DOUBLE CROPPING OF RICE IN CHINA

TAN Zhonghe* and LAN Taiyuan**

ABSTRACT

Double cropping of rice in China went through three phases: continuous cropping replacing intercropping, japonica varieties replacing indica varieties in the second cropping and use of hybrid varieties.

In 1984 the areas with double cropping of rice amounted to 10.4 million hectares, accounting for 31.3% of the total rice areas. The mean yield obtained by double cropping was 9.87 t/ha or 61.15 higher than that by single cropping. In recent years, the yield obtained by double cropping has increased due to the cultivation of hybrid rice varieties. The area in which hybrid rice varieties were used for the second cropping accounted for 58.1% of the total area in Hunan Province. The highest yield for double cropping of hybrid rice for 36.9 hectares amounted to 14.83 t/ha.

The major constraints encountered included low temperature injury of the first crop at the seeding stage, transplanting of the second crop at a late time and low temperature including spikelet sterility at the flowering time in the second crop.

The current research activities aim at the following objectives: variety improvement, increase of the benefit of and studies on the effect of the rice double cropping system on soil fertility.

The potential to develop double cropping of rice will be considerable in future in China.

History

Double cropping of rice in China has a long history.

This practice was initiated in the third century B. C. and it was extended from South of China to the Yangtze River valley in A.D.618-1279. In 1949, there were only 4.2 million hectares with double cropping of rice, accounting for 16.6% of the total rice area in China. Due to the improvement of the economic conditions, double cropping of rice in China has experienced a great development in the recent thirty years. The area with double cropping of rice was expanded to 7.7 million hectares, accounting for 23.2% of the total rice area in 1956. Until 1976, there were 12.9 million hectares with double cropping which accounted for 35.7% of the total rice area. During the last thirty years rice grain yield increased by 95 million tons including 30 million tons for rice double cropping. After 1976, the area with drouble cropping decreased slightly due to the adjustment of the rice cropping system (Table 1).

The development of rice double cropping in China went through three phases:

1 Continuous cropping of rice replaced intercropping of rice

The advantage of intercropping is that the second crop of rice can be seeded, transplanted and heads early and may avoid low temperature damage at the flowering time. However the yield is low due to the long interval between growth. After the 1950s continuous cropping of rice replaced the intercropping system due to the improvement of the varieties and techniques. Sichuan Academy of Agricultural Sciences Rice Research Institute reported (WEN, F. 1985) that the yield obtained by continuous cropping of rice was 34.4% higher than that by intercropping.

2 Japonica varieties replaced the indica varieties in the second cropping of rice

Before the 1950s, the varieties used for the second cropping were indica varieties. The main

* Agronomist, Chief of Science and Technology Section, Sichuan Academy of Agricultural Sciences, Chengdu, P. R. China.

** Agronomist, Crop Cultivation and Breeding Institute, Sichuan Academy of Agricultural Sciences, Chengdu, P. R. China.

Table 1 Area of double cropping of rice in China

Year	1949	1956	1976	1984
Area of double cropping of rice (million hectares)	4.27	7.73	12.93	10.4
Percentage of double cropping of rice to total rice (%)	15.60	23.20	35.70	31.3

problem of the second cropping of rice was the low temperature damage at the flowering time when double cropping of rice expanded from South China to North China and the continuous cropping system replaced the intercropping system. After the 1950s, the indica varieties were gradually replaced by japonica ones.

3 Use of hybrid varieties

Double cropping of rice went through a new phase when the hybrid rice varieties were successfully developed and cultivated in 1977. These varieties have given a 20-30% increase of yield and possess wider adaptability than conventionally bred rice varieties. The three developing phases of double cropping of rice are shown in Table 2 (WEN, F. 1985).

Table 2 The yield obtained by double cropping of rice at different phases

Phase	Continuous cropping of rice replaced intercropping of rice	Japonica varieties replaced the indica varieties	Use of hybrid varieties
Yield obtained by double cropping of rice (t/ha)	3.92	5.40	9.28
Yield obtained by single cropping of rice (t/ha)	3.77	4.20	6.81

The present situation

The area with double cropping of rice in China can be classified into the South China double cropping zone and Central China mixed cropping zone (Fig. 1) (SHEN, Jin-Hua, 1980).

The South China double cropping zone lies to the South of Nan-Ling (South Mountain). It is a part of the tropical and southern subtropical zone. Seventeen percent of the total rice cropping area of China is located in this zone. The main cropping system is double cropping of rice which accounts for 80% of the total rice area in the South China rice double cropping zone. In this zone, the temperature is the highest in China, the rainfall the heaviest, and the rice cropping season, the longest (usually more than 260 days). The lowest mean temperature exceeds 10°C in January, 19°C in April, and 22°C in October. During the rice cropping season the mean temperature ranges between 22 and 26°C, the temperature difference between day and night is 5.4-8.1°C. The accumulation of temperature 10°C approximates 6,500-8,000°C. The annual rainfall ranges from 1,100 to 1,600 mm.

