*Bangladesh J. fish. Res.*, 11(1), 2007: 75-92 

# Year-round and rotational freshwater prawn, *Macrobrachium rosenbergii* and paddy farming: soil quality, production, and economics

**M.J. Alam*, M.S. Islam, H.K. Pal and M. Karim[1]**
Bangladesh Fisheries Research Institute, Brackishwater Station, Paikgacha, Khulna 9280, Bangladesh
[1]Bangladesh Shrimp and Fish Foundation, House # 47, Road # 23, Block # B, Banani, Dhaka
*Corresponding author

**Abstract**
A study was carried out at five upazillas (Dumuria, Fakirhat, Pirojpur sadar, Gopalgonj sadar and Kalia) of five southern districts of Khulna, Bagerhat, Pirojpur, Gopalgonj and Narail to understand the comparative production performance and any effect on soil quality in case of year-round golda (*Macrobrachium rosenbergii*), alternate prawn-paddy and year-round paddy farming. A direct interview of 55 farmers was taken, using pre-tested questionnaire, and soil samples were taken from selected farms before and after each crop. Among the five upazillas, farmers in Gopalgonj sadar and Kalia are not practicing year-round golda. Rotational golda-paddy farming has been recorded to result in maximum profit, with the highest of Tk. 310,912/ha/year in 2003 at Dumuria. Only paddy farming is less profitable than other two cropping patterns, irrespective of study sites. The nutrient status of soil in rotational golda and paddy farming has been found improved, compared to that of only golda or paddy farming.

**Key words**: Golda-paddy farming, Economics, Soil quality

## Introduction

Increase in income from already shrunken agricultural land, particularly low-lying mono crop lands, is essential to reduce rural poverty. In recent years, many farmers in mono crop areas have changed a lot in farming pattern by introducing high priced golda (freshwater prawn, *Macrobrachium rosenbergii*) alternating with boro cultivation. Since late eighties, when there were possibly only a few thousand golda farms converting only a few hundred hectares, the golda farming has gained significant popularity. The area of golda farming has gradually extended from 6,000 ha in 1994 (Chanda and Kandker 1994) to some 30,000 ha in recent years (prs. comm., National Shrimp Cell, Department of Fisheries).

Freshwater prawn farming in Bangladesh has a number of socio-economic advantages over marine prawn farming. Unlike the marine prawn farms, which are normally large (average size above 10 ha or 25 ha) and often operated by non-resident

owners, the golda farms are mostly small (average size is less than an acre) and operated by the landowners themselves. Golda farming can be and in many cases actually is well-integrated with paddy production, horticulture and aquaculture of certain species of fish. In fact paddy production in golda ghers (farms) is usually higher than in open bills. The benefits of rice-fish culture, as a low investment entry level technology for resource-poor farmers, have been demonstrated in Bangladesh (Gupta *et al.* 1998). It has been observed frequently that total farm output increases through the inclusion of suitable fish and/or prawn in rice fields (Roy *et al.* 1991, Cai *et al.* 1995, Alam *et al.* 2006). The culture of golda prawn has apparently no conflict with agriculture. Located away from the sea, the golda farms are not usually vulnerable to cyclones or tidal bores, which almost every year cause damages to marine prawn farm infrastructures and the valuable prawn crops. Besides, golda is not susceptible to the prevailing white spot virus disease that causes huge economic losses to the marine prawn and the farmers. Although golda is a freshwater species, it can survive and grow normally in salinity up to 8 ppt salinity. The opportunity for horizontal and vertical expansion of golda farming is, therefore, enormous. For all these reasons, golda culture is socially more acceptable and technically and economically more viable and sustainable.

In recent years, it has been generally observed in golda-boro paddy farming areas that (i) many Golda-Boro fields during the Boro season remain totally or partially fallow, (ii) During the Boro season, many farms are seen to have only scattered patches of boro paddy plants with no or very little care, (iii) many farmers linger prawn production even beyond March to allow the under grown prawn to grow bigger, neglecting or altogether skipping paddy cultivation, (iv) some farmers have intentionally switched over to year round prawn farming skipping paddy cultivation for higher economic gains.

During the last two years or so, another situation has arisen. Some farmers have started farming golda prawn with over-wintered juveniles. They keep late season prawn fry in nurseries and use them for raising an early crop from February to May instead of paddy. In this system, the farmers get an opportunity to easily raise the usual traditional crop of prawn from July to December, significantly increasing income from their land. However, questions may arise whether keeping land inundated under water all the time or most of the time is creating any adverse effect on soil quality and productivity. Suspicions also may be there whether prawn production year after year without any crop rotation is all sustainable. With this prevailing background, the present study was conducted during 2004-05 in selected five golda farming districts of southern Bangladesh, aiming at understanding any changes in productivity in year-round golda farming, with those of prawn-paddy alternation, in terms of production, economics and soil quality.

## Materials and methods

Based on the concentration of golda/prawn farming activities, five study areas were selected, one from each of southern districts of Khulna, Bagerhat, Pirojpur, Gopalgonj and Narail. The study areas were Dumuria upazilla of Khulna, Fakirhat upazilla of

Bagerhat, Sadar upazilla of Pirojpur, Sadar upazilla of Gopalgonj and Kalia upazilla of Narail district.

From the five selected upazillas, a total of 55 farms and farmers were selected, considering year round prawn, alternate prawn-rice and year round rice cropping pattern, to collect information on management, production and economics (Table 1). For each type of cropping pattern, three farms were selected to collect soil samples. The sampling scheme of soil is given in Table 2.

**Table 1.** Farming pattern and number of farmers contracted and interviewed in selected study sites

| Farming pattern | Number of farmers interviewed | | | | |
|---|---|---|---|---|---|
| | Fakirhat | Pirojpur Sadar | Dumuria | Kalia | Gopalgonj Sadar |
| Year-round prawn | 5 | 5 | 5 | NA | NA |
| Crop rotation (Paddy and prawn) | 5 | 5 | 5 | 5 | 5 |
| Rice only | 5 | 5 | 5 | 5 | 5 |

NA = cropping pattern not available

**Table 2.** Scheme of soil sampling for different cropping pattern at different study sites

| Upazila/Thana | Galda-paddy rotation | | Year-round golda | | Only paddy | Total soil sample |
|---|---|---|---|---|---|---|
| | End paddy (May) | End galda (Dec) | End 1st crop (May-June) | End 2nd crop (Nov - Dec) | End of paddy | |
| Fakirhat | 3 farms x 2 samples | 3 farms x 2 samples | 3 farms x 2 samples | 3 farms x 2 samples | 2 farms x 2 samples | 28 |
| Dumuria | do | do | do | do | do | 28 |
| Pirojpur sadar | do | do | do | do | do | 28 |
| Kalia | do | do | NA | NA | do | 16 |
| Gopalgonj sadar | do | do | NA | NA | do | 16 |
| Total samples | 30 | 30 | 18 | 18 | 20 | 116 |

NA = cropping pattern not available

A traditional survey method of direct interview from the selected farmers was followed, using pre-tested questionnaire. Attempts were made to collect data and information prawn-rice production and economics under different cropping pattern and management systems for 2002-2004.

