

EFFECT OF STOCKING DENSITY AND FEEDING ON GROWTH AND SURVIVAL OF CARP FRY IN LOWLAND RICE

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ABSTRACT

Return to investment in lowland rice farming is low. Chinese carp fry were therefore integrated into the rice fields to determine the feasibility of improving the return to investment from rice farming, the influence of paddy water quality on fish fry and the management options for fingerling production in rice-fish integration. Studies were conducted at the Rice Research and Development Institute, Batalagoda, Ibbagamuwa during *yala* 96, *maha* 96/97 and *yala* 97 in paddy plots having a trench as the refuge pond and protected with chicken mesh. Carp fry were integrated with rice (variety Bg 379-2) in six different stocking densities (0, 3, 6, 9, 12 and 18 fry per m²) and fed with rice bran in three different feeding regimes (no feeding, 3% and 6% of the body weight). Application of insecticide was not needed due to timely cultivation of 4 month age rice. Rice yields were not affected by the integration of fish. No change in flood water quality with treatments (water pH, dissolved O₂, biological O₂ demand and sulphur content) and no fry deaths at the time of introduction was observed suggesting that rice paddies in the dry and intermediate zones are suitable for fingerling production. Maximum floodwater temperature was above 37°C at planting and gradually dropped to about 32°C when 50% of the ground was covered with the rice canopy at 4 weeks after transplanting. Therefore, to avoid high temperature stress, fry should be introduced to rice paddies when the crop canopy covers above 50% of the ground. Fry attained the size of fingerlings in 8 weeks after introduction. Increased fry stocking density decreased the growth rate and survival of fingerlings. However, increased feeding regime with rice bran from 3 to 6% increased the fingerling body weight by 40% and survival rate by 20%. Density of 6 fry per m² had an average survival rate of 58% indicating that the return from fingerling production was about Rs. 30,000 per hectare.

KEY WORDS: Carp fry, Rice -fish integration

INTRODUCTION

Productivity of ricelands in Sri Lanka and the income from rice farming are declining. Due to less returns, rice area under cultivation is diminishing and less attention is being given to the rice crop, which further aggravates the problem. Further, the youths are reluctant to engage in rice farming and are migrating to urban areas, which is becoming a social problem. Therefore, alternate income sources should be generated from rice farming, where possible. Although traditionally there was fish farming with rice cultivation in Sri Lanka (Ulluwishewa, 1995), it declined with time due to intensification of the rice culture. In the past, the farming community harvested all the wild fish which collected in the inundated paddy lands at the end of the season. This however is different to the present day intensive rice-fish integration.

Rice-fish integrated farming is increasing rapidly in Asia due to its capacity to generate employment and additional income while being environmentally friendly (Halwart, 1998). It has been shown that rice yields are higher in fields having the rice-fish integration (Roy *et al.*, 1991; Lightfoot *et al.*, 1990). Bambao *et al.* (1989) reported that calculated economic indices such as net return, profit margin, operating cost margin and benefit/cost ratio improved with the shift from rice monoculture to rice-fish culture, implying that the latter is a more profitable and productive farming system. These beneficial effects of rice-fish integration are however, for raising

fingerlings up to the food fish stage but the possibilities of this system in the dry and intermediate zones of Sri Lanka are low. The growing period of the present day rice crop in Sri Lanka is short (3 to 4 1/2 months) which is not sufficient for producing food fish. Further, there is no assured supply of water in many paddy lands and the water is becoming more and more expensive.

For continuous production of food fish in seasonal and perennial tanks in the dry and intermediate zones of Sri Lanka, fingerlings have to be restocked periodically in these water bodies. The annual demand of fingerlings for restocking in these inland water bodies is projected to be about 40 million. It is becoming increasingly difficult to meet this demand with the existing infrastructure in fish breeding stations in Sri Lanka. Alternative methods of raising fingerlings are needed. Rice fields may be used as nurseries to raise fry up to the fingerling stage. However, the suitability of such fields has not been studied under lowland conditions in Sri Lanka. Further, little information is available on the management of fry until they are grown up to fingerling stage in paddy fields. Therefore, we studied the integration of common carp fry with lowland rice with the objective of determining the impact of paddy water quality on fish fry, the management options for fingerling production and the feasibility of improving the return to investment from rice farming with rice-fish integration.

