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Genetic Evaluation of GIFT and Existing Strains of Nile Tilapia, *Oreochromis niloticus* L., Under On-Station and On-Farm Conditions in Bangladesh

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Abstract

Comparative production performances of Genetically Improved Farmed Tilapia (GIFT) and existing Nile, *Oreochromis niloticus* L. strains were assessed in five test environments (nursery systems, cisterns, hapas, net cages, and grow-out ponds) and six multi-locational sites (Trishal, Chandina, Manikganj, Paikgacha, Jessore Sadar, and Mithapukur) under on-station and on-farm conditions in Bangladesh. The mean weight gains at harvest of the GIFT strain was significantly higher (40-57%) than the existing Nile tilapia strain in all the trials.

Introduction

The existing strain Nile tilapia (*Oreochromis niloticus* L.) was first introduced into this country by the United Nations International Children Emergency Fund (UNICEF) in 1974, and later by the Bangladesh Fisheries Research Institute (BFRI) from Thailand (Gupta et al. 1992). Nile tilapia is preferred by farmers because of its desirable features for aquaculture such as faster growth rate compared with any other short cycled fish species including other commonly used tilapia strains, high yield, tasty flesh and ease of reproduction. Moreover, like other culturable tilapias, this species is a hardy fish, good converter of organic wastes into quality protein and resistant to disease (Stickney et al. 1979; Balarin and Haler 1982; Pullin and Lowe-McConnel 1982). Meanwhile, a red mutant tilapia (a hybrid between albino *O. mossambicus* x *O. niloticus*, Liao and Chang 1983) has also been introduced into Bangladesh from Thailand in 1988 by BFRI. Another promising Genetically Improved Farmed Tilapia strain known as GIFT (Eknath et al. 1993) has recently been introduced in July 1994 from the Philippines. The GIFT strain was developed by the International Center for Living Aquatic Resources

Management (ICLARM) through several generations of selection from a base population involving eight different strains of Nile tilapia, *O. niloticus* (Eknath et al. 1993). In on-station trials, the synthetic GIFT strain was reported to show an average 60% faster growth and 50% better survival at harvest than the "Israel strain", the most commonly farmed strain in the Philippines (Eknath 1992). In order to evaluate this strain in other Asian countries, a research programme has been initiated in Bangladesh, China, Philippines, Thailand and Vietnam under the auspices of an ICLARM project entitled "Dissemination and Evaluation of the Genetically Improved Tilapia in Asia (DEGITA, Asian Development Bank (ADB) Technical Assistance Grant Project: RETA No. 5558)". In Bangladesh, the comparative growth and production potential of GIFT and existing Nile tilapia strains (*O. niloticus*) were evaluated both under on-station and on-farm conditions.

This paper discusses in details the results of GIFT and existing Nile tilapia production in five test environments and six different regional locations of on-station and on-farm trials.

Materials and Methods

Origin of test strains

For the implementation of the DEGITA project, Bangladesh received the first batch of about 1,000 fry of GIFT strain in July 1994 from ICLARM, Manila, Philippines. The fry were brought to the Freshwater Station (FS), BFRI, Mymensingh for the proposed experiments. The locally existing Nile tilapia (*O. niloticus*) stock used in these trials came from the descendants of a pure strain "Chitralada strain" originally collected from the National Inland Fisheries Institute (NIFI), Bangkok, Thailand in 1987. Both strains were successfully bred and reared in a series of tropical earthen ponds.

Test environments

Comparative growth potentials of GIFT and existing strains of *O. niloticus* were studied in five different test environments, i.e. nursery, cistern, hapa, net cage, and pond under on-station conditions. Six multilocational sites were chosen in the different regions of Bangladesh to evaluate the GIFT strain in comparison to existing Nile tilapia under on-farm conditions. Site selection was organised to cover a wide range of environmental conditions based on the linkage of river system, climatic condition, soil type, and prevailing farming conditions.

