

THE TECHNICAL AND ECONOMICAL FEASIBILITY OF CULTIVATING NILE TILAPIA (*OREOCHROMIS NILOTICUS*) IN RICE FIELDS UNDER THE EGYPTIAN CONDITIONS

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ABSTRACT

The present study was conducted to determine the performance of Nile tilapia (*Oreochromis niloticus*) in rice–fish culture system. Six rice fields (1 feddan for each field) were cultivated with rice and divided into two groups, the first group (three fields) served as control (without fish) and the second group were stocked with Nile tilapia (1000 fingerlings/feddan). The growing season for tilapia fish was 90 days.

Results obtained can be summarized as follows:

- Water dissolved oxygen and pH in control fields (rice without fish) were higher than that obtained for treated fields (rice with fish) while water temperature, ammonia, alkalinity, phosphorus, salinity and nitrate were higher in treated fields.
- The average count of phytoplankton organisms (chlorophyta, cyanophyta and bacillarophyta) were higher in control fields compared to the treated fields and the same trend was also obtained for zooplankton groups (rotifera, copepoda and cladocera).
- Average body weight of Nile tilapia increased from 4.08 to 81.97 g, body length increased from 3.86 to 12.71 cm and condition factor decreased from 7.09 at the beginning to 3.99 at harvesting.
- The average daily weight gain ranged from 0.66 to 1.04 g with an average of 0.87g during the whole experimental period.
- Rice-fish integration system increased the rice yield by 148 kg/feddan beside 77.9 kg fish/feddan.
- Net returns were 831.6 and 1239.25 L.E./feddan for control and treatment (integration system), respectively.

INTRODUCTION

Harvesting wild fish and prawns from flooded paddy fields is an ancient practice in Southeast Asia (Li, 1988, Fedoruk and Leelapatra, 1992). Fish culture as an integrated and concurrent activity with rice culture in the same

field is important for rational utilization of limited land resources, as well as a sustainable source of fish protein, additional income and employment generation (Bimbao et al., 1990; Das et al., 1991; Mathew, 1991; Ghosh 1992; Sevilleja, 1992; Sarkar, 1993; Jamu and Costa-Pierce, 1995). Concurrent rice-fish culture uses less fertilizer and pesticides than rice monoculture but is more labor-and capital-intensive (Israel and Sevilleja, 1993).

In the central region of Thailand, Pongsuwana (1963) observed that, the income derived from fish culture was equal to or even higher than that from rice production itself. Thus fish production plays a very important role in the economy of rice farmers, especially those who do not own land. Rice farming is also being regarded as an important integrated pest management package to maintain rice farming sustainable and free from hazardous pesticides and yet maintain the financial and nutritional benefits (Kamp and Gregory, 1994; Ramaswamy, 1994 and Tuan, 1994).

Shaheen et al., (1959) reported that the first experiment of fish culture in rice fields in Egypt was undertaken in 1954, when Nile tilapia (*O. niloticus*), tilapia galilae (*Sarotherodon galilaeus*), Tilapia zilli and common carp (*Cyprinus carpio*) were grown in monoculture or polyculture. Fish production was 40 kg/ha for Nile tilapia and 69-124 kg/ha for common carp in the monoculture and 96 kg/ha in the polyculture of 60% common carp and 40% Nile tilapia. In subsequent work, El-Bolock and Labib (1967) used 20-56 g common carp in rice fields at stocking rate of 750-1250 fingerlings/ha for 2-3 months, the fish yield was about 200 kg/ha with 5-7% increase in rice yield. Jensen (1983) cultured mirror carp (avg. wt. 52 g) in paddies in the Nile delta for 47 days at a stocking rate of 1600 fish/ha, the fish yield reached 158 kg/ha, with an average individual gain of 1.1 g/day and a survival rate of 75%. Sadek and Abdel-Hakim (1986) found that, when common carp fingerlings were stocked at stocking rate of 714 fish/ha, the fish yield ranged between 91.2-104 kg/ha within a growing period of 153 days, moreover, the rice crop increased by 11.4% compared with non-stocked paddies. Sadek and Moreau (1998) found that, when prawn (*Macrobrachium rosenbergii*) cultured at stocking density of 1 and 2 fish/m² in rice fields, the mean prawn yields in the low and high densities were 429.0 and 844.6 kg/ha, respectively after 90 days of culture however, when Nile tilapia (*O. niloticus*) was stocked with prawn at a stocking rate of 1 prawn+0.5 Nile tilapia fish/m² in a polyculture system, the mean prawn yield was 254 plus 754.4 kg/ha of Nile tilapia. They added that, the rice yields in the paddies with low-density prawn monoculture,

high-density prawn monoculture, polyculture and the control (rice without fish) were 8806, 8722, 8605 and 7378 kg/ha, respectively.