MATERIALS AND METHODS

Three studies were conducted in *yala* 96, *maha* 96/97 and *yala* 97 in the lowland rice fields at the Rice Research and Development Institute, Batalagoda (7 ° 30' N and 80 ° 50' E). The study in *yala* 96 and *maha* 96/97 was to determine the optimum stocking density of fry, optimum time to harvest and the suitability of water quality in paddy fields for fry survival and growth. Five fry stocking densities (0, 3, 6, 12 and 18 fry m⁻²) and four stocking densities (0, 3, 6, 9 and 12 fry m⁻²) were tested in *yala* 96 and *maha* 96/97, respectively. In *yala* 97, a combination of three fry densities (3, 6 and 9 fry m⁻²) and three feeding regimes with rice bran (0, 3% and 6% of the body weight) were tested. Supplementary feed was not given in *yala* 96 but rice bran was given in *maha* 96/97 in equal amounts to all stocking densities. In *yala* 97, requirement of rice bran was calculated based on actual weight and fry density. Feeding regime was revised three times from introduction of fry until harvest.

Treatments were replicated three times. Each experimental plot (5.4m x 6m) consisted of a 45cm deep, 45cm wide trench as a refuge pond which was cut at the lower side of each plot (Cruz, 1990). Each plot was separated by a large and tall bund, which prevented fish migration. Rice seedlings for transplanting were raised in a separate lowland nursery and twenty-one-day-old seedlings of the variety Bg 379-2 were transplanted in rows at 20cm x 15cm spacing in the well ploughed and levelled plots. Cowdung was applied to all plots to facilitate the growth of planktons. Basal fertilizer for the rice crop (15kg N ha⁻¹, 30kg P₂O₅ ha⁻¹ and 20kg K₂O ha⁻¹) was applied at puddling stage. Two weeks after transplanting (WAT), 6 WAT and 8 WAT nitrogen fertilizer was given in the form of prilled urea at the rates of 25, 20 and 60 kg N ha⁻¹. P and K were given in the form of triple superphosphate and muriate of potash,

respectively. At 8 WAT, additional dose of K at the rate of 20kg K₂O ha⁻¹ was applied. Insecticides, weedicides or fungicides were not applied. Weeding was done manually. Fish fry of common carp at desired densities were introduced to the plots at 4 WAT. To prevent predation of fry, the experimental area was fenced with chicken mesh.

Initial body weight and length of fry were recorded from a sample of about 25 fry at the time of introduction. Water level in plot was maintained at a height of about 10 cm. Water temperature was measured five times a day (8 am, 10 am, 12 noon, 2 pm and 4 pm) at four locations in each plot, at a depth of about 5cm below the water surface. Water quality (pH, Dissolved S, Biological Oxygen Demand and Dissolved Oxygen) was monitored at 6 weeks after the introduction of fry. The abundance of phytoplankton and zooplankton was also monitored in paddy water at 6 weeks after introduction of fry. At the time of harvest, fields were drained out and the fingerlings were manually collected from the refuge pond. A random sample of 10 fingerlings from each plot was used for measuring body weight. Fingerlings, which survived, were counted to calculate the survival percentage. Rice crop was harvested at the physiological maturity stage leaving a two row border around the plot. Rice grain yield after threshing and cleaning was determined at 12% moisture.

RESULTS AND DISCUSSION

Water quality measured in *yala 96* at 6 weeks after the introduction of fish fry showed no differences between different fry densities. Water pH remained constant at 7.0 ± 0.5 . Average sulphur content of paddy water was 0.42 ppm. Dissolved oxygen and biological oxygen demand were 6.9 mg/l and 5.4 mg/l, respectively which were within the range favourable for growth of carp fry. No fry mortality was observed at the time of introduction suggesting that the water quality was acceptable for fry growth. However, at the initial stages, only a small number of fry could be seen in the rice area and reasons for this may be the increase in water temperature during the day (Fig.1) and the introduction of feed to the refuge trench.