On-station trials

A comparative nursery trial of GIFT and existing strains was initiated on 21 January 1995 in a series of 2 m^3 size hapas (i.e. rectangular shaped enclosures made of fine mesh mosquito netting material) with four repli-

cates. The hapas were stocked with fry of GIFT strain (mean weight 1.0 ± 0.2 g) and existing strain (mean weight 1.0 ± 0.1 g) at a stocking density of 150 fry/m^3. The fry were fed with a mixture of rice bran (25%), wheat flour (30%), mustard oil cake (15%) and fish meal (30%) at 8% body weight. The fry were fed with moist paste applied through a hanging metal tray 3-4 times daily at 3-h intervals. The amount of feed ration was adjusted by estimating the weight of biomass based on the fortnightly sampling (weight and length) of the fry. The experiment was terminated two months after stocking and at the time of final harvesting, at least 50 fry were randomly chosen from each of the replicated hapas, then individually weighed and measured. Total survival of fry was also recorded by counting the individual fry from each hapa.

Another study was conducted employing the Completely Randomized Design (CRD) both in cisterns (5 m^3) and pond hapas (5 m^3). In both cases, there were two treatment groups (GIFT vs existing strains) with three replicates at a stocking density of 5 fish/m^3. The experiment was initiated on 19 August 1994 in the cisterns and on 6 September 1994 in the pond hapas. The initial mean weight of the GIFT and existing strains were 9.9 ± 0.2 g and 9.3 ± 0.3 g, respectively, in the cisterns and 11.2 ± 0.1g and 11.2 ± 0.1 g in the hapas. The fish were fed twice a day with a mixture of rice bran (50%), mustard oil cake (20%) and fish meal (30%) at 10% body weight. Growth sampling was made at every 15 days interval. Both experiments were terminated after three months but before that, final estimates of standard length and body weight of all fish were made; survival number of fish in each cistern and hapa were also recorded.

A comparison of grow-out trials of GIFT vs existing strains was tested for six months in a series of 4.6 m^3 size net cages (i.e., rectangular shape enclosures made of 0.5 cm mesh netting material). There were three treatment groups in this experiment: i) 100% GIFT strain; ii) 100% existing strain; and iii) 50% GIFT strain plus 50% existing strain. For each treatment group, fingerlings of approximately 2 months age (mean weight between 8.8–9.7 g) were stocked at the rate of 5 fish/m^3 with three replicates. In treatment group- iii, where mixed stocking was made, both strains were given small numbered tags (Charles Neal, Finchley Ltd., UK). The fish were fed with rice bran twice daily at 6% body weight. Sampling of all stocked fish was made by weight at 30 days interval. At the end of the sixth month, the experiment was terminated. All the fish were harvested on the same day; and weights of fish were individually taken. At the same time, the survival rate of all the fish belonging to all treatment groups was also estimated.

The comparative production potentials of GIFT and existing strains of Nile tilapia fingerlings at two months age were evaluated under low input aquaculture management for six months also in two earthen ponds with four replicates. Each pond was equally partitioned by fine mesh wire net material into four chambers (90 m^2 each) with an average water depth of 70 cm. Fingerlings of both GIFT (mean weight 6.7 ± 0.1 g) and existing strains (mean weight 6.4 ± 0.2 g) were stocked separately in each pond at a stocking density of 2 fish/m^2. Only rice bran, as supplementary feed, was given at the

rate of 4-6% per estimated biomass. Experimental ponds were manured fortnightly with cattle dung at a rate of 750 kg/ha. To estimate the growth rate, about 25% of stocked fish were randomly sampled (body weight) at 30 days interval. At the time of termination of the experiment, the fish were harvested from each of the chambers by draining out the ponds. Final growth of adult GIFT and existing strains was individually estimated through their weight; their survival rate was also recorded accordingly.

On-farm trials

On-farm grow-out trials of GIFT vs existing *O. niloticus* strains were conducted in collaboration with several Non Government Organizations (NGOs) at six locations, i.e. Trishal, Chandina, Manikganj, Paikgacha, Jessore Sadar and Mithapokur. The trial was designed to involve at least 10-12 village ponds from each location of which 50% of the ponds were stocked with GIFT fingerlings, and the remaining ponds with the fingerlings of existing Nile tilapia strain, at a stocking density of 20,000 fish/ha. Feeding, which consisted of rice bran, at the rate of 5-6% per estimated biomass, was made once daily. Cattle dung was applied as manure at the rate of 1,000 kg/ha every month. At harvest, total production was estimated by weighing the captured biomass (both adult and young fish) and the value was expressed in kg/40 m^2 (40 m^2 = one decimal, unit of area normally used in Bangladesh).

