

## Studies on photoperiod sensitivity and suitable sowing and transplanting dates for super rice Xieyou 9308 as a double-cropping late rice

BAI Pu<sup>1</sup>, PANG Bingrong<sup>1</sup>

(Wenzhou Vocational College of Science and Technology, wenzhou, china, 325006)  
bp588@hotmail.com

**Abstract**—This paper had studied on photoperiod sensitivity and suitable sowing and transplanting dates for super rice Xieyou 9308 as a double-cropping late rice. For experiment of sowing date, 5 treatments were set up respectively sowing on June 10, June 15, June 20, June 25, June 30 for Xieyou 9308 and for experiment of transplanting date, 5 other treatments were set up respectively transplanting on July 15, July 20, July 25, July 30, August 4 transplanted for Xieyou 9308 with all treatments sown on June 20, with Shanyou 10 as the control. The experiment was conducted under the natural field environment in Wenzhou. The result showed that photoperiod sensitivity of Xieyou 9308 was stronger than that of Shanyou 10. Sowing from June 10 to June 30, the full heading stage advanced by 1 day for super rice 9308 and Shanyou 10 by 2 days with advanced sowing every 5 days. The optimum sowing date for Xieyou 9308 was fixed on June 25 according to conditions of light and temperature in Wenzhou. Too early sowing can not significantly advanced the full heading stage, but the yield of rice cut down because of the extension of seedling age and lower quality of seedling, and too late sowing will effect on the full heading of rice because of low temperature after late September. Sowing simultaneously on June 20 and transplanting from July 15 to August 4, the full heading stages advanced about 1 day with advanced transplanting every 5 days for Xieyou 9308 and Shanyou 10, and the yields of earlier transplanting treatments were significantly higher than that of later transplanting treatments. Due to its strong photoperiod sensitivity and longer growth period, Xieyou 9308 should be transplanted as early as possible when it is planted as a double-cropping late rice.

**Keywords**- Super rice Xieyou 9308 Photoperiod sensitive Sowing date Transplanting date

China was the largest producer of rice in the world and had successfully formed a complete set of three-line in hybrid rice. The yields of hybrid rice were 15%-20% more than conventional rice yield, which make a significant contribution to self-sufficiency for food in China<sup>[1][2][3][4]</sup>. In recent years, it had been succeeded in breeding new combinations of super hybrid rice, such as Xieyou 9308, Zhongzheyu 1, and Yongyou 6, by integrating ideal plant-type and utilizing stronger heterosis, which had better performance in production with high yield potential, good grain quality, disease resistance, etc.<sup>[5]</sup>, however because the characteristics of new varieties did not been known enough, it also led to the instability of their yields<sup>[6][7]</sup>. Photoperiod sensitivity was an important characteristic of rice, which is not only an basis for classification of rice

varieties, but also for suitable planting areas and sowing date<sup>[8]</sup>. This study attempted to analyze its photoperiod sensitivity, according to changes of heading stages for Xieyou 9308 after sowing in different dates under field natural environment and it was also determined to its suitable sowing and transplanting dates for super rice 9308 as a double-cropping late rice under light and temperature conditions in Wenzhou.

### I. MATERIALS AND METHODS

#### A. Experimental Design

##### 1) Experiment of sowing date

5 treatments were set up respectively sowing on June 10, June 15, June 20, June 25, June 30 for Xieyou 9308 and with Shanyou 10 as the control. Area of plot was 12.67m<sup>2</sup> and repeated 3 times. 112.5 kg seeds per ha were sown and the density of transplanting were 16.7cm × 23.3cm and all treatments were transplanted on July 30. The experiment was arranged as a completely randomized block design with 3 replications

##### 2) Experiment of transplanting date

5 treatments were set up respectively transplanting on July 15, July 20, July 25, July 30, August 4 transplanted for Xieyou 9308 and with Shanyou 10 as the control, with all treatments sown on June 20. Others of the experiment were same to experiment of sowing date.