In 1998 only 12440 tons fish was produced from 233600 feddan (rice-fish integrated system) and this contributed only 2.28% of the total Egyptian fish production (GAFRD, 1998). Therefore, the objective of the present study is to evaluate the technical and economic feasibility of cultivating Nile tilapia in rice fields under the Egyptian conditions.

MATERIALS AND METHODS

The present experiment was carried out in a private rice farm at Abbassa village, Sharkia Governorate, Egypt. A total area of land about 6 feddans representing 6 individual fields (each of an area about one feddan). The first three ponds were cultivated with rice only (control) and the second three ponds were cultivated with rice and stocked with Nile tilapia (*O. niloticus*) fingerlings.

Rice fields were prepared with ditches in the middle of the pond with a depth and width of 70 × 50 cm, respectively. Screens were fixed at the end of the canals to prevent fish escape and the entrance of foreign fishes into rice fields.

Rice was cultivated in the bedland at first 30 days, then transplanted in the permanent rice fields. After 15 days of rice transplantation three fields were stocked with Nile tilapia at a stocking rate of 1000 fingerlings/feddan with an average initial weight of 4.08±0.08 g at the start of the experiment.

Application of chicken manure at a rate of 900 kg/feddan was carried out before rice transplanting. During the entire crop season, 200 kg/feddan superphosphate and 150 kg/feddan urea were added. No artificial feed, herbicides or pesticides were used during the entire experiment period. Body weight and body length were monthly measured in 90 fish (30 per each pond) to evaluate the growth traits.

Water quality parameters, phytoplankton and zooplankton were also monthly determined in the trench center of each pond according to the procedures of Boyd (1990).

Specific growth rate (SGR) was calculated according to Hopkins (1992) by using the following formula:

$$\text{SGR} = 100 [\ln W_2 - \ln W_1 / t]$$

Where W_1 and W_2 are the first and following fish weight in grams; \ln is the natural logarithm and t is the growing period in days.

Condition factor (K) was calculated according to Bagenal and Tesch (1978) as follow:

$$K = 100 (W)/L^3$$

where W and L are the individual weight and length of the fish.

After 90 days of fish culture, tilapia were harvested from each field and a sample of 30 fish were randomly taken for body weight and body length measures. The rice was harvested after 120 days of sowing.

Statistical analysis of data was carried out by applying the computer program Harvey (1990).

RESULTS AND DISCUSSION

Water quality parameters:

Results of water quality parameters as affected by raising fish in rice fields as averages of the monthly samples are presented in table (1). Water quality parameters showed no significant differences with regard to all parameters except for nitrate where the control (rice without fish) has the lower value (0.15 mg/l) compared with 0.92 mg/l that measured in the treated fields (rice with fish). The high level of nitrate in the treated fields may be due to fish excretion of ammonia and water aeration by fish movement, Mevel and Boyd (1992) demonstrated that, nitrate concentration was greater in ponds with aeration than control ponds (without aeration).

Table (1): Water quality parameters for paddies with and without fish.

| Treatment | No. of samples | Temp. (°C) | Dissolved oxygen Mg/l | Ammonia (mg/l) | Alkalinity Mg/l (CaCO ₃) | Phosph. (mg/l) | Salinity ‰ | Nitrate (mg/l) | pH |
|--------------------|----------------|------------|-----------------------|----------------|--------------------------------------|----------------|------------|----------------|---------|
| Rice without fish | 15 | 24.7±0.6 | 2.3±0.4 | 0.59±0.1 | 391.6±50.2 | 0.16±0.05 | 0.83±0.3 | 0.15±0.25 | 8.8±0.2 |
| Rice with fish | 15 | 24.8±0.6 | 2.1±0.4 | 0.76±0.1 | 392.1±50.2 | 0.18±0.05 | 1.17±0.3 | 0.92±0.25 | 8.1±0.2 |
| <i>Probability</i> | | ns | ns | ns | ns | ns | ns | * | ns |

ns = P>0.05 * = P<0.05

Dissolved oxygen and ammonia showed small variation where the dissolved oxygen was higher and ammonia was lower for the control fields. These results indicated that, the integration system of rice and fish had no significant effect on dissolved oxygen that averaged 2.3 mg/l for control and 2.1 mg/l for treatment and on the ammonia that averaged 0.59 mg/l for control and 0.76 mg/l for treatment, which seemed to have no significant effect on tilapia survival rate. Also, the fluctuation in pH which averaged 8.8 for control and 8.1 for treatment did not also affect the survival rate of Nile tilapia. These results agreed with that obtained by Sadek and Moreau (1998).