The Central China mixed rice cropping zone lies North of Nan-Ling and South of Huaihe

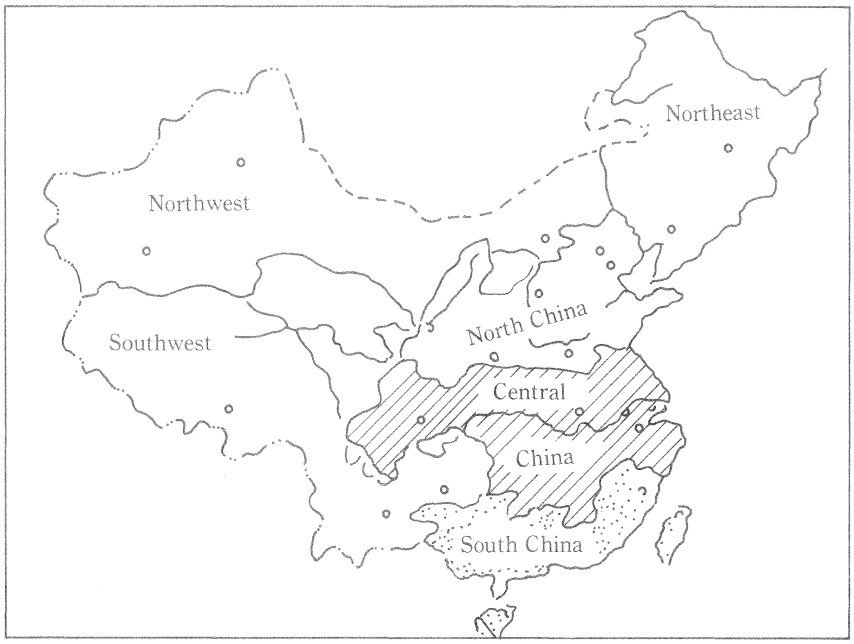

Fig. 1 Double cropping of rice in China.
Source: Adapted from SHEN Jin-Hua, 1980.

River and Chin-Ling (Chin Mountain). It is a part of the mid-subtropical zone. This zone accounts for 65.5% of China's total rice cropping area which mixes double cropping and single cropping of rice. The double cropping zone is distributed mainly South of the Yangtze River. The cropping season takes place usually from mid-March to October (220–240 days). During the rice cropping season the mean temperature is 21°C–25°C. The accumulation of the temperature 10°C approximates 4,500–6,500°C. The mean monthly temperature exceeds 14°C in April, and 17°C in October. The annual rainfall ranges from 750 to 1,300 mm.

In 1984, the areas with double cropping of rice in China amounted to 10.4 million hectares which accounted for 31.3% of the total rice cropping areas. The mean yield obtained by double cropping was 9.87 t/ha (the first cropping produced 5.20 t/ha, and the second cropping 4.67 t/ha) which was 61.1% higher than that by single cropping. In Hu-Nan Province in 1984, the area with double cropping of rice amounted to 2.0 million hectares which was the largest in China. The mean yield was 10.98 t/ha which was the highest in China. By the use of hybrid rice varieties in the first and the second croppings, the mean yield for 36.9 hectares was 14.83 t/ha (Double Cropping of Hybrid Rice Research Group, 1985).

Major constraints

1 Low temperature injures the first crop at the seeding stage

The frequency of low temperature occurrence is very high during the seeding stage of the first crop of rice. Low temperature of 12°C injures germinating seeds or seedlings. CHENG Quan-Long (1986) reported that the root absorbability and the amounts of leaf transpiration of the seedlings which suffered from freezing injury were lower than those of the healthy seedlings. WONG Yu-Qi (1986) reported that the permeability of the protoplasmic membrane of the root

apex increased when the seedlings suffered from a low temperature of 0-1°C cor 12 hours (Table 3).

Table 3 Effect of low temperature on water and nitrogen metabolism of rice seedlings

	Low temperature	Control
Amounts of bleeding sap (mg/g dry weight/hour)	0.045	0.907
Amounts of water absorbability (mg/hour)	32.5	60.7
Amounts of transpiration (mg/hour)	35.8	56.6
Margin between absorption and transpiration (mg/hour)	-3.3	+4.1
Total nitrogen (mg/g dry weight)	45.0	56.96
Proteinic nitrogen (mg/g dry weight)	36.3	48.24
Non-proteinic nitrogen (mg/g dry weight)	8.7	8.72
Amino nitrogen (mg/g dry weight)	4.42	3.06
Ammonia nitrogen (mg/g dry weight)	0.22	0.15
Relative activity of proteolytic enzymes (%)	154	100

ZHOU Xie (1978) reported that the germinating seeds which were exposed to a day temperature of 14°C and hight temperature of 2.4°C for 7 days were not injured when both soil and seeds were disinfected. A percentage of 10.5% of injured germinating seeds was observed when the soil was disinfected only, while a percentage of 54% of injured germinating seeds was recorded when the seeds were disinfected only.