Statistical analysis

The growth data (mainly weight) were analyzed at each sampling date using one-way analysis of variance (ANOVA). Significant results were further tested using Scheffe's multiple tests to identify significant differences between means. Goodness-of-fit (two tests) were used to assess the fitness of observed number of males and females to a 1:1 sex ratio. All analyses were undertaken using the Statgraphics (version 7 software).

Results

Nursery trial

The data of comparative nursery trial of GIFT and existing strains of tilapia are shown in Table 1. The final mean length and weight for GIFT and existing strains were recorded at 7.6 ± 0.4 cm and 8.4 ± 0.7 g and 6.6 ± 0.1 cm and 5.5 ± 0.2 g, respectively. ANOVA indicates significant differences ($P < 0.05$) between the mean values of length and weight of both the strains.

Grow-out trials in cisterns and hapas

The mean final weight and length of GIFT and existing strains in cisterns were 88.9 ± 0.8 g and 16.6 ± 0.1 cm and 63.6 ± 5.0 g and 15.1 ± 0.2 cm, re-

spectively. The mean final weight and length of GIFT and existing strains in hapa were 134.1 ± 5.1 g and 18.9 ± 0.1 cm and 95.5 ± 2.3 g and 17.6 ± 0.2 cm, respectively. The final mean weights of GIFT and existing strains were significantly different ($P < 0.05$) under both conditions (Tables 2 and 3).

Grow-out trials in net cages

The mean weight after six months of the GIFT and existing strains in mixed treatment group were 205.1 ± 9.3 g and 122.2 ± 15.1g, respectively. A similar trend was observed in the separate treatment groups while at the GIFT and existing strains, attained weights were 203.5 ± 19.8 g and 112.3 ± 6.3 g, respectively. The average growth performance of GIFT strain was significantly better ($P < 0.05$) than that of existing strain in both treatment

Table 1. Mean length and weight of fry attained in nursery trial of GIFT and existing strains of *O. niloticus*.

Strain	Initial		Final	
	Weight (g ± SE)	Length (cm ± SE)	Weight (g ± SE)	Length (cm ± SE)
GIFT	1.0 ± 0.2[a]	3.8 ± 0.3[a*]	8.4 ± 0.7[a]	7.6 ± 0.4[a]
Existing	1.0 ± 0.1[a]	3.8 ± 0.5[a]	5.5 ± 0.2[b]	6.6 ± 0.1[b]

Table 2. Mean weight and length of GIFT and existing strains of *O. niloticus* in cisterns.

Sampling date	GIFT strain		Existing strain	
	Weight (g ± SE)	Length (cm ± SE)	Weight (g ± SE)	Length (cm± SE)
06 Sept. 94	9.9 ± 0.2[a*]	7.6 ± 0.1	9.3 ± 0.3[a]	8.5 ± 0.6
21 Sept. 94	20.3 ± 0.9[a]	9.9 ± 0.1	19.1 ± 2.3[a]	9.9 ± 0.5
05 Oct. 94	34.8 ± 0.6[a]	11.9 ± 0.1	30.3 ± 1.5[a]	11.5 ± 0.1
20 Oct. 94	57.7 ± 1.0[a]	13.9 ± 0.1	44.1 ± 2.4[b]	13.0 ± 0.1
04 Nov. 94	73.4 ± 2.9[a]	15.4 ± 0.1	47.8 ± 2.3[b]	13.8 ± 0.1
19 Nov. 94	78.7 ± 1.0[a]	15.4 ± 0.1	55.9 ± 4.9[b]	14.3 ± 0.2
04 Dec. 94	88.9 ± 0.8[a]	16.6 ± 0.1	63.6 ± 5.0[b]	15.1 ± 0.2

Table 3. Mean weight and length of GIFT and existing strains of *O. niloticus* in hapas.

Sampling date	GIFT strain		Existing strain	
	Weight (g ± SE)	Length (cm ± SE)	Weight (g ± SE)	Length (cm± SE)
06 Sept. 94	11.2 ± 0.1[a*]	8.3 ± 0.2	11.2 ± 0.1[a]	8.7 ± 0.1
21 Sept. 94	35.0 ± 0.4[a]	11.7 ± 0.1	34.4 ± 1.4[a]	11.9 ± 0.1
05 Oct .94	53.3 ± 3.4[a]	13.5 ± 0.2	46.8 ± 3.4[a]	13.3 ± 0.4
20 Oct. 94	90.5 ± 4.8[a]	15.9 ± 0.4	72.1 ± 2.2[b]	15.3 ± 0.2
04 Nov. 94	99.6 ± 6.1[a]	16.6 ± 0.3	74.9 ± 1.8[b]	15.7 ± 0.2
19 Nov. 94	116.6 ± 5.5[a]	17.5 ± 0.4	82.5 ± 1.2[b]	16.2 ± 0.1
04 Dec. 94	134.1 ± 5.1[a]	18.9 ± 0.1	95.5 ± 2.3[b]	17.6 ± 0.2

*Different superscript letters indicate significant differences at 5% level.

groups, but the mean weight of GIFT individuals was not significantly different (P > 0.05) between the two treatment groups (Table 4).