The average values of alkalinity, phosphorus, salinity and nitrate in control water samples were lower than that measured in treated fields.

In general all water quality parameters for control and treated fields in the present study were within the permissible levels for normal fish growth and development.

Phyto- and Zooplankton:

As shown in Table (2) the average number of phytoplankton organisms per liter were higher in water samples collected from control fields (rice without fish) and the differences were highly significant ($P < 0.01$ and $P < 0.001$) for the abundance of phytoplankton groups (chlorophyta, cyanophayta and the total phytoplanktonic organisms) while the difference between control and treatment was not significant for the total number of bacillarophyta.

Table (2) also show that the average number of zooplankton organisms per liter were higher in water samples of control fields and the differences were highly significant ($P < 0.001$) for copepoda, cladocera and total zooplankton organisms per liter; while the difference between control and treatment was not significant for the total number of rotifera.

The decrease in the number of phytoplankton and zooplankton organisms in water samples of the rice fields cultured with fish compared with control may be due to the consumption of these organisms by fish and these results are in agreement with those obtained by Mang-Umphun and Arce (1988).

Table (2): Least square means and standard errors for plankton abundance in control and rice-fish culture.

| Phytoplankton (organisms/l) | | | | |
|-----------------------------|-------------|------------|----------------|---------------------|
| Treatment | Chlorophyta | Cyanophyta | Bacillarophyta | Total phytoplankton |
| Rice without fish | 2323±66.6 | 1102±31.2 | 768±35.0 | 4193±107.3 |
| Rice with fish | 1693±66.6 | 988±31.2 | 750±35.0 | 3431±107.3 |
| <i>Probability</i> | *** | ** | ns | *** |
| Zooplankton (organisms/l) | | | | |
| Treatment | Rotifera | Copepoda | Cladocera | Total zooplankton |
| Rice without fish | 1354±33.7 | 877±29.5 | 665±29.1 | 2896±107.3 |
| Rice with fish | 1348±33.7 | 726±29.5 | 505±29.1 | 2579±107.3 |
| <i>Probability</i> | ns | *** | *** | *** |

+ Mean of 18 samples (3 replicates and 6 samples for each replicate).

ns= $P > 0.05$ ** $P < 0.01$ *** $P < 0.001$

Growth traits:

As described in Table (3) the average body weight of Nile tilapia increased from 4.08 at start to 81.97 g at the experiment end and the average daily gain was 0.87 g. These values were higher than that obtained by Mang-Umphun and Arce (1988). They found that, under the integrated rice-fish system, the body weight of Nile tilapia increased from 8.30-8.59 to 33.78-36.69 g during 75 days rice-fish culture period where fields were supplied with organic and inorganic fertilizers and combinations of both. Also, they found that the daily gain ranged between 0.34-0.39 g and these values were lower than that recorded in the present study.

Table (3) also show that the body length of Nile tilapia increased from 3.86 to 12.71 cm after 90 days of treatment and the values of fish condition factor decreased from 7.09 to 3.99, therefore the overall condition factor was reduced by 43.72% at start and experiment end, respectively.

Specific growth rate (SGR) decreased from 5.87 to 1.33% day⁻¹ with an average of 3.33% day⁻¹ and these values were agreed with that reported by Haroon and Pittman (1997), they found that SGR of *O. niloticus* decreased from 4.12 to 1.8 when *O. niloticus* culture in paddies.

Table (3): Least-square means and standard errors for growth traits of Nile tilapia integrated in rice fields (average of three replicates).

| Trait | No. of fish | Initial Mean±SE | 30 days Mean±SE | 60 days Mean±SE | 90 days Mean±SE |
|---------------------------|--------------|--------------------|--------------------|--------------------|--------------------|
| Body weight (g) | 90 | 4.08±0.08 | 23.77±0.49 | 54.97±0.70 | 81.97±1.35 |
| Body length (cm) | 90 | 3.86±0.07 | 7.38±0.16 | 9.70±0.10 | 12.71±0.11 |
| Condition factor (K) | 90 | 7.09 | 5.91 | 6.02 | 3.99 |
| | No. of ponds | 0-30 days | 30-60 days | 60-90 days | Average |
| Daily gain (g) | 3 | 0.66 | 1.04 | 0.9 | 0.87 |
| Specific growth rate(SGR) | 3 | 5.87 | 2.79 | 1.33 | 3.33 |

The high value of daily gain and the other growth traits found in this study may be attributed to the presence of the natural food organisms enhanced by the fertilization of the paddy environment. The natural food organisms served as the direct source of food for tilapia (Chapman and Fernando, 1994).