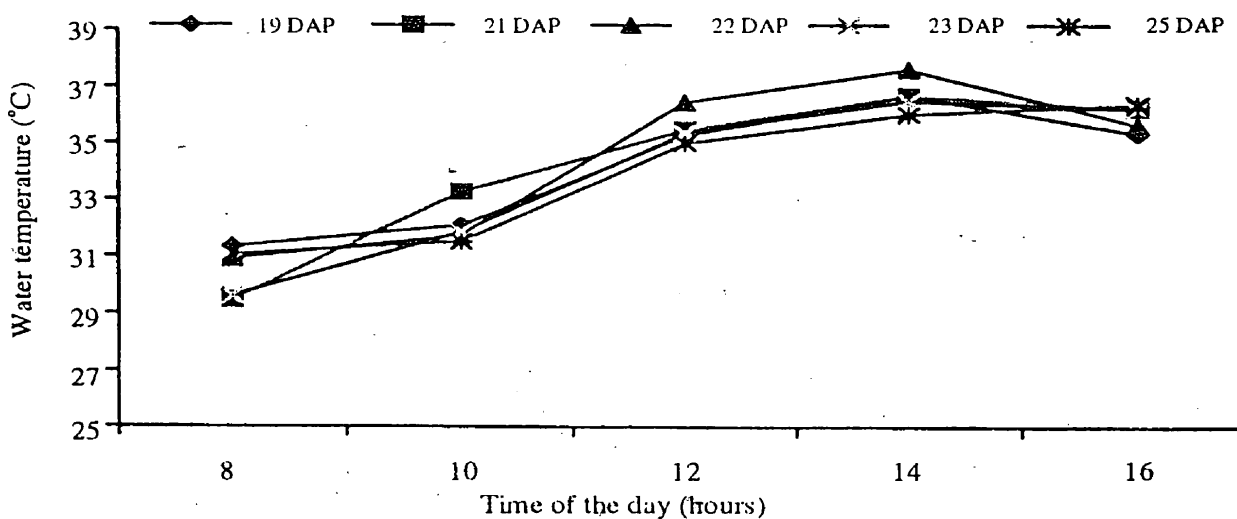


Fig.1. Change in paddy water temperature with time within the day for different days before canopy cover ; DAP=Days after planting

Paddy water temperature monitored from 2 WAT till full canopy cover is shown in Fig.2. Maximum water temperature at 20 DAT was around 37°C and was observed around 2.00 pm (Fig.1). This initial high water temperature gradually decreased, with the increasing covering by the rice canopy, down to an average of about 29°C. Maximum water temperature at the time of introduction of fry at 4 WAT was about 32-33°C (Fig.2). A sporadic increase in paddy water temperature (Fig.1) was due to the fluctuation in water level. Therefore, keeping the water level to a minimum depth of about 10 cm is essential for maintaining a constant water temperature.