Soil samples were collected at a depth of 0-15 cm from the surface. The soil samples were collected in two installments. Initially, before the specific cropping pattern starts (December'04) and then finally after harvesting (May'05). Soil samples were collected from each selected farm of different sites and cropping patterns. Collected samples were dried in room condition, ground, and then passed through a 0.5 mm sieve to separated and discard any gravel, pieces of plant root, leaves, etc. Then adulterate free soil samples

were kept in air-tight plastic bags with proper labeling for subsequent laboratory analyses. Prepared and labeled samples were sent to Soil Resource Development Institute (SRDI, Khulna and Regional Laboratory, Dhaka) to analyse for the parameters of pH (reaction), salinity (EC @ milimose/cm), organic matter (%), potassium (miliequivalent/100 g soil), total nitrogen (%), phosphorus (μg/g soil), sulfur (μg/g soil) and zinc (μg/g soil).

## Results and discussion

### *Management, production and economics of different cropping pattern*

More than 80% of farmers follow the extensive method and the rest follow improved extensive method of farming. The farmers in Khulna, Bagerhat and Pirojpur areas practice year round prawn, alternate prawn-rice and rice farming, respectively. But in Gopalgonj and Kalia sites, farmers practice only alternate prawn-rice and only rice types. Study site-wise production and economic returns, from year-round prawn, alternate prawn-paddy and only paddy farming, in terms of per hectare yield, total cost, gross profit and net profit are presented in Tables 3a - 3e.

### *Year-round prawn farming*

In this method, golda are cultured round the year. Farmers stock the galda post-larvae (PL) in their farms at a density of 22,000 - 29,000/ha. PL are fed at irregular basis. In most of the sites, farmers culture 'golda' (*Macrobrachium rosenbergii*) and 'bagda' (*Penaeus monodon*) concurrently whole the year, as bagda become marketable size within 3.0 - 3.5 months and golda is more disease resistant than bagda.

The yield of golda per hectare ranged from 302.03~428.57 kg in Fakirhat, 100~163.54 kg in Pirojpur sadar and 755.5~879.18 kg in Dumuria (Table 3a-3c). The highest yield (879.18 kg/ha) has been recorded in Dumuria in 2003 and the lowest (100.00 kg/ha) in Pirojpur sadar in 2002. The total cost of the farming was Tk. 112,036~129,423 in Fakirhat, Tk. 23,958~95,989 in Pirojpur sadar and Tk. 179,947~211,543 in Dumuria (Table 3a-3c). The net profit of prawn farming of the same sites was Tk. 135,185~151,426, 19,792~25,909 and 149,759~208,827, respectively (Table 3a-3c). The highest profit (Tk. 208,827/ha) from year round golda was obtained in Dumuria in 2003 and the lowest (Tk. 19,792/ha) was in Pirojpur sadar in 2002. During the production period, farmers followed partial harvest and partial stocking. Accordingly, golda farmers had a flow of income from golda culture round the year. This farming system has been practiced in Fakirhat, Pirojpur sadar and Dumuria upazilas. The yield of golda were dependent on various factors such as stocking density, feed, fry quality, availability of PL in time, technical knowledge, fund, disease, water quality management, training, high price of snail meat and golda PL, security, etc. Some particular issues in golda farming sites were poaching, prawn poisoning and diseases. Number of livestock was varied from site to site and year to year. No. of livestock of the year round prawn farmers were 1-6 hens with some chicken and 1-10 cows, respectively.

**Table 3a.** Per hectare yield of prawn and rice, and economic returns of only prawn, prawn-rice and only rice farming during the study period in Fakirhat, Bagerhat

| Parameters | Year round prawn | | | Alternate prawn-rice | | | Only paddy | | |
|---|---|---|---|---|---|---|---|---|---|
| | Year | | | Year | | | Year | | |
| | 2002 | 2003 | 2004 | 2002 | 2003 | 2004 | 2002 | 2003 | 2004 |
| 1. Prawn yield (kg/ha) | 302.03 (30.0) | 310.2 (51.0) | 428.57 (127) | 357.26 (124) | 230.68 (35) | 224.04 (213) | - | - | - |
| 2. Prawn PL cost (Tk/ha) | 48,975 (26,264) | 53,568 (39,698) | 55,168 (19,987) | 28,346 (6,646) | 26,966 (7,889) | 68,205 (50,531) | - | - | - |
| 3. Feed used (Tk/ha) | 63,061 (25,509) | 75,855 (19,119) | 73,870 (4,814) | 27,057 (12,620) | 26,421 (14,940) | 46,581 (37,522) | - | - | - |
| 4. Prawn sale (Tk/ha) | 263,462 (100,022) | 276,389 (135,492) | 264,223 (60,249) | 97,385 (14,706) | 73,705 (32,862) | 119,081 (142,681) | - | - | - |
| 5. Profit from prawn (Tk/ha) | 151,427 (62,664) | 146,966 (77,015) | 135,184 (41,206) | 41,982 (3,696) | 20,318 (14,244) | 4,295 (3,747) | - | - | - |
| 6. Income from dyke vegetables (Tk./ha) | 8,562 (7,450) | 4,242 (2,794) | 11,631 (10,030) | - | - | - | - | - | - |
| 7. Paddy yield (kg/ha) | - | - | - | 4,000.0 (00.00) | Nil | 4,102.67 (739) | 2,678.78 (790) | 2,233.25 (887) | 2,058.82 (958) |
| 8. Paddy seedlings, labour and others cost (Tk/ha) | - | - | - | 15,244 (8,181) | 13,942 (4,858) | 15,235 (9,599) | 6,620 (1,219) | 6,278 (1,686) | 6,216 (1,330) |
| 9. Fertilizer used (Tk/ha) | - | - | - | 900 (317.00) | 1,093 (508) | 737 (199) | 2,447 (385) | 2,632 (635) | 2,868 (848) |
| 10. Paddy sale (Tk/ha) | - | - | - | 25,000* (00.00) | Nil | 27,692 (4,990) | 16,350 (5,539) | 13,061 (5,496) | 13,113 (5,651) |
| 11. Profit from paddy (Tk/ha) | - | - | - | 8,856 (00.00)* | Negative | 11,720 (9,442) | 7,282 (4,881) | 4,151 (4,316) | 4,029 (4,842) |
| Total cost (2+3+8+9) | - | - | - | 71,547 | 68,422 | 130,758 | - | - | - |
| Gross income from prawn and rice (4+10) | - | - | - | 122,385 | 73,705 | 146,773 | - | - | - |
| Net profit from prawn & rice | - | - | - | 50,838 | 5,283 (only from prawn) | 16,015 | - | - | - |

Standard deviations are in parentheses. *No. of observation = 1.

