TECHNIQUES FOR ACHIEVING HIGH YIELD FOR DOUBLE CROPPING OF RICE

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ABSTRACT

In 1984 the areas with double cropping of rice in China 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 61.1% higher than that by single cropping. The highest yield for 36.9 hectares amounting to 14.83 t/ha was recorded in Hunan province in 1984.

The techniques to achieve high yield included the selection of rice varieties suitable for double cropping with emphasis placed on hybrid rice varieties and proper combination of varieties, proper seeding date and use of plastic film to raise the seedlings to avoid low temperature injury in the seedlings of the first crop of rice, sowing before the critical seeding date to avoid low temperature inducing sterility in the second crop of rice, zero tillage after the first cropping rice for the transplanting of the second crop at an appropriate time, light seeding and dense transplanting with small hills to increase the amount of total filled grains per unit area.

Introduction

In 1984 the areas with double cropping of rice in China amounted to 10.4 million hectares, accounting for 31.3% of the total rice cropping areas. The mean yield obtained by double cropping of rice was 9.87 t/ha (the first cropping produced 5.20 t/ha and the second cropping produced 4.67 t/ha) or 61.6% higher than that by single cropping. In Hunan Province in 1984, the area with double cropping covered 2.0 million hectares which was the largest in China. Mean yield was 10.98 t/h which was the highest in China. Through the use of hybrid rice varieties in the first and second croppings, the mean yield for 36.9 hectares amounted to 14.83 t/ha in Hunan Province in 1984 (Double Cropping of Hybrid Rice Research Group, 1985).

Major constraints to high yield

1 Low temperature injured the first crop at the seeding stage

The frequency of low temperature occurrence was very high during the seeding stage of the first crop. The low temperature of 12°C injured germinating seeds or seedlings. CHENG Quan-Long (1986) reported that root absorbability and the amounts of leaf transpiration of the seedlings which suffered from low temperature injury were lower than those of 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 for 12 hours.

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

Low temperature which induced spikelet sterility at the flowering time was the main 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 the japonica varieties and 22°C for the 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 the spikelets which had undergone anthesis without extended ovary. The spikelets with extended ovary were not injured. The most sensitive organ to low temperature was the pollen grains.

3 Delay in transplanting of the second crop

To avoid low temperature injury, it is essential that seeding of the second crop take place 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 experiment (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 3.5 t/ha when transplanting took place on 15, 20, 25 July, respectively.

Major techniques to achieve high yield

1 Selection of rice varieties suitable for double cropping with emphasis placed on hybrid rice varieties and proper combination of varieties

Selection of suitable varieties and proper combination of varieties were the essential techniques to achieve high yield for double cropping.

The major current varieties used for the first cropping are:

Early-maturing indica varieties: Er Jou Qin, Xiang Ai Zhao 7.

Middle-maturing indica varieties: Yuan Fen Zhao, Zhu Xi 26, Er Jou Fen, Lu Lan Zhao 1, Xiang Zhao Xian 1.

Middle-maturing indica hybrid variety: Wei You 49

Late-maturing indica varieties: Guang Lu Ai 4, Xiang ai Zhao 9

The major current varieties used for the second cropping are:

Early-maturing indica hybrid varieties:

Wei You 35, Wei You 63, Shan You 64, Wei You 98, Wei You 16

Middle-maturing indica hybrid varieties:

Wei You 6, Shan You 6, Shan You 2, Shan You 63, Shan You 30 Xuan, Wei You 30, Shan You Guei 33

Late-maturing japonica varieties:

Long Fu 6, Ai Geng 23, Xiu Shui 48, E Wan 5

In recent years, the yield obtained by double cropping has increased when the hybrid rice varieties were used. In Hunan Province, the area of hybrid rice varieties used for the second cropping accounted for 58.1% of the total area of the second cropping in 1984. HUANG Zhi Chong (1982) reported that the mean yield of the hybrid rice variety Wei You 35 used for the first cropping was 7.65 t/ha which was respectively 12.5% and 15.1% higher than that of conventional varieties (Guang Lu Ai 4 and Xiang Ai Zhao 9) based on the data from the first cropping rice regional yield nurseries in 18 sites in Hunan Province.

The Sichuan Academy of Agricultural Sciences Rice Research Institute (1976-1982) reported that the mean yield of the hybrid rice variety Shan You 2 used for the second cropping was 19.2% higher than that of the conventional variety Lu Wang 4 in an average of 7 years

(Hunan Chen Zhou District Agricultural Bureau, 1982).

The results of the variety combination test showed that the highest yield of 14.67 t/ha was achieved when the hybrid varieties were used for the first and second croppings of rice (Table 1).