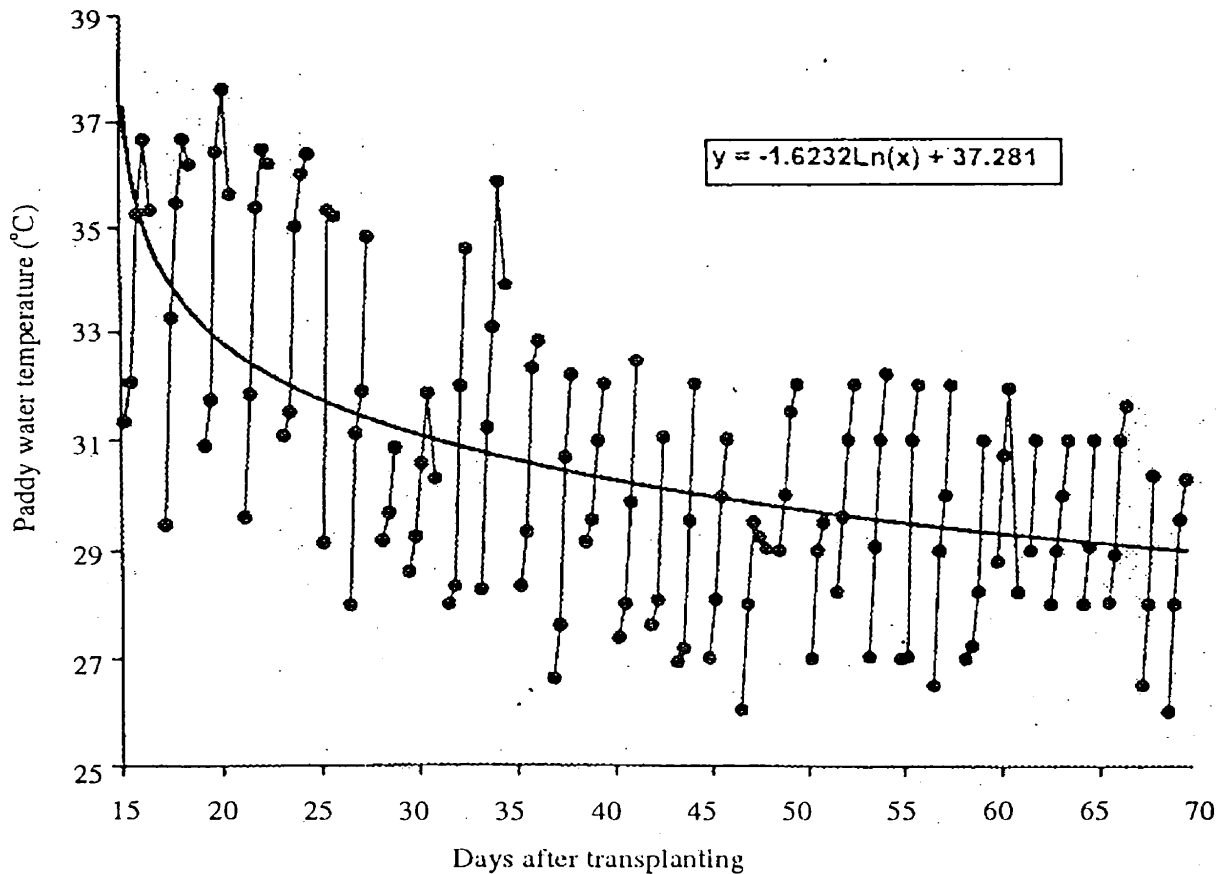


Fig.2. Change in paddy water temperature with growth of the rice plant from 18 to 70 days after planting. Each data point denotes water temperature at 8, 12, 14 and 16 hours on each day as shown in Fig.1.

Fry reached the size of fingerlings at 8 weeks after stocking in rice paddies. Increased fry density in *yala 96* decreased the survival rate and the daily weight gain of fry (Table1). Individual fingerling weight dropped by 40% as the fry density increased from 3 to 6 m⁻². Even though the survival rate decreased, higher initial density increased the total fingerlings harvested and the total fingerling weight per plot (Table1). Decrease in fingerling weight with the increase in density could be partly due to the competition for food among fry. Visual observations showed that the amount of natural food such as plankton in paddy water was very low. However, feeding with rice bran in *maha 96/97* increased the survival and growth of fry (Table1). Survival rate in *maha 96/97* increased significantly with the increased fry density up to 6 m⁻² but the differences among higher densities were not statistically significant. Weight gain of fry per day

Table 1. Effect of fry density on fingerling survival and growth at harvest, and grain yield of rice

Fry density, (Number m ⁻²)	Survival rate (%)		Fingerlings harvested (Number m ⁻²)		Fingerling weight at harvest (g fingerling ⁻¹)		Weight gain (g day ⁻¹)		Grain yield (t ha ⁻¹)		
	Y	M	Y	M	Y	M	Y	M	Y	M	Y
	97	96/97	96	96/97	96	96/97	96	96/97	96	96/97	97
3	58.80	39.60	1.77	1.16	4.30	9.90	0.480	0.110	3.31	4.46	4.56
6	43.20	58.80	2.59	3.53	2.57	8.00	0.030	0.078	3.09	4.70	4.20
9	-	49.80	-	4.46	-	7.10	-	0.063	-	5.02	4.60
12	33.30	52.50	4.00	6.26	2.80	8.10	0.026	0.081	4.20	4.83	-
18	23.80	-	4.30	-	2.94	-	0.023	-	3.30	-	-
No fry	-	-	-	-	-	-	-	-	3.71	4.41	3.83
SE	4.99*	6.34*	0.51*	0.73*	1.53*	ns	ns	0.01*	ns	ns	ns