**Table 3b.** Per hectare yield of prawn and rice, and economic returns of only prawn, prawn-rice and only rice farming during the study period in Pirojpur sadar, Pirojpur.

| Parameters | Year round prawn | | | Alternate prawn-rice | | | Only paddy | | |
|---|---|---|---|---|---|---|---|---|---|
| | Year | | | Year | | | Year | | |
| | 2002 | 2003 | 2004 | 2002 | 2003 | 2004 | 2002 | 2003 | 2004 |
| 1. Prawn yield (kg/ha) | 100.00 (43) | 163.54 (126) | 145.31 (77) | 187.5 | 66.57 (64) | 123.74 (85) | - | - | - |
| 2. Prawn PL cost (Tk/ha) | 12,500 (11,110) | 55,781 (50,165) | 23,333 (9,718) | 50,000 | 29,261 (26,172) | 25,347 (18,990) | - | - | - |
| 3. Feed used (Tk/ha) | 11,458 (6,505) | 40,208 (14,202) | 34,196 (10,806) | 62,500 | 19,539 (10,983) | 13,447 (10,106) | - | - | - |
| 4. Prawn sale (Tk/ha) | 43,750 (10,825) | 69,271 (60,462) | 83,438 (34,116) | 125,000 | 36,900 (35,704) | 56,313 (37,406) | - | - | - |
| 5. Profit from prawn (Tk/ha) | 19,792 (17,835) | (-)26,718** (48,614) | 25909 (24,819) | 12,500 | 17,567 (23,771) | 17,519 (14,102) | - | - | - |
| 6. Income from dyke vegetables (Tk./ha) | 75,000 (69,597) | 80,729 (72,825) | 37,969 (39,573) | - | - | - | - | - | - |
| 7. Paddy yield (kg/ha) | - | - | - | 2,666.67* | 2,058.08 (700) | 2,284.09 (603) | 4,664.15 (1,017) | 4,237.25 (863) | 3,900.33 (814) |
| 8. Paddy seedlings, labour and others cost (Tk/ha) | - | - | - | 5,000 | 6,345 (2,814) | 5,869 (1,943) | 6,724 (4,479) | 7,122 (4,912) | 7,488 (5,100) |
| 9. Fertilizer used (Tk/ha) | - | - | - | 1,667 | 1,267 (710) | 1,408 (735) | 1,695 (957) | 1,808 (732) | 2,001 (814) |
| 10. Paddy sale (Tk/ha) | - | - | - | 15,333 | 12,623 (5,498) | 16,943 (3,478) | 31,118 (6,924) | 26,669 (5,461) | 25,352 (5,289) |
| 11. Profit from paddy (Tk/ha) | - | - | - | 8,667 | 5,812 (2,939) | 9,677 (1,490) | 22,698 (5,455) | 17,739 (6,034) | 15,863 (6,072) |
| Total cost (2+3+8+9) | - | - | - | 119,166 | 26,144 | 46,060 | - | - | - |
| Gross income from prawn & rice | - | - | - | 140,333 | 49,523 | 73,256 | - | - | - |
| Net profit from prawn & rice | - | - | - | 21,167 | 23,379 | 27,196 | - | - | - |

Standard deviations are in parentheses. *No. of observation = 1. Prawn culture in rice field has been started from 2001-02 in Pirojpur site. **Profit was negative due to poaching.

**Table 3c.** Per hectare yield of prawn and rice, and economic returns of only prawn, prawn-rice and only rice farming during the study period in Dumuria, Khulna.

| Parameters | Year round prawn | | | Alternate prawn-rice | | | Only paddy | | |
|---|---|---|---|---|---|---|---|---|---|
| | Year | | | Year | | | Year | | |
| | 2002 | 2003 | 2004 | 2002 | 2003 | 2004 | 2002 | 2003 | 2004 |
| 1. Prawn yield (kg/ha) | 755.5 (104.4) | 879.18 (96.05) | 776.11 (32.03) | 637.05 (250.87) | 754.64 (288.04) | 708.31 (147.24) | - | - | - |
| 2. Prawn PL cost (Tk/ha) | 81,047 (6,353) | 90,663 (14,314) | 86,815 (7,341) | 39,607 (16,317) | 45,117 (15,753) | 47,945 (15,938) | - | - | - |
| 3. Feed used (Tk/ha) | 98,900 (94,668) | 1,20,880 (4,815) | 1,08,514 (2,483) | 58,159 (26,088) | 69,955 (28,320) | 64,666 (18,758) | - | - | - |
| 4. Prawn sale (Tk/ha) | 329,706 (57,446) | 420,370 (65,843) | 368,174 (67,004) | 3,24,173 (1,14,843) | 4,07,300 (1,77,665) | 3,86,414 (94,070) | - | - | - |
| 5. Profit from prawn (Tk/ha) | 149,759 (52,674) | 208,827 (57,917) | 172,845 (60,706) | 226,407 (73,276) | 2,92,228 (1,40,945) | 273,803 (97,019) | - | - | - |
| 6. Income from dyke vegetables (Tk./ha) | -- | 1,500 (500) | 2,250 (250) | - | - | - | - | - | - |
| 7. Paddy yield (kg/ha) | - | - | - | 3,342 (1,370) | 3,465 (1192) | 3,689 (9,46) | 3,071 (1,027) | 2,897 (967) | 2,789 (1,723) |
| 8. Paddy seedlings, labour and others cost (Tk/ha) | - | - | - | 1,079 (433) | 1,217 (452) | 1,354 (384) | 7,499 (1,642) | 8,462 (1,103) | 6,578 (4,252) |
| 9. Fertilizer used (Tk/ha) | - | - | - | 2,214 (697) | 2,451 (688) | 2,387 (762) | 2,661 (432) | 2,824 (520) | 1,783 (966) |
| 10. Paddy sale (Tk/ha) | - | - | - | 21,341 (8,377) | 22,352 (8,050) | 19,755 (8,622) | 20,574 (7,548) | 18,857 (6,386) | 25,158 (5,926) |
| 11. Profit from paddy (Tk/ha) | - | - | - | 18,048 (7,251) | 18,684 (7,063) | 17,568 (6,971) | 10,414 (7,102) | 7,571 (5,895) | 16,797 (6,771) |
| Total cost (2+3+8+9) | - | - | - | 101,096 | 118,740 | 114,798 | - | - | - |
| Gross income from prawn and rice (4+10) | - | - | - | 345,514 | 429,652 | 406,169 | - | - | - |
| Net profit from prawn & rice | - | - | - | 244,455 | 310,912 | 291,371 | - | - | - |

Standard deviations are in parentheses.

