

Research Article

Effects of Different Culture Conditions to Middle-season Rice “Feng-liang-you-xiang-1”

Zhi-hua Yuan, Yan-xia Zhang, Peng-fei Li, Wen-jing He,
Ming-zhu Jin, Huan Liu, Bin Du and Wen-jie Zhu
Agricultural College of Yangtze University, Jingzhou 434025, China

Abstract: To study the impact of different culture conditions to the growth and yield, an orthogonal experiment was conducted with four factors-sowing date, basic seedling, nitrogen rate and water depth and three levels (L_93^4) about Mid-season Hybrid Rice Feng-liang-you-xiang-1 for 3 years (2009-2011). The results showed that: (1) the effect of the climatic conditions in different years on the growth duration and yield of mid-season rice is very significant; (2) the effect of sowing date on the growth duration and yield of mid-season rice is very significant. As the sowing date is delayed, the growth duration is shortened. ($y = -0.2222x + 132.98$; $R = 0.9983^*$, y represents growth duration and x represents sowing date). When the sowing date was May 1, the yield was the highest; (3) the effect of nitrogen rate on the growth duration and yield of mid-season rice is also very significant. As the nitrogen rate increases, the growing duration and yield shows an increasing trend. The overall conclusion was that the yield was the highest when planting on May 1, with a basic seeding number of 480000/hm², a nitrogen rate of 135 kg + 120 kg + 105 kg/hm² and a water depth just casing the surface of field when transplanting.

Keywords: Medium rice, nitrogen rate, planting density, sowing date, water, yield

INTRODUCTION

Rice is an important crop for human and about 50% of population all over the world mainly feed on rice (Zhang, 2007). At the same time, middle-season rice is an important part of grain production in China. Rice yield and quality are not only controlled by genetic factors, but also largely influenced by environmental factors (Gao and Zang, 1994), such as light, temperature, soil type, soil water, cultivation measures, etc (Cheng and Zang, 2003; Hiroyuki *et al.*, 2002). A great number of studies show that sowing date, basic seedling number, nitrogen rate and water depth have great influence on rice yield (Wang *et al.*, 2003; Wang *et al.*, 1997). Feng-liang-you-xiang-1 is a kind of two-line hybrid middle-season rice with high yield and quality bred by HeFei Fengle seed co., Ltd. To provide a reference for the rice production of Jiangnan Plain, cultivation techniques which can produce high yield and be more able to exploit the yield potential was studied. For that reason and an experiment from 2009 to 2011 of sowing date, basic seedling number, and nitrogen rate and water depth about hybrid middle-season rice Feng-liang-you-xiang-1 was used to study the impact on the growth duration and yield.

MATERIALS AND METHODS

Experimental materials: The experimental material was Feng-liang-you-xiang1, which was provided by the HeFei Fengle Seed Co., Ltd.

Experimental methods: The test adopted orthogonal design with four factors and three levels (L_93^4). There were four factors: A, Sowing date; B, Basic seeding number; C, Nitrogen rate (the amount of P, K fertilizer is changeless and nitrogen was applied in the form of urea); D, Water depth (different in the basis of field irrigation). Each experimental factor was divided into three levels: A₁ (April 20), A₂ (May 1) and A₃ (May 11); B₁ (240000 holes/hm²), B₂ (480000 holes/hm²) and B₃ (720000 holes/hm²); C₁, 75, 60 and 45 kg/ha (supplied to promote tillering, panicle initiation and flowering and seed setting respectively), C₂, 105, 90, 75 kg/ha and C₃, 135, 120, 105 kg/ha; D₁ (covering soil), D₂ (water layer, 5 cm), D₃ (water layer, 10 cm). Water rice-nursery was used in this experiment. The rice seedling was transported to the field, three or two seedlings per hole, with a spacing of 26.7×16.7cm and a plot size of 12 m² (2×6 m) and 3 repetitions, when the rice seedling had grown 30 days in seedbed.