Y-yala; M - maha; ns = non significant; SE - standard error of means; * mean differences were statistically significant at 5% probability

for all densities in maha 96/97 was more than double when compared to that of yala 96 due to feeding with rice bran (Table 1). Results of maha 96/97 study also confirmed that a density of 6 fry per m⁻² was the optimum and feeding with rice bran is essential for better growth and increased survival.

The study to reconfirm the effect of feeding on growth and survival of fry in yala 97 clearly showed that feeding increased survival of fry (Fig.3). Survival rate maximised at feeding regimes between 3 and 6% of the fish body weight. However,

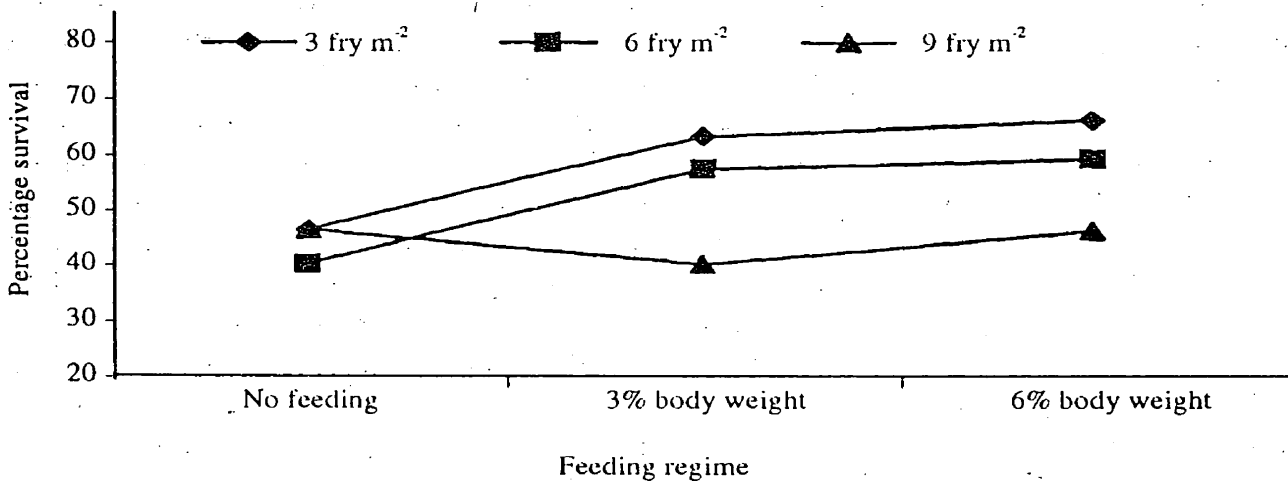


Fig.3. Fry survival at different stocking densities and feeding regimes

the fingerling number harvested per m² continued to increase at densities of 3 and 6 fry m⁻² with increasing feeding regime (Fig.4). There was no significant interaction between feeding regime and density on fry survival. Percentage survival averaged over feeding regime, dropped from 58.7% at 3 fry m⁻² to 50.6% at 6 fry m⁻², but the difference was not statistically significant. However, percentage survival was significantly lower (44%) with 9 fry m⁻² than the lower densities. This confirms the earlier finding that stocking density of 6 fry m⁻² is optimal for rice-fish integration.