**Table 3d.** Per hectare yield of prawn and rice, and economic returns of prawn-rice and only rice farming during the study period in Gopalgonj sadar, Gopalgonj.

| Parameters | Alternate prawn-rice | | | Only paddy | | |
|---|---|---|---|---|---|---|
| | Year | | | Year | | |
| | 2002 | 2003 | 2004 | 2002 | 2003 | 2004 |
| 1. Prawn yield (kg/ha) | 75 (25) | 167 (71) | 89 (10) | - | - | - |
| 2. Prawn PL cost (Tk/ha) | 10,666 (8,326) | 24,277 (14,545) | 92,500 (10,606) | - | - | - |
| 3. Feed used (Tk/ha) | 7,000 (3,605) | 18,555 (11,814) | 75,277 (56,864) | - | - | - |
| 4. Prawn sale (Tk/ha) | 31,527 (9,504) | 1,13,333 (32,145) | 51,222 (25,386) | - | - | - |
| 5. Profit from prawn (Tk/ha) | 13,861 (10,338) | 70,501 (58,101) | Total Loss (-116,555) | - | - | - |
| 6. Income from dyke vegetables (Tk./ha) | - | - | - | - | - | - |
| 7. Paddy yield (kg/ha) | 4,460 (197) | 5,226 (643) | 6,014 (537) | 4,235 (632) | 4,916 (144) | 4,558 (654) |
| 8. Paddy seedlings, labour and others cost (Tk/ha) | 13,455 (5,758) | 17,888 (10,490) | 16,520 (6,487) | 7,556 (4,355) | 12,254 (424) | 11,916 (854) |
| 9. Fertilizer used (Tk/ha) | 3,733 (1,101) | 4,544 (2,573) | 4,857 (1,744) | 2,091 (290) | 2,450 (85) | 2,664 (456) |
| 10. Paddy sale (Tk/ha) | 29,040 (1,357) | 37,500 (1,500) | 34,796 (1,753) | 26,995 (4,633) | 37,500 (250) | 33,492 (2,016) |
| 11. Profit from paddy (Tk/ha) | 11,852 (2,936) | 15,068 (3,894) | 13,419 (3,654) | 17,348 (3,398) | 22,794 (509) | 18,912 (1,175) |
| Total cost (2+3+8+9) | 34,854 | 65,264 | 189,154 | - | - | - |
| Gross income from prawn and rice (4+10) | 60,567 | 150,833 | 86,018 | - | - | - |
| Net profit from prawn & rice | 25,713 | 85,569 | (-)1,03,136 | - | - | - |

Standard deviations are in parentheses.

**Table 3e.** Per hectare yield of prawn and rice, and economic returns of prawn-rice and only rice farming during the study period in Kalia, Narail.

| Parameters | Alternate prawn-rice | | | Only paddy | | |
|---|---|---|---|---|---|---|
| | Year | | | Year | | |
| | 2002 | 2003 | 2004 | 2002 | 2003 | 2004 |
| 1. Prawn yield (kg/ha) | 49.16 (12) | 216 (164) | 197 (79) | - | - | - |
| 2. Prawn PL cost (Tk/ha) | 20,696 (25,559) | 50,378 (21,985) | 49,058 (13,224) | - | - | - |
| 3. Feed used (Tk/ha) | 37,257 (54,354) | 52,871 (42,348) | 48,861 (44,331) | - | - | - |
| 4. Prawn sale (Tk/ha) | 220,485 (1,33,832) | 267,000 (79,057) | 87,557 (65,411) | - | - | - |
| 5. Profit from prawn (Tk/ha) | 162,532 (1,05,962) | 163,750 (28,284) | Loss (-10,362) | - | - | - |
| 6. Income from dyke vegetables (Tk./ha) | - | - | - | - | - | - |
| 7. Paddy yield (kg/ha) | 5,075 (2,167) | 5,370 (2,213) | 4,968 (1,866) | 7,205 (518) | 7,611 (347) | 7,388 (346) |
| 8. Paddy seedlings, labour and others cost (Tk/ha) | 14,560 (5,530) | 16,363 (6,299) | 15,489 (5,874) | 12,083 (721) | 13,750 (1,250) | 14,444 (1,577) |
| 9. Fertilizer used (Tk/ha) | 2,840 (1,933) | 3,409 (1,382) | 3158 (1,778) | 4,791 (360) | 5,000 (500) | 6,186 (524) |
| 10. Paddy sale (Tk/ha) | 32,606 (14,394) | 36,098 (14,988) | 37,058 (13,272) | 45,034 (3,238) | 48,236 (3,300) | 48,027 (4,133) |
| 11. Profit from paddy (Tk/ha) | 15,206 (9,420) | 16,325 (9,332) | 18,411 (8,665) | 28,160 (3,489) | 29,486 (2,437) | 27,397 (2,588) |
| Total cost (2+3+8+9) | 75,353 | 123,021 | 116,566 | - | - | - |
| Gross income from prawn and rice (4+10) | 253,091 | 303,098 | 124,615 | - | - | - |
| Net profit from prawn & rice | 177,738 | 180,077 | 8,049 | - | - | - |

Standard deviations are in parentheses.

*Alternate prawn-paddy farming*

Alternate cropping of golda and rice is followed in all study sites. In this pattern, one crop, transplanted *boro* rice (HYV) is grown in between December/January to April/May, when water and soil salinity are very low, and is followed by crop of golda in between May/June to December. The rice farms with strong embankment having peripheral trenches are stocked with golda PL at a density of 1,500-15,000/ha. Stocking density of golda PL mainly depends on farmer's solvency and secondly availability of PL. Rosenberry (1990) reported a stocking density of 10,000-30,000/ha of golda in the coastal belt of Bangladesh. Tuyen (1993) stated a stocking density of golda in alternate golda-rice farming in Vietnam was 10,000-20,000/ha. These stocking density more or less support the present findings. Ahmed (1996) recommended to stock golda PL in alternate golda-rice farming at a density of 15,000-18,000/ha. Farmers themselves introduce the cropping pattern of golda and rice alternately in Pirojpur sadar. They stock golda PL in their farms at very low density (1,500-2,000/ha). Under this system, golda is completely harvested by December or January. On the other hand, fin-fishes such as tilapia, rui, carpio, etc. are reared in the deeper canals during the period of rice cultivation. After transplantation of *boro* seedlings, shallow/rain water is allowed to accumulate inside the farm to flood the land for growing the rice, where the fin-fishes are allowed to grow until harvest. In very few cases, T. aman rice is transplanted in the farm in August-September and harvested in December-January. After harvesting of aman rice, golda is cultured in the farm alone or with other carp species/fin fishes and whole the crop is harvested in April-May.

The production of golda in Fakirhat, Pirojpur sadar, Dumuria, Gopalganj sadar and Kalia was 224.04~389.95, 66.57~187.5, 637.05~754.64, 75~167 and 49.16~216 kg, respectively (Table 3a-3e). Highest production of golda (754.64 kg/ha) was found in Dumuria followed by Fakirhat, Pirojpur sadar, Kalia and Gopalgonj. Sinha (1991) and Tuyen (1993) reported a production of 100-300 kg/ha of prawn in alternate prawn-rice farming in India and Vietnam, which is almost similar with the present findings except Dumuria. Ahmed (1996) expected that golda production would be 500 kg/ha in alternate golda-rice culture. The total cost of production were Tk. 68,422~130,758, 26,144~119,166, 101,096~118,740, 34,854~167,777 and 75,353~123,023 in Fakirhat, Pirojpur sadar, Dumuria, Gopalganj sadar and Kalia, respectively (Table 3a-3e). Net profit of the alternate cropping system of the same areas was Tk. 5,283~50,838, 21,167~27,196, 244,455~310,912, (-)103,136~85,569 and 8,049~180,075, respectively (Table 3a-3e). The highest profit (Tk. 310,912/ha) was observed in Dururia in 2003 and the lowest (Tk. 5,283/ha) in Fakirhat in 2003. The results indicated that profit from golda constituted overwhelmingly higher proportion of return under alternate galda-rice farming system. Farmers of Vietnam obtained a net returns of Tk. 20,000-52,000 (US$ 400-1,000)/ha/crop from alternate prawn-rice farming (Tuyen 1993), which slight agrees with the present findings. Profit from golda was negative in Gopalgonj sadar and Kalia in 2004 might be associated with poaching and prawn poisoning (Table 3d-3e). Poaching and prawn poisoning are serious constraints in the surveyed sites of Pirojpur, Gopalgonj and Fakirhat upazilas.

