Rice–Fish Culture in China

Edited by
Kenneth T. MacKay

International Development Research Centre
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International Development Research Centre
Ottawa • Cairo • Dakar • Johannesburg • Montevideo
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Ridge-Cultured Rice Integrated with Fish Farming in Trenches, Anhui Province

Yan Dejuan, Jiang Ping, Zhu Wenliang, Zhang Chuanlu, and Wang Yingduo

The earliest record of rice–fish farming in Anhui is from the Ming Dynasty. Traditional techniques produce low yields; however, improved methods have been introduced in recent years in many parts of the country. Changes include mixed culture of fish instead of monoculture; release of adult fish instead of fry; provision of feed for the fish; and disease prevention and control. Research on biology and ecology have attempted to find ways to increase the yields of rice and fish. Engineering facilities for rice–fish farming have been continuously modified. Some new ecological techniques include digging trenches that surround the field, horizontal trenches, and ditches, semidry cultivation, and ridge-cultured rice integrated with fish farming in trenches (high ridge and deep trench).

Advanced Cultivation Techniques

In 1987, the Provincial Aquatic Product Technique Extension Station in Fengtai County, Anhui Province, conducted experiments and established a project to demonstrate advanced techniques of ridge-cultured rice integrated with fish farming in trenches that obtained bumper harvests of rice and fish.

Selection of Experimental Plot

A 7.1-ha ricefield managed by 31 households at Xinji Village, Chengbei Township, Fengtai County, was selected. The plot was smooth and had medium soil fertility and a convenient irrigation and drainage system. The cropping pattern was wheat–rice. Field preparation began in early June after the wheat harvest. Trenches were dug and ridges constructed. Ditches (1–1.7 m deep and 1.5–2 m wide) were dug in 3–7% of the ricefield. Three types of ditches were used:

- Ridge type. Ridges 50 cm wide with two rows of rice seedlings spaced 25 x 12 cm; 165 000–168 000 plants/ha with each hole

27 Anhui Aquatic Product Technique Extension Station, Hefei, Anhui Province.

28 Fengtai Animal Husbandry and Anhui Bureau of Aquatic Product, Fengtai, Anhui Province.

29 Chengbei Township, Fengtai County, Anhui Province.
containing 1-2 transplanted rice plants; trenches 50 cm wide and 40 cm deep.

- Wide ridge type. Ridges 1 m wide with six rows of transplanted rice seedlings, rows and plants spaced 20 x 20 cm; 180 000-186 000 plants/ha; trenches 50 cm wide and 40 cm deep.

- Bed type. Bed 2 m wide with 12 rows in the bed, rows and plants spaced 20 x 22 cm; 195 000-201 000 plants/ha; trenches 60 cm wide and 40 cm deep.

Plot Management

Before the rice seedlings were transplanted, 600-900 kg/ha ammonium sulphate and 450-600 kg/ha calcium superphosphate and manure were applied. From 15 to 20 June, seedlings of hybrid rice varieties (Xianyou 3 and Xianyou 6) were transplanted. A week later, fish fingerlings were released. For adult fish culture, 2700-3 000 fingerlings (10-20 cm in length) were released. The major varieties for fish culture were grass carp (Ctenopharyngodon idella) and common carp (Cyprinus carpio) mixed with a few variegated carp (C. carpio), silver carp (Hypophthalmichthys molitrix), and crucian carp (Carassius carassius). For fingerling production, about 225 000-300 000/ha C. idella and C. carpio fingerlings 3-5 cm long were released into the ricefield.

To accommodate the water requirements of both the rice and fish, the depth of the irrigated water was controlled according to the needs of the different growing stages of the rice. A week after the rice seedlings were transplanted, the ridge was flooded to a depth of 3-6 cm. After the seedlings turned green, the field was irrigated frequently. The trench was kept full of water to saturate the ridge and promote the growth of the plant-root system. The time from booting to milking is the peak period when both rice and fish need water; therefore, the ridge was flooded to a depth of 7-10 cm with irrigation water. After the rice had reached the milking stage, the trench was filled with water to continuously saturate the field and ensure full development of the rice grains. During the growth period for the rice plants, 7-10 kg of urea applied as one or two top dressings were used according to the soil fertility of each plot. Two or three applications (one or two times less than that applied in ricefields without fish) of pesticide were used depending on the rate of insect-pest infestation.

