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Demonstration of High-Yield Fish Farming in Ricefields

Cai Guanghui,41 Ying Yuguang,42 Wu Baogan,43 He Zhangxiong,44 and Lai Shengyong45

Traditional fish farming in ricefields yields about 150 kg of fish per hectare. To improve economic efficiency and stimulate the development of a commodity economy in rural areas, improvements have been made in rice–fish culture since 1984 in several major rice producing provinces (e.g., Sichuan, Hunan, Hubei, Jiangxi, Guangxi, Anhui, Jiangsu, Zhejiang, Guizhou, Guangdong, and Yunnan). In 1986, the Science and Technology Commission of Guangxi Autonomous Region assigned a rice–fish project through the Spark Program to the Guangxi General Station of Aquatic Technical Extension. Demonstration experiments were conducted in ricefields for 2 years. High yields of rice and fish were obtained over large areas using a ditch and pit method. In 1986, the experimental area amounted to 48 ha and 29 657 kg of fish were harvested. The average yield was 620 kg/ha which was 3.8 times the average yield of other rice–fish systems in the region. The average rice yield was 10 700 kg/ha. In 1987, the demonstration area was increased to 55.5 ha, the total fish yield was 40 268 kg (average 725 kg/ha), and the average rice yield was 11 610 kg/ha. These results surpassed the target of the specialized contract by 525–600 kg/ha of fish and more than 7 500 kg/ha of rice.

Experimental Methods

Experimental Fields

The two methods that were used were the pit and ditch method and the ridge and ditch method.

41 Guangxi General Station for Extension of Aquatic Technology, Nanning, Guangxi Autonomous Region.

42 Livestock and Aquatic Bureau of Yulin Prefecture, Yulin, Guangxi Autonomous Region.

43 Aquatic Technology Extension Station, Guilin Prefecture, Guilin, Guangxi Autonomous Region.

44 Aquatic Technology Extension Station, Wuzhou Prefecture, Wuzhou, Guangxi Autonomous Region.

45 Agriculture, Animal Husbandry, and Fishery Bureau, Quanzhou Prefecture, Quanzhou Autonomous Region.
Pit and ditch method. In 1986, there were 48 ha of demonstration fields and 529 households participated. In 1987, there were 55.5 ha of fields and 658 households. The experimental fields were distributed from north to south in a total of 26 towns in 14 counties.

Water resources in the experimental fields were abundant, drainage and irrigation were convenient, and yields were ensured despite drought or flood. Before the early rice was transplanted, 6–8% of the ricefields were dug into fish pits that were 65–100 cm deep. At the same time, the footpaths between ricefields were dug 20 cm deeper to form fish ditches that connected all of the fish pits.

Ridge and ditch method. In 1987, in Cenqui County of Wuzhow District, experiments were conducted using a ridge and ditch method on 3.4 ha. Seven days before the early rice was transplanted, the ricefields were tilled and base manure was spread. All of the water was then drained from the field. A ditch (50 cm wide and 40 cm deep) was then dug around the field. If the field was large area, an x- or #-shaped ditch was dug. After the ditch was dug, the ridges were made in an East–West direction. The ridges were 24–26 cm wide and 20–22 cm high. The ditches were 36–40 cm wide and 20–22 cm deep.

Stocking Methods

Two methods of stocking were used: single stocking and two stockings. Single stocking is usually done before the end of April. When two stockings are used, the first is between early April and early May when the early rice is transplanted. The second stocking occurs during the second half of July. Larger fish are partly harvested before or after the harvest of the early rice, and fish fry (4–7 cm long) are stocked.

In 1987, fish fry were stocked at the rate of 11,985 fry/ha. The fish stocked were 80% common carp, 6.1% grass carp, 11% nile tilapia, 2% silver carp, and 0.6% bighead carp. Various experiments were conducted to investigate the effects of: stocking carp at different densities, different species (common carp, grass carp, and nile tilapia), and different feeds (fresh plants, concentrates, and fresh plants mixed with concentrates). Additional comparisons were made between rice yields with and without fish in one ricefield divided into two parts. These experiments were carried out at all the 14 counties.

Day-to-Day Management

Rice production in the demonstrations field was conducted according to the conventional methods used by farm households. In most demonstration fields no weeding was done. The depth of water in the ricefields was generally between 6 and 10 cm; however, during the flowering period the water depth was increased to 15 cm. Atmospheric temperature varied between 16.5°C and 39°C, water temperature was 20–36.5°C, and pH was 6.4–7. Bran cake, green forage, and fertilizer was applied as required.
Collection of Data

In each of the 14 districts, one observation station was established for every 3.3 ha of ricefields and 37 farm households were used for observation. Aquatic scientists and technicians visited the experimental fields periodically to make observations and record data.