Rice production was totally nil in Fakirhat in 2003 due to high salinity intrusion(Table 3a). The factors that changed the yield of rice were rice variety, quality of seeds, fertilizers, pesticides, insecticides, salinity intrusion, flood, drought, heavy shower, fund, soil fertility, training, technical know-how, etc. The factors that influenced the yield of golda were feed, fry quality, fund, salinity intrusion, flood, water quality management, high price of prawn PL and scientific knowledge. It is implied from the study that the farmers of the Dumuria site are more conscious than other sites. The farms of year round golda and alternate golda-rice are well managed. Number of livestock in alternate golda-rice growing areas was higher compared to year round golda growing areas.

*Year-round paddy farming*

In study sites, agro-ecosystem and salinity vary even within a short distance. Farmers prefer rice cultivation in golda farming areas and they protect their land from intrusion or flooding saline water. Different types of crops are cultivated in high land and medium high land, which are not suitable for golda culture. Depending on availability of freshwater, farmers produce their year round crop. However, year-round rice cultivation may not be profitable compared to golda culture, but it has many social advantages and requires low inputs. Accordingly, farmers are still continuing rice cultivation in golda growing areas. So, they produce rice during the month of July/August to October/November/December and January to April/May and in other months, the land remains fallow.

Farmers produce rice two times a year. But due to various effects of topography and coastal agro-ecosystem, per hectare rice production is not that low, as compared to other areas of Bangladesh. The rice yield in Fakirhat, Pirojpur sadar, Dumuria, Gopalganj sadar and Kalia was 2,058.82~2,678.78, 3,900.33~4,664.15, 2,789~3071, 4,235~4916 and 7,205~7,611 kg, respectively (Table 3a-3e). Yield of rice per hectare was highest (7,611 kg) in Kalia followed by Gopalgonj, Pirojpur, Dumuria and Fakirhat. Moreover, total cost of rice in these areas was Tk. 8,910~9,084, 8,419~9,489, 8,361~11,286, 9,647~1,4704 and 1,6874~20,630, respectively (Table 3a-3e). The net profit was Tk. 4,029~7,283, 15,863~22,699, 7,571~16,797, 17,348~22,796 and 27,397~29,486, respectively (Table 3a-3e). The highest net profit (Tk. 29,486) were found in Kalia in 2003 (Table 3e) and the lowest net profit (Tk. 4,029/ha) were in Fakirhat upazila (Table 3a). However, it was found that economic return from year round rice farming was lower than other farming activities.

The yields of rice has been recorded dependent on various factors like fertilizers, seed quality, rice variety, insecticides, pests, soil fertility, availability of water, fund, inundation, scientific knowledge etc. Some particular issues that faced by the farmers were attack of 'mazra poka', other harmful insects, high prize of fuel and fertilizers, low quality of fertilizers, prolong drought and heavy rainfall. Straw is available in year round rice growing sites and its price is low compared to other sites. So, the highest number of hens, ducks, goats and cows was found in year round rice growing sites than other farming sites.

*Physico-chemical analyses of soil*

The soil samples of different locations and cropping patterns were analyzed to determine the pH, salinity, organic matter, potassium, total nitrogen, phosphorus, sulfur and zinc. The results have been presented location wise in Tables 5~9 and parameter wise in Figs. 1 - 8.

*Soil pH*

The initial soil pH that recorded in Gopalganj, Dumuria, Pirojpur, Kalia and Fakirhat were ranged from 7.5~8.1, 7.66~7.9, 7.1~7.6, 7.75~8.1 and 5.8~7 and the values of final samplings were 7.76, 6.63~7.56, 6.33~7.3, 8 and 6.46~6.87 respectively among all the cropping patterns. Soil pH around 7.5 is best for rice fields (BARC guide 1997). A graphical distribution of soil pH considering location wise cropping pattern is shown in Fig. 1. There is no significant variation in soil pH among different sites and cropping patterns.

*Salinity (EC)*

The initial soil salinity recorded in Gopalganj, Dumuria, Pirojpur, Kalia and Fakirhat were ranged from 0.87~1.16, 2.25~6.14, 1.24~1.41, 2.4~3.7 and 5.67~6.88 milimose/cm and the final values were 1.44, 2.16~3.8, 2.07~3.28, 1.86 and 10.4~15.2 milimose/cm, respectively among all the cropping patterns. A graphical distribution of soil salinity considering location wise cropping pattern is shown in Fig. 2. Soil salinity in Fakirhat, especially fields having crop-rotation practices showed remarkably high salinity (15.2 milimose/cm) in the second sampling (May'05) and lowest (0.13 milimose/cm) in Gopalganj (December'04). Other than Fakirhat and Gopalganj, there is no remarkable variation in soil salinity among sites, samples and cropping patterns.

*Organic Matter (OM)*

The initial organic matter in the soil recorded in Gopalganj, Dumuria, Pirojpur, Kalia and Fakirhat were ranged from 1.86~2.21, 1.6~3.78, 2.48~5.09, 3.36~3.58 and 5.23~8.01% and the final values were 3, 2.84~3.92, 2.9~4.87, 2.19 and 4.04~9.57%, respectively among all the cropping patterns. The optimum level of OM is 2.5-5.0% for rice fields (BARC guide 1997). A graphical distribution of OM considering location wise cropping pattern is depicted in Fig. 3. Soil organic matter in Fakirhat, especially in year round prawn farming practices (May'04) showed highest (9.57%) and lowest (1.16%) in Dumuria for only rice type (December'04). Farmers in Fakirhat with year round prawn farming type dump huge cow dung in their ponds. Other than Fakirhat and Dumuria, there is no significant variation in soil organic matter among sites, samples and cropping patterns.