In early September 1987, the fields surrounding the experimental plot at Chengbei Township were attacked by rice planthoppers. The farmers shook the rice plants with sticks to knock the planthoppers into the water. This method of controlling insect pests did not use chemicals that pollute the environment and provided fish with additional food.

Fish management included control and prevention of disease, prevention of fish escape, the timed supply of feed in the ricefield, and the culture of adult C. idella mixed with secondary fish varieties. The feed consisted of fodder grass (10 500-12 000 kg/ha) and concentrated feed (450 kg/ha). In ricefields in which
Table 1. Rice yields from different culture types.

<table>
<thead>
<tr>
<th>Type</th>
<th>Area (ha)</th>
<th>Harvest (kg/ha)</th>
<th>Hills/ha</th>
<th>Panicles/Hill</th>
<th>Grains/Panicle</th>
<th>1000-Grain Weight (g)</th>
<th>Empty Grains (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ridge</td>
<td>0.5</td>
<td>7125</td>
<td>165000</td>
<td>13.9</td>
<td>107.9</td>
<td>30.2</td>
<td>18.6</td>
</tr>
<tr>
<td>Wide ridge</td>
<td>0.8</td>
<td>6870</td>
<td>195000</td>
<td>12.3</td>
<td>115.6</td>
<td>28.6</td>
<td>19.7</td>
</tr>
<tr>
<td>Bed</td>
<td>2.9</td>
<td>6990</td>
<td>195000</td>
<td>10.9</td>
<td>112.2</td>
<td>30.0</td>
<td>23.2</td>
</tr>
<tr>
<td>Conventional</td>
<td>4.3</td>
<td>6795</td>
<td>232500</td>
<td>9.1</td>
<td>114.0</td>
<td>29.1</td>
<td>25.6</td>
</tr>
<tr>
<td>Control</td>
<td>0.3</td>
<td>6150</td>
<td>249000</td>
<td>8.8</td>
<td>105.0</td>
<td>29.0</td>
<td>21.6</td>
</tr>
</tbody>
</table>

grass carp were the main fish variety, concentrated feed and green feed were used; in ricefields with fingerlings 450 kg/ha of concentrated feed and some green feed were applied.

Rice and Fish Yields

Rice yields. On 10 September, before the rice was harvested, a sample was taken of ridge-cultured rice integrated with fish farming. There were 15.5 panicles/bunch, 175 kernels/panicle, and 19.2% empty grains. With the other types of rice–fish farming, there were 12 panicles/hill, 166.8 kernels/panicle, and 19.3% empty grains. An estimate of yield was made by selecting a representative plot from each experimental model. The yield of each experimental plot was independently calculated after the harvest (Table 1). The rice yield from the ridge-cultured rice integrated with fish farming was 1–5% higher than from conventional rice–fish farming (Table 1). The ridge-cultured rice–fish system produced 12–16% more rice than ricefields without fish.

Edge effect. Experiments on wide-ridge rice–fish farming in Huo Shan County in 1987 indicated that the number of panicles per bunch, grains per panicle, and weight per thousand grains were higher in outside crop rows than in the rows at in the centre (Table 2). However, the ridge and wide-ridge systems require excessive labour to dig the trenches. Field preparation and transplanting is done during the busy season; therefore, it is difficult to popularize this method.

Fish yield. Before the rice harvest, adult fish with commercial value were marketed; the remaining fish were counted, weighed, and put into the trenches and fishpond. The fingerlings were 10–20 cm in length, the adult C. idella weighed 0.5–1.5 kg, and H. molitrix weighed about 0.5 kg. The total harvest of fish from the wide-ridge treatment was over 800 kg of adult fish and 312 kg of fingerlings per hectare (Table 3).
Table 2. Growth indicators and harvest of rice cultured on wide ridges in Huoshan County (1987).

<table>
<thead>
<tr>
<th>Project/Head of Household</th>
<th>Panicles/Hill RI (%)</th>
<th>Grains/Panicle RI (%)</th>
<th>1000-Grain Weight RI (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ye Liping</td>
<td>16.0 12.4 29.0</td>
<td>230.0 135.0 70.0</td>
<td>24.4 24.0 1.7</td>
</tr>
<tr>
<td>Ye Youmiao</td>
<td>14.5 9.3 56.0</td>
<td>127.0 88.0 44.0</td>
<td>27.3 24.5 11.5</td>
</tr>
<tr>
<td>Tang Qiancun</td>
<td>25.0 21.0 19.0</td>
<td>164.0 107.0 53.0</td>
<td>28.0 25.0 12.0</td>
</tr>
</tbody>
</table>

* OR outside row; CR central row; and RI rate of increase.