Rice and fish yield:

Table (4) show that, rice yield in the present study was 3200 and 3052 kg/feddan for fields stocked with and without fish, respectively, so approximately about 5% increase in rice yield was achieved as a result of the integration of fish in rice fields. Such increase can be attributed to (1) improved aeration of soil and water as a result of fish movement (2)

increased soil fertility as a result of fish excreta (3) reduced algae or weed from rice fields and (4) reduced insect populations. The increase in rice yield is in agreement with that obtained by El-Bolok and Labib (1967). Jensen (1983) and Sadek and Abdel-Hakim (1986) reported that stocking of carp in rice fields in Egypt resulted in an increase of 10-15% of the rice yield. Cepada (1982) found that the average rice yield in ponds with and without prawns were 1140 and 1050 kg/ha. Under the polyculture system of Nile tilapia and prawns in paddies Sadek and Moreau (1998) found that, rice field increased by 16.6-19.4% in paddies with and without fish, respectively.

As illustrated in Table (4) fish yield was 77.9 kg/feddan (187 kg/ha). The fish yield in the present study was higher than that obtained by Sadek and Abdel-Hakim (1986) with common carp and also higher than that obtained by Jensen (1983) with mirror carp. Haroon and Pittman (1997) found that the total fish yield of *O. niloticus* was 59.4 and 158.2 kg/ha when the initial weight of *O. niloticus* were 3.1 and 30.7 g, respectively.

Fish yields from rice-fish culture need to be expressed as net yields to have clear understanding of the yield potential. Gross fish yields vary widely from 50 kg/ha to 2.25 tons/ha depending unsystematically on country, fish species, density, fish diets, culture tenure and a variety of other factors (Leelapatra et al., 1992 and Li, 1992).

Survival rate:

As shown in table (4) survival percentage was 94% for *O. niloticus* cultured in rice field. In Panama, Perez-Athanasiadis and Bellido-deCedeno (1989) obtained 90% survival rate for Nile tilapia in rice-culture, while in Bangladesh, Haroon and Pittman (1997) found a survival percentage ranged from 66.4 to 65.6% for *O. niloticus* cultured in paddies for 78 days.

The high rate of fish survival in the present study reflects the good management and suitability of Nile tilapia for this integration system. Haroon et al., (1992) in Bangladesh, reported that Nile tilapia (*O. niloticus*) seems to be better suited for rice-fish systems than Indian carps.

Economic analysis:

Rice seeds contributed by 86.8% of the returns and the fish contributed by 13.2% of the total returns in the integrated system while rice seeds contributed 100% of the returns of the control (Table, 4).

Labor and land renting were the most important cost items and accounted 80.75 and 76.02% for control and the integrated system, respectively. The other components of the operating costs, included rice seeds, fingerlings, organic and chemical fertilizers which contributed by

19.25 and 23.98% of the total costs of the control and integrated system, respectively. The percentage of net returns to operating costs were 51.65 and 72.47% for control and the integrated system, respectively. The net profit per for rice field stocked with fish obtained in our study was higher than that obtained by Jensen (1983) with mirror carp which was 37-46%.

Based on the above economic analysis it is cleared that, net returns increased by 407.65 L. E./feddan for the rice-fish integrated system compared with the control (rice without fish), and this increase may be due to the increases in rice yield by 148 kg/feddan beside 77.9 kg fish/feddan.

Table (4): Stocking data, total production, costs and returns of integrated system of rice and Nile tilapia (*O. niloticus*).

| Item | Rice fields without tilapia/feddan (control) | Rice fields with tilapia/feddan) |
|---|--|----------------------------------|
| Stoking data | | |
| Stocking rate (no. /feddan) | - | 1000 |
| Average size at stocking (g) | - | 4.1 |
| Average size at harvesting (g) | - | 82.0 |
| Survival percentage | - | 94.0 |
| Production (kg/feddan) | | |
| Rice | 3052 | 3200 |
| Fish | - | 77.9 |
| A-Operating costs (L. E.) | | |
| 1-Fish fingerlings | - | 100 |
| 2-Rice seeds | 75 | 75 |
| 3-Fertilization | | |
| Chicken manure | 75 | 75 |
| Urea 46.5% | 100 | 100 |
| Superphosphate | 60 | 60 |
| 4-Labor | 700 | 700 |
| 5-Land renting | 600 | 600 |
| Total costs/feddan | 1610 | 1710 |
| B>Returns | | |
| Rice | 2441.6 | 2560 |
| Fish | - | 389.25 |
| C-Total returns/feddan | | |
| | 2441.6 | 2949.25 |
| D-Net returns | | |
| | 831.6 | 1239.25 |
| E-% Net returns to operating costs | | |
| | 51.65% | 72.47% |

Price per kg rice=0.8 L.E. Price per kg fish=5.0 L.E.