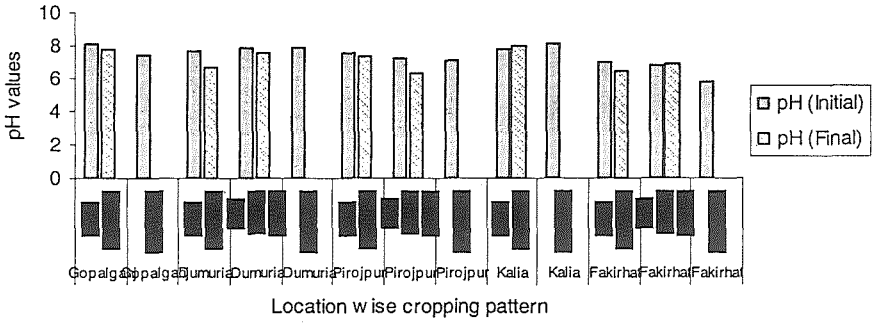


Fig.1. Mean pH values of soil in different locations and cropping patterns

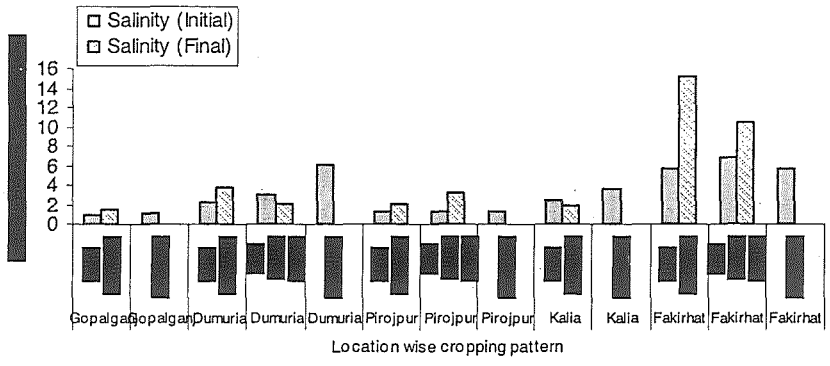


Fig.2. Mean salinity (EC) values of soil in different locations and cropping patterns

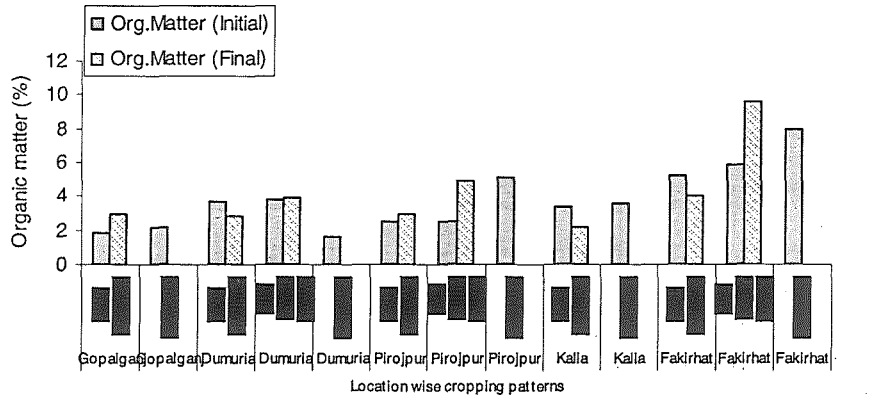


Fig.3. Mean organic matter in soil of different locations and cropping patterns

*Potassium (K)*

The initial amount of K in the soil recorded in Gopalganj, Dumuria, Pirojpur, Kalia and Fakirhat were ranged from 0.41~0.42, 0.46~0.5, 0.35~0.47, 0.42~0.54 and 0.61~0.83 and the final values were 0.49, 0.49~0.73, 0.57~0.61, 0.58 and 1~1.18 (miliequivalent/100g soil), respectively among all cropping patterns. The best level of K is 0.151~0.225 miliequivalent/ 100g K for rice fields (BARC guide 1997). A graphical distribution of K considering location wise cropping pattern is shown in Fig. 4. Amount of potassium in soil in Fakirhat, especially in year round prawn farming practices (May, 2005) showed highest (1.18 miliequivalent/100g soil) and lowest (0.35 miliequivalent/100g soil) in Pirojpur for only rice type (December'04). Farmers in Fakirhat with year round prawn farming type intermittently apply TSP as fertilizer in their ponds. Other than Fakirhat and Pirojpur, there is no remarkable variation in amount of potassium in the soil among sites, samples and cropping patterns.

*Total Nitrogen (TN)*

The initial total nitrogen value in Gopalganj, Dumuria, Pirojpur, Kalia and Fakirhat were ranged from 0.126~0.136, 0.078~0.261, 0.15~0.33, 0.171~0.192 and 0.281~0.397% and the final values were 0.2, 0.19~0.2, 0.15~0.28, 0.15 and 0.22~0.49%, respectively among all the cropping patterns. The suitable range of TN for rice fields is 0.181~0.27 % (BARC guide 1997). A graphical distribution of TN considering location wise cropping pattern is depicted in Fig. 5. Amount of nitrogen in soil in Fakirhat, especially in year round prawn farming practices showed highest (0.49%) the second sampling (May, 2005) and lowest (0.08 %) in Dumuria with only rice type in initial sampling (December'05). Farmers in Fakirhat with year round prawn farming type are used to use urea as fertilizer in their ponds. Other than Fakirhat and Dumuria, there is no significant variation in amount of nitrogen in the soil among sites, samples and cropping patterns.

*Phosphorus (P)*

The initial P value in Gopalganj, Dumuria, Pirojpur, Kalia and Fakirhat were found from 10.25~11.84, 5.11~10.45, 3.67~6.65, 9.92~9.98 and 4.96~9.72 μg/g soil and the final values were 17.47, 2.83~3.83, 4.11~4.42, 10.35 and 4.67~6.61 μg/g soil, respectively. The suitable range for rice fields is 12~18 μg/g P (BARC guide 1997). A graphical distribution of P considering location wise cropping pattern is shown in Figure 6. Amount of phosphorus in soil in Gopalganj, especially in crop rotation practices showed highest (17.47 μg/g soil) the second sampling (May'05) and lowest (2.83 μg/g soil) in Dumuria with crop rotation type in initial sampling (December'05). The trend of higher amount of phosphorus in the soil of that particular site of Gopalganj is found to be a natural phenomenon. Other than Gopalganj and Dumuria, there is no significant variation in amount of phosphorus in the soil among sites, samples and cropping patterns.