Table 3. Comparison of fish yield between different culture types.

<table>
<thead>
<tr>
<th>Type</th>
<th>Fingerlings</th>
<th>Adult Fish</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Yield (kg/ha)</td>
<td>Survival Rate (%)</td>
</tr>
<tr>
<td>Ridge</td>
<td>396</td>
<td>46.5</td>
</tr>
<tr>
<td>Wide ridge</td>
<td>312</td>
<td>44.7</td>
</tr>
<tr>
<td>Bed</td>
<td>204</td>
<td>47.1</td>
</tr>
<tr>
<td>Conventional</td>
<td>167</td>
<td>38.4</td>
</tr>
</tbody>
</table>

Economic Efficiency Analysis

Production value and cost accounting showed that income from the ridge and wide-ridge fish farming systems was much higher than from conventional rice–fish culture. Income from the ricefields with adult fish culture was also higher than the income from the field with fingerlings. Net income was 2–3 times greater than that from ricefields without fish culture (Table 4).

Discussion and Conclusion

Ridge-cultured rice integrated with fish farming in trenches has several advantages. It is suited to lowland ricefields, cold waterlogged fields, and level ricefields. The optimum sizes for the ridges and trenches are being studied in different parts of the country. The economic efficiency of the ridge-based system is higher than for conventional rice–fish farming. The rice plants grow vigorously and have many
Table 4. Comparison of economic efficiency of different culture models.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Area (ha)</th>
<th>Income (CNY/ha)</th>
<th>Expenditure (CNY/ha)</th>
<th>Total Net Income (CNY/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Rice</td>
<td>Fish</td>
<td>Total Income</td>
<td>Rice</td>
</tr>
<tr>
<td>Adult Fish</td>
<td>8</td>
<td>1963.5</td>
<td>3690.0</td>
<td>5653.5</td>
</tr>
<tr>
<td>Ridge</td>
<td>24</td>
<td>2080.5</td>
<td>3216.0</td>
<td>5296.5</td>
</tr>
<tr>
<td>Fingerlings</td>
<td>8</td>
<td>2287.5</td>
<td>1980.0</td>
<td>4267.5</td>
</tr>
<tr>
<td>Wide ridge</td>
<td>12</td>
<td>2325.0</td>
<td>1561.5</td>
<td>3886.5</td>
</tr>
<tr>
<td>Bed</td>
<td>43.5</td>
<td>2376.0</td>
<td>1018.5</td>
<td>3394.5</td>
</tr>
<tr>
<td>Conventional</td>
<td>6.5</td>
<td>2310.0</td>
<td>831.0</td>
<td>3141.0</td>
</tr>
<tr>
<td>Control</td>
<td>4.5</td>
<td>2089.5</td>
<td>—</td>
<td>2089.5</td>
</tr>
</tbody>
</table>

large panicles and full grains. The wide-ridge system requires less labour than the ridge system and is therefore easier to popularize.

The wide-ridge system and especially the ridge system are more economical and efficient than conventional rice-fish culture because:

- Frequent irrigation with shallow water is the most appropriate environment for rice growth and development. The model of ridge-cultured rice integrated with fish farming in trenches is suited to irrigation with shallow water.
- Hybrid rice, the high-yielding varieties, need wider spaces between rows and narrow spaces between plants. Ridge-cultured rice integrated with fish farming in trenches fulfils these requirements and provides suitable growing conditions for high-yielding varieties. The ridge and wide-ridge systems can alleviate the conflicts between the water requirements of rice and fish. These systems meet the need of rice for water depth at different growing stages, provide a good environment for fish, and enlarge the holding capacity for fish. They also make full use of edge effects for the rice by improving ventilation and light penetration, which enhance photosynthesis, reduce diseases and pests of rice, and deepen the symbiosis of rice and fish to increase the yields of both crops.

Based on previous experiments, experiments have been initiated using zero tillage in high ridges, deep trenches, and wheat-rice cropping patterns. This system could
reduce the need for field preparation and trench digging, improve conditions of water, fertility, atmosphere, and heat, and prevent damage to the soil structure. In addition, mechanical diggers must be designed to replace manual labour. If successful, this system could play an important part in improving economic efficiency.