The experiment was conducted in 2009, 2010 and 2011 in Yangtze University, Jingzhou, Hubei, China. The local climate is a northern subtropical monsoon

Corresponding Author: Ming-zhu Jin, Agricultural College of Yangtze University, Jingzhou 434025, China, Tel.: +86-716-8060558; Fax: +86-716-8060558

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Table 1: Growth process of different treatments (2009-2011)

Treatment	Combination	Sowing date (mm.dd)	Heading (mm.dd)			Maturity (mm.dd)			Growth duration (day)			
			2009 (year)	2010 (year)	2011 (year)	2009 (year)	2010 (year)	2011 (year)	2009 (year)	2010 (year)	2011 (year)	Mean (day)
1	A ₁ B ₁ C ₁ D ₁	4.20	7.22	7.25	7.23	8.25	8.29	8.27	128	132	130	130
2	A ₁ B ₂ C ₂ D ₂	4.20	7.24	7.26	7.24	8.26	8.30	8.27	129	133	130	131
3	A ₁ B ₃ C ₃ D ₃	4.20	7.25	7.27	7.24	4.60	9.10	8.28	130	134	131	132
4	A ₂ B ₁ C ₂ D ₃	5.10	8.10	8.70	8.60	9.30	9.90	9.60	126	132	129	129
5	A ₂ B ₂ C ₃ D ₁	5.10	7.31	8.10	8.50	9.20	9.10	9.40	125	133	127	128
6	A ₂ B ₃ C ₁ D ₂	5.10	7.29	8.60	8.40	9.20	9.80	9.40	125	131	127	128
7	A ₃ B ₁ C ₃ D ₂	5.11	8.10	8.20	8.16	9.12	9.17	9.15	125	130	128	128
8	A ₃ B ₂ C ₁ D ₃	5.11	8.80	8.21	8.14	9.10	9.15	9.13	123	128	126	126
9	A ₃ B ₃ C ₂ D ₁	5.11	8.90	8.23	8.15	9.10	9.14	9.14	123	127	127	126

The last lane of the table is the mean growth duration of the 3 years

humid climate. The total annual radiation is from 4366.8 to 4576.2 trillion joules/m². The annual sunshine hours is from 1823 to 1978 h. The sunshine rate is from 41 to 44%. The annual temperature on the average is from 16.2-16.6°C. The frost-free season is from 250 to 267 days and the annual precipitation is from 1100-1300 mm or so. The altitude of the experimental site is 34 m and the soil fertility is on upper-middle level. Previous crop (green manure) was turn over as fertilizer. And compound fertilizer (N:P:K = 16:16:16) 750 kg/hm² was applied as basal fertilizer When the field was raked.

RESULTS AND DISCUSSION

Growth process: Growth processes of different treatments were listed in Table 1. It showed that different combinations of cultivation factors in different years had some influence on growth duration of middle-season rice. The number of days of growth duration reduced with the delay of sowing date. In the nine treatments, the growth processes were also different from each other significantly. The average growth duration in the 3 years ranged from 131.7 day (treatment 3) to 125.7 day (treatment 8 and 9), differing by 6 day.

Further analysis shows a significant negative correlation between sowing date and growth duration (Fig. 1):

$$y = -0.2222x + 132.98, R = 0.9983^*$$

Growth duration reduces with the delay of sowing date. As the sowing date is postponed for every 10 day, the growth duration is shortened by 2.2 day. This is mainly caused by the difference of temperature and sunshine hours in different sowing dates.

There is also a significant positive correlation between nitrogen rate and growth duration (Fig. 2):

$$y = 0.0079x + 126.36, R = 0.9993^*$$

With the increase of nitrogen rate, the growth duration is delayed. The growth duration is extended by 1 day, with the increase of nitrogen rate for every 90 kg/hm². Nitrogen fertilizer can delay leaf senescence to extend the growing duration.