#### B. Process of experiment

The experiment was conducted in farm of Academy of Agricultural Sciences in Wenzhou Municipality, with the former crop Zhongsi 2. The 177.5kg/ha pure nitrogen were applied with basic fertilizer, tillering fertilizer and spikelet developing fertilizer by 70%, 20%, 10% application. The 225 kg/ha superphosphate and KCl 75kg/ha were applied as basic fertilizer, The 75kg/ha KCl were applied as spikelet developing fertilizer. The water management, pest control were conducted by the local high-yielding cultivation measures. The temperature and light conditions were normal and there were no typhoon, drought, cold and other adverse climate during the experiment.

### II. Results and Analysis

#### A. Yield and Economic Traits

##### 1) Yield and economic traits for different sowing dates

Sowing on same date, the yield of Xieyou 9308 was higher than that of Shanyou 10, except that the yields of two varieties were close sowing on June 30. Seed-Setting rate of Xieyou9308 was higher than that of Shanyou 10, but 1000-grain weight was lower than that of Shanyou 10. Sowing date just a little effected on 1000-grain weight, 1000-grain for Xieyou 9308 weight ranging from 26.0-26.4g and Shanyou 10 1000-grain weight ranging from 27.8 to 28.4g,although the 20 day difference in sowing date. The highest seeding of sowing before June 20 was lower, because of its long seedling age with poor seedlings.The effective panicle number was most for Xieyou 9308 sowing on June 25 and the effective panicles was most for Shanyou 10 sowing on June 30.The treatments of sowing on the same day, the highest seedling for Xieyou 9308 and effective panicle number was lower than that for Shanyou 10, but the ear forming rate was higher than that of the latter. The coefficient of variation for each trait of Xieyou 9308 was secondary branch (33.8% to 47.1%)> total grains (23.6% to 35.4%)> height (9.3% to 15.0%)> the number of primary branches (7.6% to 13.4 %).The coefficient of variation for each trait Shanyou 10 was the number of secondary branches (33.7% to 37.2%)> total grains (23.6% to 33.7%)> height (9.5% to 12.4%)> the number of primary branches (7.4% to 12.8%)(Table 1).

2) *The yield and economic traits for different transplanting date*

Transplanting on different date,the yield of Xieyou9308 was significantly higher than that of Shanyou 10. The yields of 3 treatments respectively transplanting on July 15, July 20, July 25 were significantly higher than that of other two treatments for Xieyou 9308, while extremely significantly higher than those of Shanyou 10,however the yield transplanting on August 4 Xieyou9308 was significantly lower than that of the early transplanting treatment. Early transplanting had more highest seedling number and effective panicle number because of long growth stage after transplanting. Since seedling age was too long and growing duration after transplanting shortened, the plant height for two varieties, seed setting rate and grain weight were significantly decline for treatments transplanting on August 4.Because Xieyou 9308 had stronger photosensitivity and longer growth period, the earlier transplanting was a key measure for obtaining high yield in double late rice cropping, so for early rice,it was appropriate to planting early or mid-maturing varieties , and it was necessary to practice earlier harvest,earlier ploughing and transplanting Xieyou9308 as early as possible.Coefficient of variation for each trait was similar to experiment of sowing date, which was the number of secondary branches (31.8% to 48.0%)>

total grains (27.8% to 34.0%)> height (10.0% to 20.8% )> Number of primary branches (8.5% to 10.0%) for Xieyou 9308 and which was the number of secondary branches (30.3% to 54.5%)> total grains (22.8% to 33.6%)> height (10.1% to 18.0%) > Number of primary branches (8.5 to 15.4%) for Shanyou 10 (Table 2).