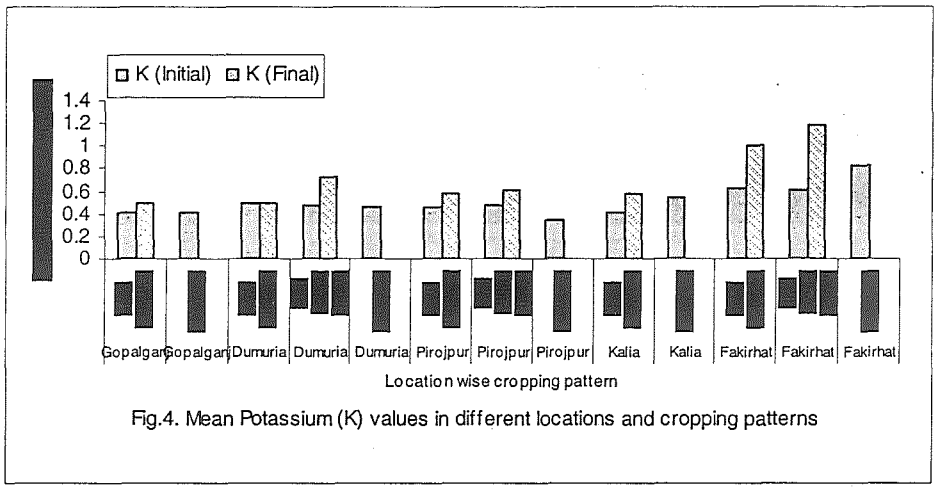


Fig.4. Mean Potassium (K) values in different locations and cropping patterns

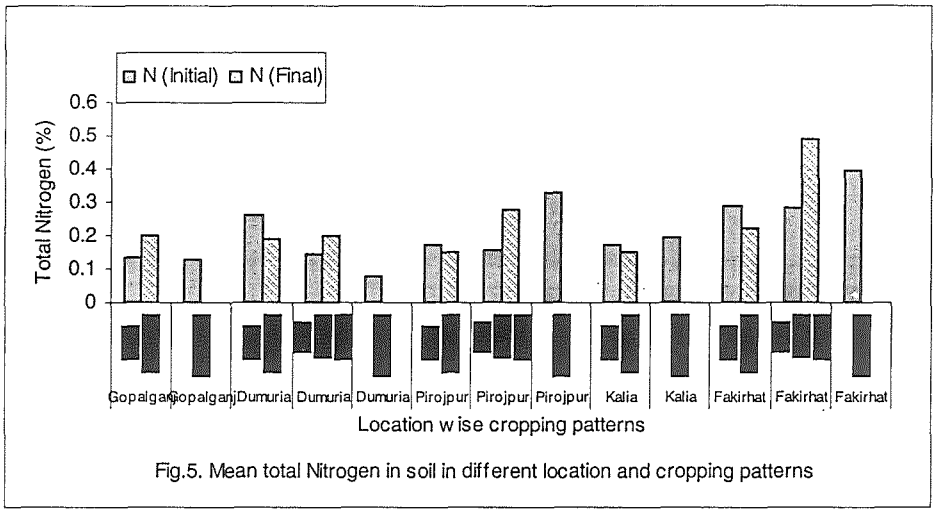


Fig.5. Mean total Nitrogen in soil in different location and cropping patterns

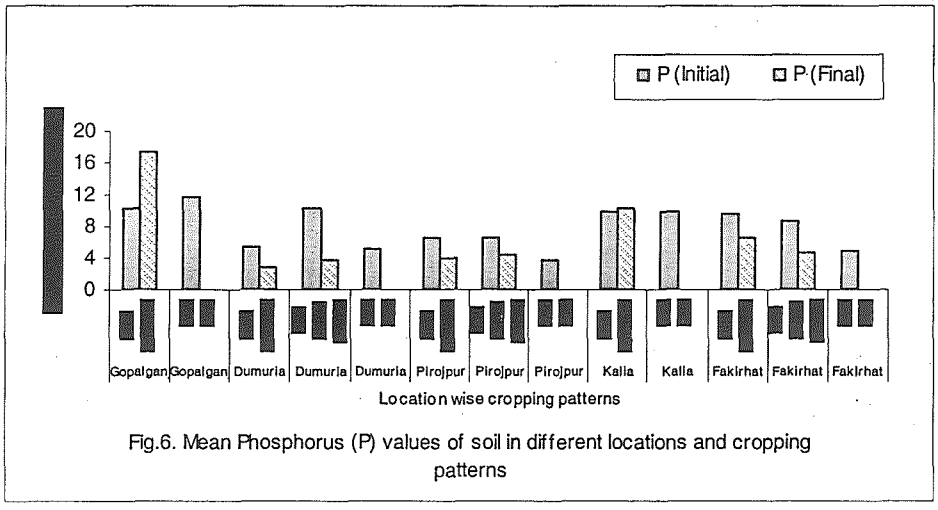


Fig.6. Mean Phosphorus (P) values of soil in different locations and cropping patterns

*Sulfur (S)*

The initial S value in Gopalganj, Dumuria, Pirojpur, Kalia and Fakirhat were ranged from 42.24~113.45, 215.49~311.2, 68.12~196.66, 160.98~177.96 and 55.06~410.82 μg/g soil and the final values were 270.41, 293.89~316.02, 277.86~346.57, 270.9 and 395.35~410.48 μg/g soil, respectively among all the cropping patterns. The recommended range of S for rice fields is 18.1~27 μg/g (BARC guide 1997). A graphical distribution of S considering location wise cropping pattern is shown in Fig. 7. Amount of sulfur in the soil in Fakirhat showed higher (around 400 μg/g soil) for both crop rotation and year round prawn farming practices and lowest in Gopalganj (42.24 μg/g soil). The variation in amount of sulfur in the soil is remarkably high among sites.

*Zinc (Zn)*

The initial Zn value recorded in Gopalganj, Dumuria, Pirojpur, Kalia and Fakirhat were ranged from 0.85~0.86, 0.61~0.92, 0.64~0.91, 0.63~0.79 and 0.47~0.61 μg/g soil and the final values were 1.19, 1.15~1.25, 0.92~1.61, 2.62 and 1.81~3.55 μg/g soil, respectively among all the cropping patterns. It is recommended that 0.91~1.35 μg/g Zn in soil is essential for rice fields (BARC guide 1997). A graphical distribution of Zn considering location wise cropping pattern is shown in Figure 8. Amount of zinc in soil in Fakirhat, especially in year round prawn farming practices showed highest (3.55 μg/g soil) in the second sampling (May'05). Farmers in this type are used to use zinc sulfate as fertilizer in their ponds. Other than Fakirhat and Kalia, there is no significant variation in amount of zinc in the soil among sites, samples and cropping patterns.

## Conclusion

From the production and economic points of view, galda farming, either alone or in rotation with paddy cultivation, has been found profitable in the study sites, particularly in the coastal upazilas. However, the farmers are becoming more inclined to rotational galda-paddy farming, due to its higher benefit. Similar to what has been reported by Middendorp (1985), Xu and Guo (1992), Guant *et al.* (1993), Chowdhury (1999), rotational cropping of galda and paddy in the same land has also been found to result in maintaining improved nutrient status of soil. The economic returns are highly variable, depending on technical knowledge and economical conditions of farmer. The uncertainty in timely supply of various inputs (fry, feeds, etc.), social problems like poaching, and climatological factors have also been triggering the farming benefit or loss. Formulation of policy on land use and cropping pattern, ensured supply of inputs, credit, social security, etc. needs to be developed for the sustainability of rice-prawn farming.