Grow-out trial in ponds

The mean final weights of GIFT and existing strains were 134.4 ± 2.4 g and 85.3 ± 2.4 g, respectively. The average gross production of GIFT and existing strains were estimated at 4,411 and 2,966 kg/ha/6 months, respectively. Total yield of the GIFT (57%) was significantly higher (P < 0.05) than that of the existing strain (Table 5).

Least square mean (LSM) values across the test environments

The growth performance expressed as LSM values of body weight at harvest of individual strains across different environments reveal that GIFT was consistently the best performing strain while the existing one showed the poorest performance in respect to growth in the respective environmental means (Fig. 1).

Table 4. Growth performance (mean weight) of GIFT and existing strains of *O.niloticus* in net cages.

Sampling months	GIFT strain (g ± SE)	Existing strain (g ± SE)	Mixed stock	
			GIFT strain (g ± SE)	Existing strain (g ± SE)
Initial	8.8 ± 0.1[a*]	8.9 ± 0.3[a]	9.7 ± 0.3[a]	9.1 ± 0.6[a]
Month-one	56.2 ± 3.0[a]	39.0 ± 0.9[b]	58.8 ± 5.0[a]	41.3 ± 1.8[b]
Month-two	112.0 ± 9.0[a]	73.0 ± 3.7[b]	116.0 ± 9.8[a]	77.0 ± 4.4[b]
Month-three	130.0 ± 8.8[a]	79.0 ± 11.5[b]	139.0 ± 4.5[a]	90.0 ± 3.7[b]
Month-four	155.3 ± 6.6[a]	95.2 ± 8.7[b]	148.7 ± 8.6[a]	96.0 ± 5.1[b]
Month-five	191.7 ± 5.9[a]	102.7 ± 10.9[b]	200.7 ± 12.4[a]	109.3 ± 8.5[b]
Month-six	203.5 ± 19.8[a]	112.3 ± 6.3[b]	205.1 ± 9.3[a]	122.2 ± 15.1[b]

Table 5. Growth performance (mean weight) of GIFT and existing strains of *O. niloticus* in earthen ponds under on-station condition.

Sampling months	GIFT strain (g ± SE)	Existing strain (g ± SE)
Initial	6.7 ± 0.1[a]	6.4 ± 0.2[a]
Month-one	33.6 ± 2.7[a]	22.4 ± 0.4[b]
Month-two	50.7 ± 1.3[a]	31.2 ± 0.8[b]
Month-three	65.4 ± 1.1[a]	46.4 ± 3.2[b]
Month-four	87.4 ± 4.7[a]	62.0 ± 4.2[b]
Month-five	96.7 ± 2.4[a]	70.8 ± 4.8[b]
Month-six	134.4 ± 2.4[a]	85.3 ± 2.4[b]
Gross production (Kg/ha)	4411.0[a]	2966.0[b]

*Different superscript letters indicate significant differences at 5% level.

Multi-locational on-farm trials in ponds

At harvest, the production of GIFT strain were 10.1, 7.2, 3.2, 7.4, 9.3 and 6.6 kg/40 m^2 after 6, 7, 3, 6, 6 and 6.5 months, in Trishal, Chandina, Manikganj, Paikgacha, Jessore sadar and Mithapukur, respectively. But in the case of existing strain the production in Trishal, Chandina, Manikganj, Paikgacha, Jessore Sadar and Mithapukur were 6.6, 4.6, 2.0, 4.8, 6.2 and 4.7 kg/40 m^2 after 6, 7, 3, 6, 6 and 6.5 months, respectively (Fig. 2). Average production of the GIFT strain (52%) per unit area in the on-farm locations was significantly ($P < 0.05$) higher than that of existing strain.