Table 1 Variety combination for rice double cropping

Variety combination		Seeding date		Transplanting date		Heading date		Yield (t/ha)		
first cropping	second cropping	first cropping	second cropping	first cropping	second cropping	first cropping	second cropping	first cropping	second cropping	(t/ha)
Wei you 35+Shan you 2		3/10	6/ 5	3/27-30	7/14-19	6/16-23	9/11-11	9.09	5.58	14.67
Wei you 98+Wei you 98		3/10	6/28	3/27-4/1	7/13-14	6/13-20	9/3- 6	8.64	4.67	13.31
Wei you 35+Wei you 35		3/10	6/28	3/27-30	7/14-19	6/16-23	9/4- 5	9.09	4.06	13.15
Wei you 35+Wei you 6		3/10	6/28	3/27-30	7/14-19	6/16-23	9/1- 6	9.09	5.25	14.34
Lo Lanzhaol+Shan you 2		3/10	6/ 5	3/27-30	7/9 -12	6/15-18	9/1- 6	7.86	6.07	13.93

Average of 5 trials (Sichuan Academy of Agricultural Sciences Rice Research Institute, 1984).

2 Determination of proper seeding date and use of plastic film to raise seedlings to avoid low temperature injury in the first cropping

In order to avoid low temperature injury in the seedlings of the first cropping, it is essential to determine the proper seeding date. In the field, the critical low temperature injuring rice seedlings was usually 12°C for the indica varieties. According to this criterion, the proper seeding time ranged from the last ten days of March to the second ten days of April in the double cropping zone of Central China and from the last ten days of February to the second ten days of March in the South China double cropping zone. Within this duration seeding at an early time enabled to achieve high yield. To ensure that sowing takes place at a proper time and to avoid low temperature injury in rice seedlings, raising seedlings by covering them with a plastic film was recommended. For the application of this method, rice heading date was 4-5 days earlier, the survival rate of the seedlings was 30-35% higher, the dry matter weight of 100 seedlings was 86.4-90.9% higher as compared with the raising seedlings in open field (YONG Dejing, 1984) (Table 2).

Table 2 Effect of covering seedlings with a plastic film on the survival rate of seedlings and heading date

	Days of covering	Mean daily temperature (°C)	Survival rate (%)	Dry matter weight (g/100 seedlings)	Days from seeding to heading
Covered with plastic film	10	24.70	80.6	4.1	86
Covered with plastic film with 0.5 cm hole	10	23.80	85.8	4.2	87
Open field	0	18.83	50.3	2.2	91

Hole distance 5 × 5 cm; hole: 0.5 cm in diameter.
Source: YONG Dejing, 1984.

3 Sowing before the critical seeding date for avoiding low temperature inducing sterility in the second crop of rice

To avoid low temperature inducing sterility, it is essential that rice come to heading before the critical heading date by means of sowing at the proper time for the second crop of rice.

The critical low temperature was 20°C for 5 days on the average for the japonica varieties or 22°C for the indica ones. According to this criterion, the critical heading date ranged from the first ten days of October to the end of October for the japonica varieties or from the last ten days of September to the second ten days of October for the indica varieties in the South China double cropping zone. In the central China double cropping zone, the critical heading date extended from the second ten days of September to the first ten days of October for the japonica varieties or from the beginning of September to the last ten days of September for the indica ones.

4 Raising seedlings with "double transplanting" for the second crop transplanted at a late time

Late transplanting resulted in old age of the seedlings which was a constraint for achieving high yields in the second cropping of rice. The area with late-transplanted rice accounted for 10-20% of the total area of the second cropping of rice in various years. To deal with this problem, raising seedlings with "double transplanting" was adopted. To apply the "double transplanting" method, the seedlings were divided into two groups. In the first group, raising of seedlings with a heavy seeding rate (10 kg/m^2) was performed in a greenhouse for 7 days. In the second group, young seedlings were temporarily transplanted in a seed bed (5 × 6 cm density) for 40-50 days. In order to save labor, transplanting was carried out with pieces of seedlings or by throwing some of the seedlings. FEI Huai Lin (1981) reported that the yield obtained by the method of double transplanting was 32.4%-226.2% higher than that of the conventional method when transplanting took place at a late time. This effect on yield increased regularly following the delay in the transplanting date (Table 3) FEI Huai Lin, 1981).

Table 3 Effect of double transplanting on yield

Method of raising seedlings	Transplanting date (month/day)				
	7/23	7/28	8/2	8/7	8/12
1 Double transplanting (t/ha)	7.25	7.06	6.45	3.67	4.04
2 Conventional (t/ha)	5.47	5.20	3.88	2.11	1.24
1 to 2 (+-%)	32.40	35.60	66.30	74.30	226.60

Variety: Shan you 6, seeding date: 6/10 (FEI Huai Lin, 1981).