2 Low temperature induced spikelet sterility at the flowering time of the second crop

The low temperature which induced spikelet sterility at the flowering time was the major constraint to high yield for the second cropping. The China Central Meteorological Research Institute (1975) suggested that the critical low temperature causing sterility was 20°C for japonica varieties and 22°C for indica varieties for a 5 day exposure at the flowering time. The Shanghai Plant Physiological Research Institute (1986) reported that low temperature injured the spikelets which had not undergone anthesis and those which had undergone anthesis with unextended ovary. The spikelets with extended ovary were not injured. The most sensitive organ to low temperature was the pollen grains (Table 4).

3 Delay in transplanting of the second crop

To avoid low temperature injury, the second crop should be seeded at a proper time.

Transplanting of the second crop was usually delayed due to the late maturity of the first crop following the cultivation of barley/rape/wheat.

The presence of old seedlings was a major constraint for achieving high yield in the second cropping. Based on the Hunan Li-Line County experiments (1982), the yield of Wei You 6 which had been seeded on 15 June as a second crop was respectively 5.17 t/ha, 4.73 t/ha, 4.28 t/ha and 3.52 t/ha when transplanting took place on 15, 20, 25 July respectively.

Current research activities and future prospects

1 Varietal improvement with emphasis placed on high yield with shorter growth duration, disease resistance and good quality

Breeding for rice double cropping in China has achieved a great success especially in the case of hybrid rice breeding. The present problems to solve include improvement of the yielding potential, disease resistance, grain quality and growth duration.

In recent years, some improved varieties with high yield, disease resistance, good quality

Table 4 Percentage of fertile spikelets treated by low temperature at different growth stages (X-ray photograph)

Temperature (°C)	28			17.5			15			12.5		
Spikelet growth stage before treatment	-1	0	1	-1	0	1	-1	8	1	-1	0	1
Number of spikelets	37	27	37	58	2	7	36	12	7	24	16	9
Number of fertile spikelets	11	5	29	23	1	6	9	9	6	5	8	9
Percentage of fertility	29.7	18.5	78.4	39.7	50.0	85.7	25.0	75.0	85.7	20.8	50.0	100
Number of unfilled grains	0	0	0	0	0	1	4	0	0	5	4	9
Percentage of unfilled grains	0	0	0	0	0	14.3	11.1	0	0	20.8	25.0	0

* -1 spikelets which did not undergo anthesis
0 spikelets with non-elongated ovary
1 spikelets with elongated ovary

Source: The Chinese Academy of Sciences, Plant Physiology Institute Phytotron, 1975.

and a shorter growth duration have been recommended such as the hybrid rice varieties Wei You 35, Wei You 64, Di You 3, Shan You 63. Scientists have obtained some male sterile materials with long stigma and a high percentage of outcrossing seed setting.

2 Effect of rice double cropping system on soil fertility

Results of long term experiments (YANG Weng Yuan, 1985) indicated that the continuous cropping of green manure-rice-rice resulted in the yield decrease of green manure due to potassium deficiency and soil hardening. The continuous cropping of wheat-rice-rice resulted in the yield decrease of wheat due to the decrease in the amounts of soil microorganisms. The continuous cropping based on the rape seed-rice-rice system did not affect the yield of rice or rape seed.

3 How to increase the benefit of the double cropping system is a problem which should be considered from the view point of component technique inputs to minimize and increase the income (LIOU Guang Yu, 1980).

China has the largest population in the world, but arable land is limited. To increase the yield per unit area is the only way to solve the food problem. One of the measures to increase the yield is to develop double cropping of rice. There are rich natural resources to promote double cropping of rice in the South China double cropping rice zone and Central China rice zone. The techniques and varieties suitable for double cropping of rice have made great progress. The potential to develop double cropping of rice will be very great in future in China.

References

1) China Central Meteorological Research Institute (1975): *In*: The Symposium of "Effect of low temperature on fertility of the second cropping rice at flowering time". Held at Lan Lin on 1th-8th April 1975.

2) Chinese Academy of Agricultural Sciences (1986): China Rice Crop Science. Agricultural Publishing House. (Unpublished).
3) Double Cropping of Hybrid Rice Research Group (1985): The techniques of high yielding of 15 t/ha in double cropping of hybrid rice. *Hunan Agricultural Science, J.* **3,** 37-38.
4) FANG Wen (1985): The techniques of double cropping rice (Unpublished data).
5) Hunan Chen Zhou District Agricultural Bureau (1982): Techniques of the second cropping hybrid rice. Published by: Hunan Science and Technology Publishing House. 25-28.
6) LIOU Guang Yu, L.G. (1980): Studies on economic benefit of rice cropping system in Shu Zhou District. *Jiang Shu Agricultural Science J.* **6,** 18-25.
7) SHEN Jin-Hua (1980): Rice breeding in China. *In*: Rice improvement in China and other Asian countries. Published by: International Rice Research Institute and Chinese Academy of Agricultural Sciences. p.10-12.
8) YANG Weng Yuan (1985): Long term experiment on different cropping systems in Chengdu Plain. *In*: International multiple rice cropping system conference. Held at Lan Jing in 1985.
9) ZHOU Xie (1978): The reason and prevention of seedling death of early rice. *Jiang Shu Agricultural Science and Technology J.,* **1,** 1-9.