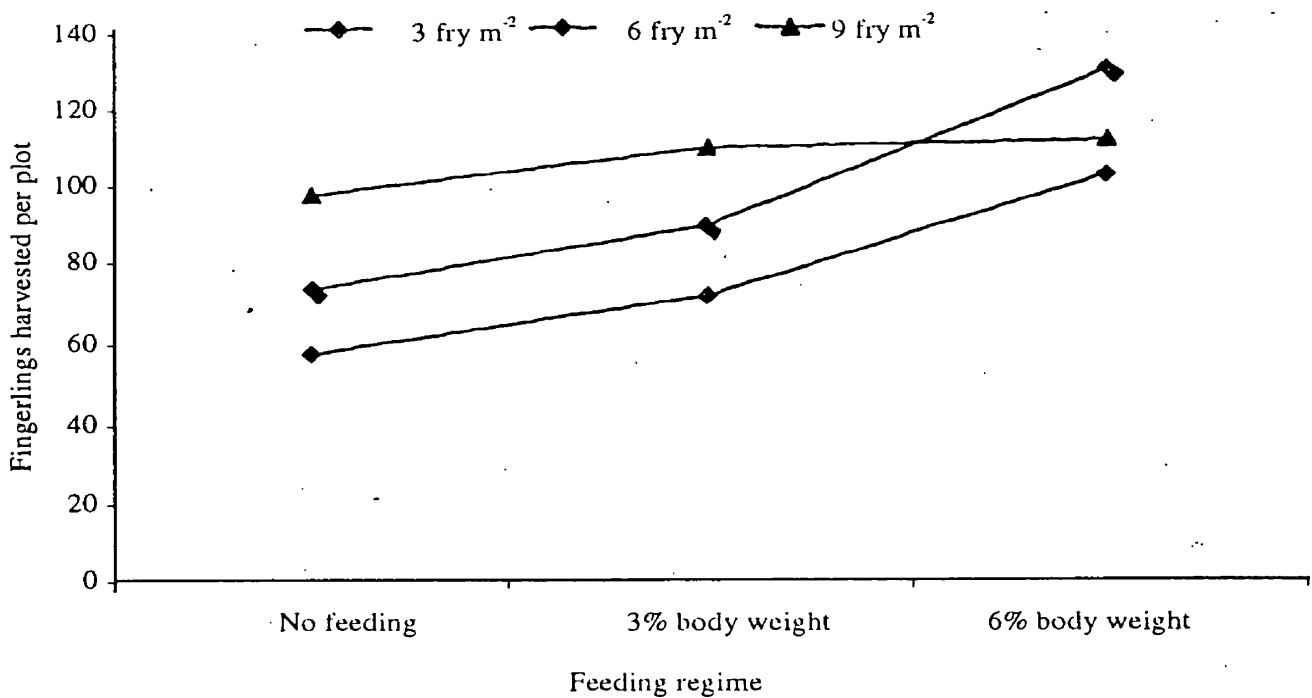


Fig.4. Fingerlings harvested per plot (30m²) at different fry densities and feeding regimes

The weight gained by fingerlings at harvest with different feeding regimes in *yala 97* is presented in Fig.5. Initial body weight and length (head to tail) of fry was 0.8 ± 0.05 g and 2.6 ± 0.1 cm, respectively. A significant increase in fingerling weight with feeding was observed in all stocking densities (Fig.5). However, the interaction for body weight gain between feeding and density was statistically significant only at higher densities. The weight gained without feeding was maximum with 3 fry m⁻² which is different to the weight gained at higher densities; however, weight gained among higher densities was not significantly different. Feeding with rice bran at the rate of 3% of the body weight, did not change the weight gained when density increased from 3 to 6 fry m⁻² but decreased significantly at the highest density. There was no difference in weight gained by fry of different densities at the highest feeding regime (6% of the body weight) suggesting that this amount of feed was more than adequate for fingerling growth. The individual weight of fingerlings at feeding regime of 6% of the body weight was more than 10 g per fingerling. Therefore, considering the required size of fingerlings for restocking in water bodies and the expenditure of rice bran, feeding at the rate of 3% of the body weight and a density of 6 fry m⁻² are optimal for rice-fish integration.