5 Light seeding and dense transplanting with small hills

Formerly, the yield obtained by double cropping of rice only depended on the number of panicles per unit area. In recent years, the cultivation techniques for double cropping of rice have been improved. The yield depends on the number of filled grains per unit area due to varietal improvement, especially by adopting hybrid varieties and increasing the application of fertilizers.

Light seeding and dense transplanting with small hills were the main measures to increase both the number of filled grains per panicle and panicles per unit area.

JIANG Pengyan (1984) reported that the number of total filled grains per unit area increased by light seeding and dense tranplanting with small hills. By the use of this method of cultivation, the yield became 7.9–16.9% higher than by the use of conventional techniques (Table 4).

Table 4 Effect of light seeding and dense transplanting with small hills on yield

Year	Treatment	Number of basal plants (plants/m²)	Number of effective panicles (panicles/m²)	Number of filled grains (per panicle)	Weight of 1000 grains (g)	Yield (t/ha)	Yield (%)
1979	1	119.9	545.7	62.8	24.8	8.23	107.9
	2	488.7	605.6	49.7	24.6	7.63	100
1980	1	119.9	467.7	65.3	24.8	7.56	116.5
	2	479.7	575.7	54.0	23.8	6.49	100
1981	1	125.9	544.2	61.1	25.2	8.33	110.9
	2	481.2	632.6	48.3	25.1	7.62	100
1982	1	152.9	547.2	51.5	24.6	7.70	114.3
	2	457.2	668.6	36.6	23.9	6.74	100
1983	1	191.1	493.2	56.1	24.5	6.69	116.9
	2	467.7	592.2	41.8	23.4	5.72	100

1: Light seeding and dense transplanting with small hills
2: check

6 Zero tillage after the first cropping of rice for transplanting of the second cropping at an appropriate time

To ensure that transplanting takes place at a proper time, zero tillage or low tillage was recommended for the second cropping of rice.

The Sichuan Academy of Agricultural Sciences Rice Research Institute (1981) reported that zero tillage after harvesting of the first crop of rice was favorable to the transplanting at a proper time of the second crop. The yield of the zero tillage crop was higher than that of conventional tillage due to the possibility of transplanting rice at an appropriate time by means of zero tillage. The yield of the zero tillage crop was equal to that of conventional tillage when rice was transplanted at the same time (Table 5) (FANG Wen, 1985).

Table 5 Effect of zero tillage on yield of the second crop of rice

Transplanting (day/month)	Treatment	Yield (t/ha)	Zero tillage to tillage-transplanting at the same time (+-%)	Zero tillage transplanting on 22/7 to tillage-transplanting on 29/7 (+-%)	Zero tillage transplanting on 29/7 to tillage-transplanting on 5/8 (+-%)
22/7	Zero tillage	5.00	101.8	107.0	
	check	4.91	100		
29/7	Zero tillage	6.59	100 .3		146.4
	check	4.67	100	100	
5/8	Zero tillage	3.22	100 .5		
	check	3.20	100		100

Source: Sichuan Academy of Agricultural Sciences Rice Research Institute, 1981.

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Discussion

Khush, G.S. (IRRI): Would you please tell me what is the percentage of the rice area in the Sichuan Province which is double-cropped with rice?

Answer: About 35% of the total area was double-cropped with rice in the southern part of Sichuan Province in the 1970s. Presently the percentage of the area with double cropping has been reduced to 5% due to the adjustment of the cropping systems. In the whole Sichuan Province the percentage of the area with double cropping which used to be 18% in the 1970s presently amounts to 2%.

Perez, A.T. (ADB): What is the consumer acceptability of the japonica rice varieties in China which were used for the second cropping due to their tolerance to low temperatures?

Answer: Generally the Chinese do not like the taste of japonica rice. Therefore presently indica hybrid varieties are being planted by adjusting the seeding time and adopting the double transplanting method.

Kaneda, C. (Japan): When zero tillage culture of the second crop is practiced, I understand that the farmers keep the fields always irrigated. Even so, the transplanting must be very hard due to the tight root system of the previous crop. Is there any method to improve the situation?

Answer: Zero tillage culture of the second crop is practiced immediately after harvesting of the first crop of rice. The fields remain irrigated and the transplanting of the second crop is difficult.

Soetjipto Partohardjono (Indonesia): To transplant seedlings in untilled soil in the second cropping, farmers in Indonesia use a wooden stick to make a hole to facilitate seedling establishment in the paddy fields. Fields are not flooded but saturated with water. Straws and mulch remain on the fields. This method helps to save water.

Tan Zhonghe (People's Republic of China): In the Sichuan Province the farmers always keep the fields with a water layer and do not use tools to transplant seedlings.