for Catla, Rohu, Mirror carp and Nilotica respectively. Fish fries were stocked in the rice field 7 days after transplanting (DAT) in a morning.

Thirty ducks (500 ducks ha⁻¹) of Zending breed was selected with the average initial age of 150 days and weight of 1.1 kg. A small duck house was constructed at the corner of rice-fish-duck plot in a way so that duck droppings can be fallen into the water for supplying nutrients for both rice and fishes. Duck foraging was restricted only to the plot of rice-fish-duck system by

fencing. Ducks were allowed to forage into the rice field after 2 weeks of fish stocking. The duck foraging was allowed only in daytime. They were supplied with supplemental feed containing wheat bran, rice polish, soybean meal, meat meal, snail meal vitamin and common salt at a recommended rate of 90 g duck⁻¹day⁻¹. Eggs were collected each morning and counted. Rice was harvested 115 DAT and paddy yield was measured. Before harvesting fishes were allowed to enter into a small pond from which they were harvested.

Descriptive analyses and analyses of variance (ANOVA) were performed on the data collected using SPSS statistical program and Microsoft-Excel program.

RESULTS AND DISCUSSION

Fish Production: The performances of all four species of fish were better under the rice-fish-duck culture system as compared to rice-fish system both in terms of average weight gain and total production (Table 1). The total fish productions were 1.23 and 0.91 t ha⁻¹ in rice-fish duck system and rice-fish system respectively. The result was consistent with the findings of Man^[9] who reported that fish yield from ponds with duck rearing was 30–40% higher than from ponds without ducks in duck-fish integrated system where the duck manure reduced 20–25% of fish feed requirement. Latif *et al.*^[12] found fish production of 4.0 to 6.0 t ha⁻¹ year⁻¹. This better performance of fish integrated with duck and rice may due to increased plankton production from ducks manure and spilled duck feed which was allowed to fall directly to the fishpond. Ali, *et al.*^[10] investigated the nutrient content of duck excreta and its effect on fish production and found that excreted organic carbon, phosphorus, nitrogen, potassium and calcium significantly contributed to fish production. Cagauan^[8] conducted a research project on integrated rice-fish-*Azolla*-duck farming system and found that Nile tilapia (*Oreochromis niloticus*) yield was highest in the production system of rice-fish-*Azolla*-duck followed by rice-fish-duck and rice-fish-*Azolla* systems. The results indicate that systems with more feed available for Nile tilapia such as *Azolla* and spilled duck feed gave higher fish yields.

Among the four different fish species under both systems Mirror carp showed the best performances followed by Nilotica, Catla and Rohu. These better performances may because of the feeding habit of Mirror carp and favorable environment existed in the rice field and genetics of their growth rate.

Rice yields: Yield of rice has been shown in Table 2. According to the Bangladesh Bureau of Statistics^[1] the national average yields of local transplanted Aman were

Table 1: Fish yields in two different culture systems

Fish Species	Culture systems	Average weight (gfish ⁻¹)			Total production (Kg/ha)	F-value
		Initial	Final	Weight gained		
Rohu	With duck and rice	18	110	92	138	19.901(***)
	With rice	18	87	69	109	
Catla	With duck and rice	27	200	173	250	24.904(***)
	With rice	27	150	123	188	
Mirror Carp	With duck and rice	9	225	216	563	71.884(***)
	With rice	9	161	152	403	
Nilotica	With duck and rice	18	73	55	274	3.230(***)
	With rice	18	63	45	236	

***P ≤ 0.001

Table 2: Rice yields in two different systems

Culture systems	Plot size	Yields (kg/ha)
Rice with fish only	7.14	1450
Rice with fish and duck	14.28	690

Table 3: Performances of duck during rearing period (from 5 months to 8 months of age)

Parameters	Quantitative values
Number ducks	30.00
Number of ducks died	2.00
Mortality (%)	6.67
Number of days of egg collection	52.00
Total number of eggs collected	764.00
Number of eggs/day/24 ducks	14.69
Percentage of egg production	61.21

1.17, 1.48 and 1.56 t ha⁻¹ in the years 1998-1999, 1999-2000 and 2000-2001 respectively. The rice yields of the present study were little lesser than the reported national average for local transplanted Aman varieties. The cause that may lower the rice yield was flood occurred during the vegetative period of the paddy. These evidences suggested that under lower level of management and under the flood condition the rice-fish farming system perform to a satisfactory level. However, in Vietnam the integrated duck-fish treatment at flooding time eliminated the snail pests^[13]. Tuyen^[14] in his study in Vietnam found that rice yield was increased from 2.29 to 2.87 t ha⁻¹ without adding fertilizer. Men and Ogle^[13] found that grain yield of the duck-rice-fish treatment was higher although there was no significant difference in yield compared to the duck-rice and control (rice only) treatments. However, due to the high costs of pesticide and herbicide applications of the control treatment the net economic benefits from rice were lower. In the study fertilization and weeding were not applied as cultural practices. Relative contribution (%) of fertilizer, weed and insect control to grain yield was 0.77, 0.46 and 0.23 in transplanted Aman^[15].

Performances of ducks: Duck mortality rate was relatively higher (~ 7 %). This may because of diseases associated with environment changes during flooding. Das *et al.*^[16] carried out an experiment to assess the performance of Indian Runner, Khaki Campbell, Zending ducks in an integrated duck-cum-fish farming system and the results

showed that the three genotypes were almost similar in body weight gain, mortality, egg production, feed conversion and egg weight. Few literatures are available for the performances of Zending ducks. Therefore, if compare the laying performance of the ducks in our study with that of Khaki Campbell, laying percentage was lower in the ducks of the study (61%). For Khaki Campbell laying percentage was reported as 76 % in the first year in small-scale farming^[17]. For a laying period of 52 days 32 eggs layer⁻¹ was obtained (Table 3).

In this study, the growth performance of three fish species (Rohu, Catla, Mirror carp) were better where they were cultured with ducks and rice. Fishes also performed as biological pest control agents. Ducks dropping played a role as manure for rice and it helped to form natural feed for fishes. As a result no fertilizer or pesticide were used. The egg production of ducks was also satisfactory and it was about 61%. Ducks met up a portion of their feed requirement by grazing. The yield of rice on both sides was not satisfactory due to unexpected flood. The yield of rice was lower due to lack of proper control and untimely duck grazing. Thus it is expected to obtain better rice yield from such a polyculture if proper precautions could be maintained in the absence of unexpected natural hazards, flood for instance. However, growth performance of fish, rice yields and egg production percentage show that such type of polyculture would be an effective step to increase the total production of agricultural farm compared to the monoculture and/or biculture systems.

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