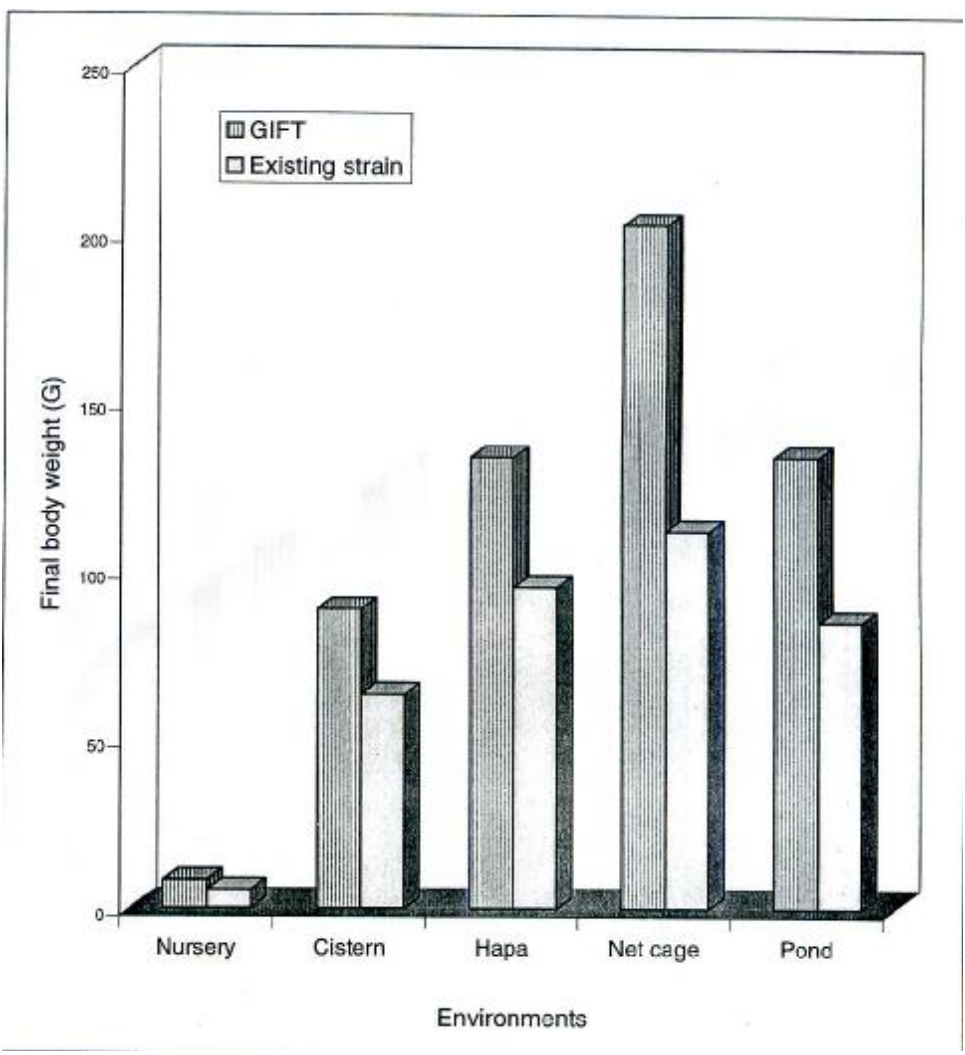

Fig. 1. Least square mean (LSM) values of final body weight of GIFT and existing Nile Tilapia strains across five test environments under on-station condition.

Discussion

In Bangladesh, tilapia culture has a short history with a very limited brood stock management under hatchery condition. The GIFT strain in five different micro environments under on-station conditions in the present study showed to be 57% superior on the average in terms of growth, to the existing local strains. Hussain and Mazid (1996) also reported significant differences in growth performance between GIFT and existing strains in Bangladesh. In China, Indonesia, Thailand and Vietnam, where there are longer histories of tilapia farming, greater climatic variation, and the possibility of both natural and artificial selection of local strains to their environments, the GIFT strain appears to be about 10-15% superior to the local strains in terms of growth (Dey 1996).