The availability of natural food was further studied during *yala 97*. Water samples collected at 6 weeks after introduction of fry showed traces of diatoms, blue green algae, rotifers, filamentous algae and green algae in the rice plots. This confirms the earlier findings that natural food is low in rice fields and artificial feeding is essential.

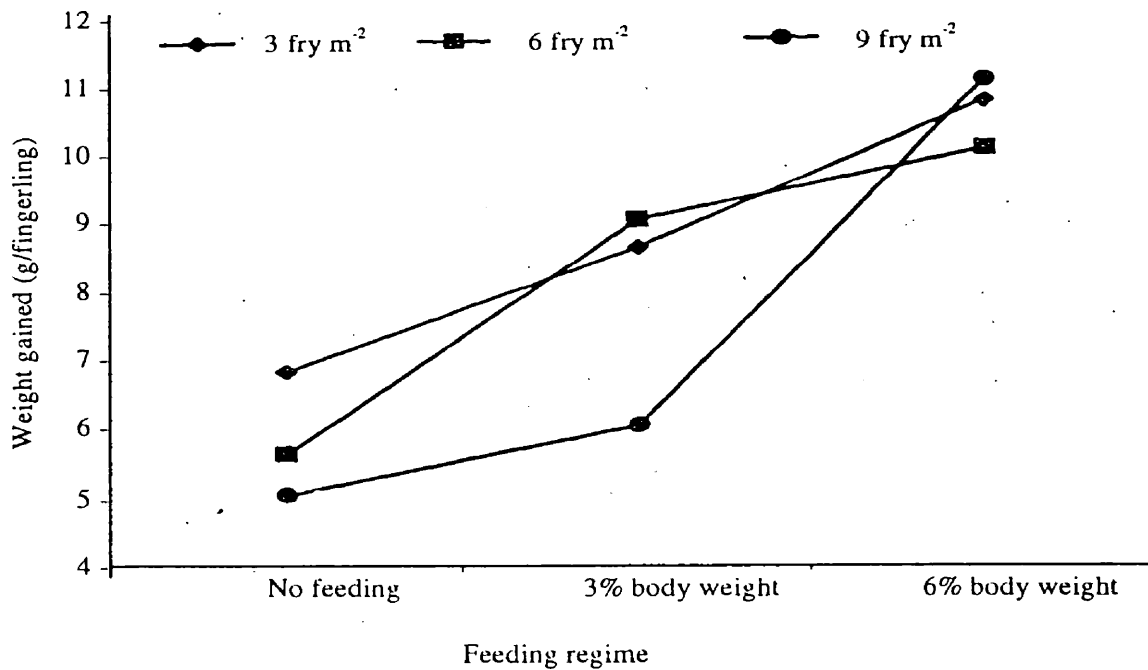


Fig.5. Weight gained from introduction until harvest at different stocking densities and feeding regimes

Rice grain yield did not differ significantly with the integration of fish in all seasons. This is in contrast to the previous reports that integration of fish increased rice yield. However, in this system of rice-fish integration, fry were stocked in paddy fields for only 8 weeks, which may not be adequate to influence rice yields. Even though it is not statistically significant, the grain yield of plots with fish integration where feeding was done (*maha* 96/97 and *yala* 97) was always higher suggesting that rice bran may have had an effect on the rice plant growth and yield. A marked reduction in the need for the application of insecticides and weedicides was observed in all three seasons. This was primarily due to the usage of long age (4 month) rice varieties and the proper timing of planting, which prevented insect damage. Because of the need of water for fish fry, water management was carefully done in these transplanted rice paddies which suppressed weed growth. All these factors that are needed for management of fish had an indirect effect on the management of the rice crop. This may have an overall impact on rice grain yield.

If fingerlings were valued at one rupee each, with the survival rate of about 50% and a stocking density of 6 fry m⁻², farmer could have harvested more than 30,000 fingerlings from one hectare of rice crop and obtain an additional income of Rs. 30000 per hectare. The additional cost for rice bran and the labour cost for preparing trenches are small when compared to the saving from agrochemicals. Therefore, the fingerling harvest will be an additional income to the farmer from the same rice field while providing much needed fish fingerlings for restocking in water bodies.

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