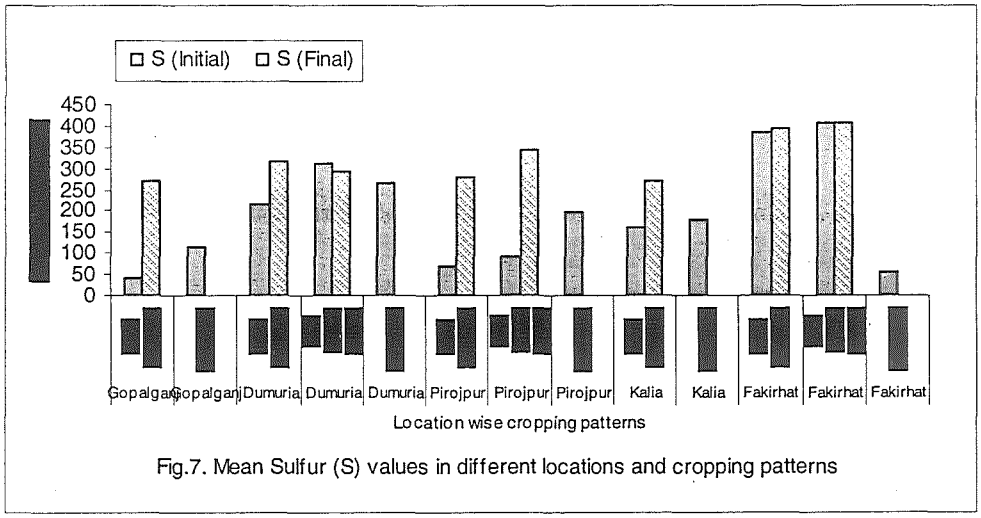


Fig.7. Mean Sulfur (S) values in different locations and cropping patterns

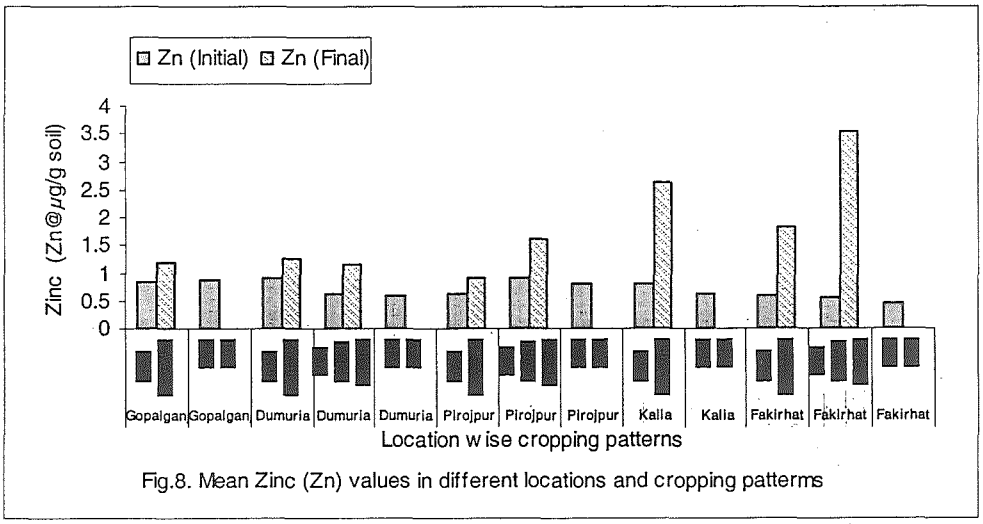


Fig.8. Mean Zinc (Zn) values in different locations and cropping patterns

## Acknowledgement

The authors acknowledge the sponsorship given by Bangladesh Shrimp & Fish Foundation, Dhaka, Bangladesh for the study.

## References

Ahmed, M., 1996. Golda culture in rice fields. *In:* Fish and golda culture in rice field (eds. S.N. Choudhury, M.A. Khaleque, M.S. Karim, M.M. Haque and Kh.H. Rahman), Department of Fisheries, Ramna, Dhaka. pp 16-30. (in Bengali)

Alam, M.J., S.B. Saha, M.L. Islam and T.P. Toung, 2006. Integrated rice-fish farming in saline and freshwater interface in coastal region of Bangladesh. Paper presented in the 2nd Fisheries

Conference and Research Fair 2006 organized by the Bangladesh Fisheries Research Forum, 28-29 December 2005, Dhaka, Bangladesh.

BARC guide, 1997. Fertilizer recommendation guide. Soils Publications No-41. The Bangladesh Agriculture Research Council, Farmgate Dhaka.

Cai, R.K., D.S. Ni and J.G. Wang, 1995. Rice-fish culture in China: the past, the present and the future. In: Rice-fish culture in China (ed. K.T. Mackay). IRDC, Ottawa, Canada. pp: 3-14.

Chanda, A.C. and H.R. Kandker, 1994. Galda chingri farming. Fish compendium 1994, Department of Fisheries, Dhaka, Bangladesh. pp: 24-28.

Chowdhury, M.T.H., 1999. Studies on the sustainability of culture od *Amblypharyngodon mola* in rice fields alone and combination with *Puntius gonionotus* and *Cyprinus carpio*. M.S. Thesis, Department of Fisheries Management, Bangladesh Agricultural University, Mymensingh. 109 p.

Guant, L.J., H.U. Neue and I.F. Grant, 1993. Integrated rice-fish systems. Methodologies for the quantification of nitrogen within the soil plant system. Paper persecuted at the 3rd Asian Regional Workshop on Rice-Fish. Sukamandi, Indonesia, p. 6-11.

Gupta, M.V., J.D. Swallow, M.A. Mazid, A. Rahman, M.G. Hussain and M.M. Dey, 1998. Integrating aquaculture with rice farming in Bangladesh. Feasibility and economic viabilit, its adoption and impact. *ICLARM Technical Report* 55. ICLARM, Penang, Malaysia.

Middendorp, A.J, 1985 Integrated rice-fish culture: practices and prospects. Working group report on small scale integrated aquaculture. International Agricultural Centre, Wageningen, The Netherlands.

Roy, B., D.N. Das and P.K. Mukhopadhyay, 1991. Rice-fish/prawn vegetable integrated farming -- viable proposition in deepwater rice ecosystem. Proceedings of the national symposium on new horizons in freshwater aquaculture, 23-25 January, 1991. Central Institute of Freshwater Aquaculture, Kausalyagang, Bhubaneswar, Orissa (India). pp. 24-25.

Rosenberry, B., 1990. Shrimp farming in Bangladesh. World shrimp farming, 15 (1) : 4-7.

Sinha, V.R.P., 1991. Paddy-fish production systems. In: Sinha, V.R.P. and H.C. Srivastava (Eds.), Aquaculture Productivity. Published by Mohan Primlani for Oxford and IBM Publishing Co. Pvt. Ltd., 66 Janpath, New Delhi 110001, India. 374-377.

Tuyen, N.Q., 1993. Rice-freshwater prawn (*Macrobrachium rosenbergii*) farms in the Mekong Delta, Vietnam. NAGA, ICLARM Quarterly report, Vol. 16, No. 4.: 18-20.

Xu, Y and Y. Guo, 1992. Rice-fish farming system research in China. *In*. C. R. Dela Cruz, C. Lightfoot, B. A. Costa-Pierce, V. R. Carangal and M. P. Bimao (eds). Rice-fish research and development in Asia. ICLARM Conf. Proc., 24: 457.

(Manuscript received 4 October 2006)