Conclusion:

Since rice yield is not impaired by fish culture, nor is production area lost to fish refuge and ecological conditions are favorable, concurrent rice-fish integration should be encouraged. The rice-cultivated land in Egypt is about 1.552 million feddan/year (FAO, 1997). According to the results of the present

study, if we cultivate 1 million feddans only, we could get productivity about 80 thousand tons of fish beside 5% an increase in rice yield.

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الملخص العربي

النواحى الفنية والإقتصادية لإستزراع أسماك البلطى النيلية فى حقول الأرز تحت الظروف المصرية

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٢ قسم الإنتاج الحيوانى - كلية الزراعة بمشهر - جامعة الزقازيق (فرع بنها)

٣ المعمل المركزى لبحوث الثروة السمكية بالعباسه - مركز البحوث الزراعيه - وزارة الزراعة

أجريت هذه التجربة بغرض تقييم أداء وإنتاجية أسماك البلطى النيلية عند إستزراعه تحت نظام التربية المتكامله فى حقول الأرز وكذلك دراسة العائد الإقتصادى من تربية أسماك البلطى تحت هذا النظام. وقد أجريت هذه الدراسة فى إحدى المزارع الخاصه بقريه العباسه مركز أبوحامد محافظة الشرقية وذلك بإستخدام مساحة مقدارها ٦ أفدنه والتي قسمت إلى ٦ حقول بواقع فدان لكل حقل. ثم قسمت هذه الحقول الستة إلى مجموعتين (٣ مكررات لكل مجموعه) المجموعه الأولى أستخدمت كمجموعه مقارنة (أى زراعة الأرز بدون أسماك) أما المجموعه الثانية فقد تم استزراع اسماك البلطى النيلية بها بمعدل كثافه ١٠٠٠ أصبغيه لكل حقل (فدان) وقد أستمرت فترة نمو البلطى ٩٠ يوم بعدها تمت عملية حصاد الأسماك وأظهرت النتائج أن:

- زاد الأوكسجين الذائب وكذلك رقم الحموضه فى مياه حقول الأرز الغير مستزرعه بالأسماك مقارنة بمياه الحقول المستزرعه بالأسماك بينما كانت درجة حرارة الماء والأمونيا والقلوية والفسفور والملوحة والنترات كانت أعلى فى الحقول المستزرعه بالأسماك.
- كان متوسط العدد الكلى لمجاميع الكائنات النباتية والحيوانية كبيراً فى مياه حقول الأرز الغير مستزرعه بالأسماك مقارنة بمياه الحقول المستزرعه بالأسماك.
- زادت أوزان أسماك البلطى النيلية من ٤٠٨ ر ٤٠٨ جرام عند بداية التجربه إلى ٨١٩٧ ر ٨١٩٧ جرام عند نهاية فترة التجربه كما زاد طول الجسم من ٣٨٦ ر ٣٨٦ عند بداية التجربه الى ١٢٧١ ر ١٢٧١ سم عند نهاية التجربه كما إنخفضت قيمة معامل الظروف من ٧٠٩ ر ٧٠٩ عند بداية التجربه الى ٣٩٩ ر ٣٩٩ سم عند نهاية التجربه.
- تراوحت قيمة الزيادة المطلقه اليومية فى وزن الجسم الأسماك ما بين ٠٠٦-٠٠٤ ر ١٠٤ جرام بمتوسط مقداره ٠٨٧ ر ٠٨٧ جرام خلال فترة التجربه.
- أدت عمليه استزراع أسماك البلطى فى حقول الأرز إلى زيادة محصول الأرز بمقدار ١٤٨ كجم للفدان بجانب الحصول على ٧٧٩ ر ٧٧٩ كجم من أسماك البلطى للفدان.
- كان العائد الإقتصادى الصافى من إستزراع الأسماك فى حقول الأرز ٨٣١٦ ر ٨٣١٦ ، ١٢٣٩ ر ١٢٣٩ جنيه مصرى للفدان وذلك بالنسبة لحقول الأرز التي لم تستزرع بأسماك البلطى وحقول الأرز المستزرعه بأسماك البلطى.