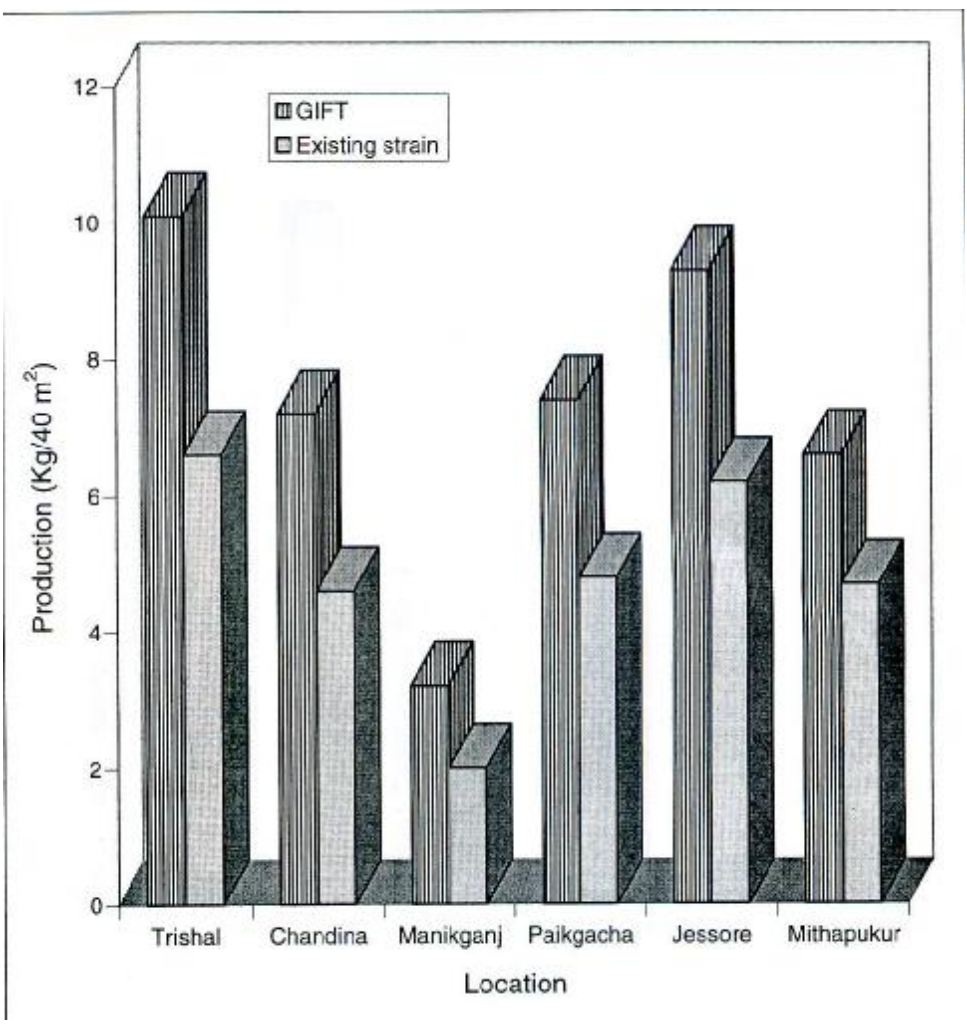

Fig. 2. Mean production per unit area of GIFT and existing Nile Tilapia strains of *O. niloticus* in six different on-farm locations in Bangladesh.

Results of the present trials carried out under on-farm condition in six different locations throughout Bangladesh reveal further the superiority of GIFT strain in terms of production per unit area where GIFT gave an average of 52% better performance than the local strain of Nile tilapia. In on-farm trials in the Philippines, the GIFT strain showed 60% better growth than the other local strains (Eknath 1992; ICLARM 1994). According to Dey (1996), the GIFT strain showed about 15 - 25% higher yield than the genetically superior existing strains like the "1978" introduced, "1988" introduced, the hybrid strain of China, and the Chitralada strain of Thailand.

Among the South East Asian countries, Bangladesh in particular abounds with hundreds and thousands of seasonal water bodies in the form of ditches, shallow ponds, road side canals, borrow pits etc. which retain water for 4 - 6 months where carps can not be cultured. No doubt, these water bodies have tremendous potential for aquaculture of fish species with short life cycle and characteristic of faster growth rate and require low input support. In such a case, GIFT strain can be a promising candidate for aquaculture in seasonal ditches/ponds and similar bodies of water. Adoption of the GIFT technology in various forms of seasonal bodies of water can not only lead to an increase in the intake of animal protein in rural areas but can also generate income and employment opportunities for the end users (i.e., resource poor farmers) in Bangladesh.

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