B. *Quality of seedlings*

1) *Quality of seedlings after sowing on differencnt dates*

Quality of seedlings after sowing on differencnt dates were measured on July 30,when the seedlings were transplanted. The result showed that the leaf age of Xieyou 9308 changed from 6.9 to 11.1, and that of Shanyou 10 changed from 7.1 to 11.4,the height of Xieyou9308 was from 60.2 to 71.5cm,and that of Shanyou 10 was from 49.1 to 66.5cm, the dry weight per 100-seedling of Xieyou 9308 was from 144.6 to 171.5g,and Shanyou from 10 was 137.5 to 162.8g.So the former had shown the growth advantages in nursery seedling period. Tillers per plant of Xieyou 9308 was form 3.6 to 4.4,and that of shanyou 10 was from 3.9 to 4.2, just a little difference between the two varieties and among different treatment,although the difference 20 day at seedling age, because seedlings shading each other inhibited the further occurrence of the tiller in early sowing treatments(Table 3).

2) *Quality of seedlings after transplanting on differencnt dates*

Sowing at June 20 and transplanting on different dates,the change of seedling quality was consistent with the sowing experiment.The tillers per plant between two varieties was similar, however the other treats of Xieyou9308 were better than that of Shanyou 10(Table 4). The advance of heading stage for Xieyou9308, which was sown too early,was not obvious, but seedling quality was poor because of its extension of seedling age in nursery stage.

C. *Photoperiod sensitivity and growth periods*

1) *Photoperiod sensitivity and growth periods after sowing on different dates*

The growth period for early sowing extended with early sowing every 5 day,full heading stage earlier about 1day for Xieyou 9308; early sowing every 5d, full heading stage earlier about 2d for Shanyou 10(Table 5). Rice was a short-day crop and it was shorten to the duration from sowing to heading under short-days,which was more apparent for variety of stronger photoperiod sensitive<sup>[9]</sup>

TABLE 1 POPULATION STRUCTURE AND ECONOMIC CHARACTERS OF HYBRID RICE PLANTS AFTER SOWING ON DIFFERENCE DATES

Transplanting date	Hybrid combination	Plant height (cm)	Effective panicle number (× 10 <sup>4</sup> /ha)	Grain number per panicle	Filled grains per panicle	Seeding-setting rate (%)	1000-grain weight	Yield (kg/ha)

10 June	Xieyou 9308	97.0	282.0	148.8	128.6	86.4	26.3	8500.5Aa
	Shanyou 10	84.4	292.5	114.8	98.8	86.1	27.4	7473.0Cbc
15 June	Xieyou 9308	96.7	291.0	151.4	129.3	85.4	26.1	8473.5ABa
	Shanyou 10	87.6	310.5	119.8	104.1	86.9	28.3	7473.0Cbc
20 June	Xieyou 9308	97.2	279.0	161.8	138.5	85.6	26.0	8368.5ABa
	Shanyou 10	90.1	304.5	122.5	107.1	87.4	28.1	7420.5Cbc
25 June	Xieyou 9308	90.9	282.0	156.0	133.2	85.4	26.1	7737.0BCb
	Shanyou 10	84.6	291.0	115.7	97.2	84.0	28.1	7237.5Cbc
30 June	Xieyou 9308	82.0	273.0	153.2	121.2	79.1	25.8	7131.0CDc
	Shanyou 10	76.0	283.5	117.3	95.7	81.6	27.8	6421.5Dd