Results

Yield of Fish and Rice

Fish and rice were grown in the experimental fields for between 176 and 320 days. In 1986, the 48 ha of ricefields yielded an average 620 kg of fish per hectare. This represented an increase of 4.8 times the average yield of 106 kg/ha obtained from rice-fish culture in the district. The average rice yield with fish was 10 700 kg/ha, an increase of 4.8% compared with ricefields without fish at the same location.

In 1987, there were 55.5 ha of demonstration fields. The average fish yield was 725 kg/ha, which was an increase of 5.5 times compared with the average yield in the district. The average rice yield with fish was 11 605 kg/ha, an increase of 7.2% compared with fields without fish. There were 3.4 ha of rice-fish in the ridge and ditch method. The average rice yield was 12 307 kg/ha, an increase of 8.9% compared with other ricefields.

Survival Rate and Average Weight

In 1987, 665 711 fish were stocked in the demonstration fields and 439 557 fish were harvested. The average survival rate was 66%. Survival rates for each species were: carp 65% (52–79%); grass carp 67% (52–75%); nile tilapia 65% (50–78%); silver carp 68% (62–76%); and bighead carp 75% (71–77%).

The average weights of the different fish varieties were: carp 69.6 g; grass carp 242.6 g (the largest fish was 400 g); nile tilapia 116.1 g; silver carp 255.3 g; and bighead carp 343 g. The yield proportion of the different species was: carp 60%, grass carp 16%, nile tilapia 14%, silver carp 6%, bighead carp 3%, and others 1.1%.

Stocking Densities

In 1987, at Guangyang County, Guilin District 3, 0.16 ha were used for trials of different stocking densities (4 500, 9 000, and 15 000 fish/ha). Stocking at a density of 9 000 carp fry per hectare produced the highest yield (834 kg/ha). At a density of 4 500 carp fry per hectare yield was 495 kg/ha. At 4 500 carp fry per hectare, the average weight per fish was highest. The largest fish was 73.1 g. At a density of 9 000 fish per hectare, the largest fish was 70.8 g; at 15 000 fish per hectare the largest fish was only 37.9 g.
Varieties

In 1986, trials were conducted with crucian carp, grass carp, and nile tilapia as the main stocked fish. High yields could be obtained for all species. When summer grass carp were stocked at 27,000 fish per hectare, with the objective of rearing large fingerlings, 14,400 fry larger than 10 cm were harvested per hectare (survival rate 53%).

Feeding

In 1986, trials of different fish feeds were undertaken. No matter what kind of feed was used (e.g., farmyard manure, green fodder, bran cakes, or combinations of all three), the yield of fish could be increase. A combination of concentrated feed, green fodder, and farmyard manure produced the highest yields.

Rice-fish Compared with No Fish

In 1987, in a total of 1.7 ha of ricefields owned by 22 households in four districts, experiments were conducted to compare rice–fish farming with rice-only farming. The heading rate, fruiting rate, number of grain per head, 1000-grain weight, and nitrogen, phosphorus, and potassium levels in the soil were higher in the rice–fish systems. The average yield from the rice–fish fields was 5.6% higher (Tables 1 and 2).

Economic Efficiency

The direct economic gain from the experimental fields during the 2-year period was increased to CNY222,840. Of this amount, CNY181,902 was net income derived from fish farming. The demonstration experiments on 1,070 ha of ricefields produced an average fish yield of 293 kg/ha and net income was increased to CNY11,530/ha. The total benefit (direct plus indirect benefits) was over CNY1 million. The ratio between input and output was 1:5.51.

Ecological Effects

Fish grown in the ricefield eat mosquitoes and control diseases. Research conducted in 1987 in Quanzhou County by the Parasitic Disease Research Institute of Guanxi Autonomous Region, and the Sanitation and Antiepidemic Station of Quanzhou County. Carp and grass carp raised in ricefields successfully controlled mosquitoes. The relative density index (RDI) was between 0.9 and 42.9. In general, the number of larva and pupa in rice–fish fields was remarkably lower than in the fields without fish.

Conclusion

Several new techniques have been introduced to help improve traditional rice–fish culture:
Table 1. Rice yields with and without fish culture in four districts (1987).