TABLE 2 POPULATION STRUCTURE AND ECONOMIC CHARACTERS OF HYBRID RICE PLANTS AFTER TRANSPLANTING ON DIFFERENCE DATES

Sowing date	Hybrid combination	Plant height (cm)	Effective panicle number ( $\times 10^4$ /ha)	Grain number per panicle	Filled grains per panicle	Seeding-setting rate (%)	1000-grain weight	Yield (kg/ha)
10 June	Xieyou 9308	89.9	270.0	143.4	128.0	89.3	26.1	7684.5
	Shanyou 10	87.3	306.0	115.3	100.0	86.7	28.3	7263.0
15 June	Xieyou 9308	90.9	271.5	147.5	131.0	88.8	26.0	7552.5
	Shanyou 10	86.9	295.5	120.3	103.6	86.1	28.2	7263.0
20 June	Xieyou 9308	90.0	274.5	152.5	135.4	88.8	26.1	7527.0
	Shanyou 10	88.7	298.5	117.9	98.8	83.8	28.2	7183.5
25 June	Xieyou 9308	91.7	283.5	146.0	129.4	88.6	26.4	7737.0
	Shanyou 10	90.4	316.5	110.7	96.4	87.1	28.4	7342.5
30 June	Xieyou 9308	94.4	279.0	147.0	123.2	83.8	26.2	7527.0
	Shanyou 10	91.8	319.5	120.7	99.1	82.1	27.8	7395.0

TABLE 3 QUANTITY OF HYBRID RICE SEEDLINGS AFTER SOWING ON DIFFERENCE DATES							
Sowing date	Hybrid combination	Leaf age	Leaves per plant	Seedling height (cm)	Tillers per plant	Width of stem base (mm)	Weight of hundred plants (g)
10 June	Xieyou 9308	11.1	21.9	71.5	4.4	9.5	171.5
	Shanyou 10	11.4	20.6	66.5	4.2	9.3	162.8
15 June	Xieyou 9308	10.0	21.0	68.3	4.2	9.4	166.7
	Shanyou 10	10.3	21.8	60.8	4.3	9.3	157.5
20 June	Xieyou 9308	9.1	20.1	64.2	3.9	9.4	158.6
	Shanyou 10	9.3	19.8	57.4	4.0	9.1	149.1
25 June	Xieyou 9308	8.0	19.9	62.9	4.1	9.3	150.0
	Shanyou 10	8.2	18.8	56.7	4.0	9.1	132.7
30 June	Xieyou 9308	6.9	13.7	60.2	3.6	9.1	144.6
	Shanyou 10	7.1	15.3	49.1	3.9	8.9	137.5

TABLE 4 QUANTITY OF HYBRID RICE SEEDLINGS AFTER TRANSPLANTING ON DIFFERENCE DATES							
Transplanting date	Hybrid combination	Leaf age	Leaves per plant	Seedling height (cm)	Tillers per plant	Width of stem base (mm)	Weight of hundred plants (g)
15 July	Xieyou 9308	5.6	12.8	48.8	3.1	8.5	118.3
	Shanyou 10	5.8	13.0	41.1	3.3	8.5	110.1
20 July	Xieyou 9308	6.9	13.0	58.1	3.2	9.0	140.2
	Shanyou 10	7.0	14.8	51.1	3.3	8.8	135.2
25 July	Xieyou 9308	8.0	19.0	60.1	3.7	9.1	150.2
	Shanyou 10	8.1	18.1	55.3	3.8	8.9	140.1
30 July	Xieyou 9308	9.1	20.1	64.2	3.9	9.4	158.6
	Shanyou 10	9.2	19.8	57.4	4.0	9.1	149.1
4 August	Xieyou 9308	10.0	20.2	68.5	4.0	9.5	162.5
	Shanyou 10	10.2	19.9	62.1	4.2	9.2	154.3

TABLE 5 GROWTH STAGES OF HYBRID RICE PLANTS AFTER SOWING ON DIFFERENCE DATES

Hybrid combination	Sowing date (day/month)	Leaf age at transplanting	Total Leaves of main stem	Initial heading stage (day/month)	Full heading stage (day/month)	Maturing stage (day/month)	Growth duration from sowing to harvest (days)
Xieyou 9308	10/6	11.1	17.3	9/9	15/9	1/11	144
	15/6	10.0	16.5	10/9	16/9	2/11	140
	20/6	9.1	15.7	12/9	18/9	3/11	136
	25/6	8.0	15.2	13/9	19/9	5/11	133
	30/6	6.9	14.5	14/9	21/9	8/11	132
Shanyou 10	10/6	11.4	16.6	2/9	8/9	25/10	137
	15/6	10.3	15.7	4/9	11/9	27/10	134
	20/6	9.3	15.3	7/9	13/9	28/10	130
	25/6	8.2	14.7	9/9	15/9	30/10	127
	30/6	7.1	14.3	11/9	17/9	1/11	125

The experiment was conducted in Wenzhou, located in subtropical region of the northern hemisphere, where Summer solstice in lunar calendar (about on June 23) was the day with the longest sunshine duration, then sunshine duration of every day was gradually shortened<sup>[10][11]</sup>. According to this experiment, effect of shortening the duration from sowing to heading for Xieyou 9308 under short-day was more obvious than that of Shanyou 10, so photoperiod sensitivity of Xieyou 9308 was stronger than that of Shanyou 10. It had reported that Shanyou 10 was a variety of strong photoperiod sensitivity, so the photoperiod sensitivity for Xieyou 9308 is very strong.

Though all treatments in the experiment could be safely heading, but treatment sown on June 30 for Xieyou 9308 was full heading on September 21, which did not benefit for its flower and pollination because of low temperature after late September. Therefore, it was decided that the suitable sowing date for Xieyou 9308 in Wenzhou was on June 25 or so.

#### 2) growth periods after transplanting on different dates

The result of transplanting experiment showed that growth periods for both Xieyou 9308 and Shanyou 10 were advanced when they were early transplanted, with growth period advancing about 1d while early transplanting 5d. But growth period for treatment on August 4 transplanting was significantly delayed, with longer 3d for Xieyou 9308 and 2d for Shanyou 10 (Table 6).

### III. Discussion

According to this experiment, the photoperiod sensitive of Xieyou 9308 was stronger than that of Shanyou 10, therefore

early sowing did evidently not advance full heading stage. Too early sowing also resulted in prolonged nursery stages, seedling quality worse, which caused tillering and reduced yield, too late sowing delayed full heading stage so that flowering, pollination was influenced by low temperature after late September. So reasonable sowing date in Wenzhou can be fixed on June 25, with a difference of 1 to 2d.

While it was sown at same time, early transplanting advanced growth period of rice, furthermore duration in seedling field was shortened evidently and the vegetative period was extended after transplanting, which was benefit for the early development, nurturing big spike and obtaining high yield. So it should be a reasonable match with variety of the early rice with shorter growth duration from sowing to harvest, rushing in the harvest rotation, transplanting as early as possible. Because of its longer growth period and longer nursery stage, Xieyou 9308 should be thinly sown and soaking seed with uniconazole to inhibit height of seedling to promote tillering and nurture strong seedling for high yield production.

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TABLE 6 GROWTH STAGES OF HYBRID RICE PLANTS AFTER TRANSPLANTING ON DIFFERENCE DATES

Hybrid combination	Transplanting date (day/month)	Leaf age at transplanting	Total Leaves of main stem	Initial heading stage (day/month)	Full heading stage (day/month)	Maturing stage (day/month)	Growth duration from sowing to harvest (days)
Xieyou 9308	15/7	5.6	15.0	10/9	15/9	1/11	133
	20/7	6.9	15.1	10/9	16/9	2/11	134
	25/7	8.0	15.3	11/9	17/9	3/11	135
	30/7	9.0	15.5	12/9	18/9	4/11	136
	4/8	10.1	15.6	14/9	21/9	7/11	139
Shanyou 10	15/7	5.8	14.4	5/9	11/9	27/10	129
	20/7	7.0	14.5	6/9	12/9	28/10	130
	25/7	8.1	14.6	7/9	13/9	28/10	130
	30/7	9.2	14.9	8/9	14/9	29/10	131
	4/8	10.2	15.1	9/9	17/9	1/11	133

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