<table>
<thead>
<tr>
<th>District</th>
<th>Rice (ha)</th>
<th>RF Rice-Fish</th>
<th>Cont.</th>
<th>RF Full Grains (%)</th>
<th>Cont.</th>
<th>RF Grains/Head</th>
<th>Cont.</th>
<th>Yield (kg/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Guilin (0.1 ha)</td>
<td>early</td>
<td>28.3</td>
<td>27.8</td>
<td>86.4</td>
<td>82.3</td>
<td>126.0</td>
<td>117.0</td>
<td>7632</td>
</tr>
<tr>
<td></td>
<td>late</td>
<td>27.0</td>
<td>26.9</td>
<td>82.1</td>
<td>78.4</td>
<td>118.0</td>
<td>105.0</td>
<td>6750</td>
</tr>
<tr>
<td>Wuzhou (0.3 ha)</td>
<td>late</td>
<td>25.3</td>
<td>24.8</td>
<td>80.2</td>
<td>78.8</td>
<td>127.7</td>
<td>109.6</td>
<td>6606</td>
</tr>
<tr>
<td></td>
<td>early</td>
<td>25.6</td>
<td>24.8</td>
<td>89.0</td>
<td>87.5</td>
<td>124.3</td>
<td>118.4</td>
<td>11654</td>
</tr>
<tr>
<td>Yulin (0.6 ha)</td>
<td>late</td>
<td>24.8</td>
<td>24.1</td>
<td>86.9</td>
<td>81.9</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Qinzhous (1.7 ha)</td>
<td></td>
<td>26.6</td>
<td>25.3</td>
<td>83.0</td>
<td>72.2</td>
<td>125.4</td>
<td>121.1</td>
<td>5537</td>
</tr>
</tbody>
</table>

*RF rice–fish culture; Cont. no fish culture.

Weeds were reduced by 430 kg/ha in rice–fish fields in Yulin District; 3117 kg/ha in Qinzhous District. Weeds in rice–fish fields in Guilin District were 7.7% of the level in the control field.

Table 2. Weed and insect infestation and soil fertility of ricefields with and without fish culture.

<table>
<thead>
<tr>
<th>District</th>
<th>Rice (ha)</th>
<th>RF Rice-Fish</th>
<th>Cont.</th>
<th>RF Weeds (g/m²)</th>
<th>Cont.</th>
<th>RF Insects (no./m²)</th>
<th>Cont.</th>
<th>RF Soil Fertility (%)</th>
<th>Cont.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Guilin (0.1 ha)</td>
<td>early</td>
<td>—</td>
<td>1.5</td>
<td>—</td>
<td>19.5</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td></td>
<td>late</td>
<td>—</td>
<td>2.8</td>
<td>—</td>
<td>3.6</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Wuzhou (0.3 ha)</td>
<td>early</td>
<td>79.0</td>
<td>103.6</td>
<td>0.67</td>
<td>4.97</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td></td>
<td>late</td>
<td>67.9</td>
<td>111.0</td>
<td>0.81</td>
<td>2.11</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Qinzhous (1.7 ha)</td>
<td>early</td>
<td>31.0</td>
<td>343.0</td>
<td>0.51</td>
<td>0.60</td>
<td>0.12</td>
<td>0.44</td>
<td>0.16</td>
<td>0.03</td>
</tr>
<tr>
<td></td>
<td>late</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
</tbody>
</table>

*RF rice–fish culture; Cont. no fish culture.
Pit, ditch, and ridge and ditch fish-farming systems in ricefields are modifications of traditional methods. The objective of these new methods is to reduce conflicts between fish farming and rice growing and to increase the yields of both rice and fish and raise the economic efficiency of the ricefields.

Carp, grass carp, nile tilapia, silver carp, and chub are now mixed for rearing. The traditional method of raising only carp was changed to increase fish yields, promote rice production, and improve sanitary conditions in the rural areas.

The use of over-wintered fingerlings has significantly increased fish output compared with the traditional method of breeding fingerlings the same year.

The combination of the production of edible fish with the culture of fingerlings has changed the habit of breeding only fingerlings or only edible fish. This has provided edible fish and abundant fish varieties for market.

The introduction of appropriate feeding has promoted fish growth and increased income.

One species of fish adapted to local conditions is now used as the major species. Selection of brood stock has also been improved.

The key techniques used to increase fish yields in ricefields are:

- Use reasonable stocking densities and ratios of multiple fish varieties. Grass carp, nile tilapia, silver carp, and variegated carp were stocked at a rate of about 12,000 fish/ha.
- Breed and stock over-wintered fingerlings.
- Dig fish pits and fish ditches to solve the contradictions between fish farming and rice management.
- Apply appropriate fertilizers and feeds to supplement natural feeds found in the ricefields.