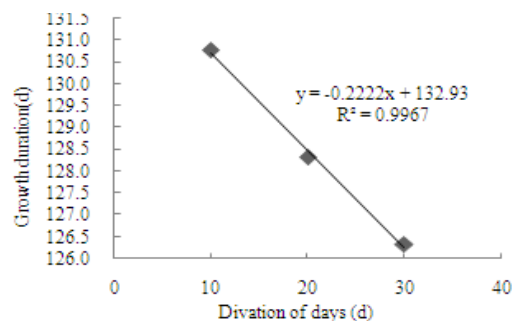


Fig. 1: Relationship between sowing date and growth duration

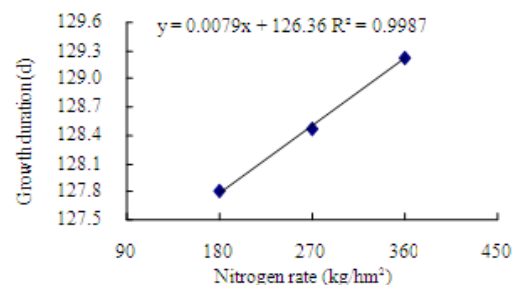


Fig. 2: Relationship between nitrogen rate and growth duration

Analysis of variance showed that the climatic condition of different years has a significant impact on the growth duration of middle-season rice ($F = 63.64 > F_{0.01} = 6.23$); Sowing date has a significant effect on the growth duration of middle-season rice ($F = 48.16 > F_{0.01} = 6.23$). The impact of nitrogen rate on the growth duration of middle-season rice is significant ($F = 5.08 > F_{0.05} = 3.63$). But water depth and basic seedling number have no significant effect on the growth duration of middle-season rice. It suggests that sowing date and nitrogen rate effect growth duration more than water depth and basic seedling number do.

Yield components: The major yield components of different treatments were listed in Table 2. It showed that there were big differences in the major yield components of different treatments. The average panicles of the 3 years of different treatments ranged from 2.6895×10^6 panicles/hm² to 3.1075×10^6 panicles/hm², with a mean of 2.9257×10^6 panicles/hm².

Table 2: Yield components of different treatments (2009-2011)

Treatment	Panicles (10000/hm ²)	Grains/panicle	Seed setting rate (%)	1000 grain weight (g)	Yield (kg/hm ²)
1	268.95	191.4	82.28	26.19	7991.40
2	288.25	194.3	82.00	25.68	8882.25
3	293.00	192.9	80.43	26.34	9057.65
4	304.95	203.6	85.54	26.31	9384.15
5	310.45	201.3	87.71	25.79	9635.65
6	310.75	207.8	78.18	25.65	8590.65
7	281.50	198.0	81.77	25.79	8926.15
8	278.55	194.2	78.31	25.95	8085.70
9	296.75	198.4	75.82	25.87	8900.95

Table 3: Average yield of different treatments

Treatment	Average yield (kg/hm ²)	Significant difference	
		0.05	0.01
5	9635.65	a	A
4	9384.15	b	B
3	9057.65	c	C
7	8926.15	cd	C
9	8900.95	d	C
2	8882.25	d	C
6	8590.65	e	D
8	8085.70	f	E
1	7991.40	f	E

The number of effective panicles increased with the increase of basic seedling number and it was the maximum of treatment 6 and the minimum of treatment 1. The grains panicle was 191.4-207.8 grains/panicle, with an average of 198.0 grains/panicle. At the same density, the grains panicle was better when the sowing date was May 1 instead of April 20 and may 11. The seed setting rate ranged from 75.82 to 87.71 %, with an average of 81.34%. The 1000 grain weight ranged from 25.68 to 26.34 g, with an average of 25.95 g. And the yield ranged from 7991.4 to 9635.65 kg/hm², with an average of 8828.3 kg/hm².

A four-linear regression analysis of the mean yield, effective panicles and grains per panicle, seed setting rate and 1000 grain weight in the 3 years was made. The regression can be expressed as:

$$y = 3271.1317 + 37.6077x_1 - 45.7207x_2 + 58.2289x_3 - 43.5354x_4$$

where,

- y : Yearly average yield
- x₁ : Effective panicles
- x₂ : Grains panicle
- x₃ : Seed setting rate
- x₄ : 1000-grain weight

The effective panicles and seed setting rate show in positively correlation to yield, while grains/panicle and 1000 grain weight show in negative correlation to yield.

Further analysis on the mean yield of different treatments in different years was listed Table 3.

It showed that the yield ranged from 9635.65 kg/hm² (treatment 5) to 7991.4 kg/hm² (treatment 1), differing by 1644.25 kg/hm². The difference between the yield of treatment 5 and of other night treatments reached a significant level. It also showed that the difference between the yield of 2011 and both 2010 and

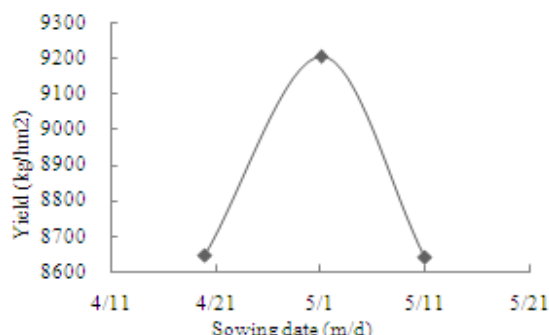


Fig. 3: Relationship between sowing date and yield

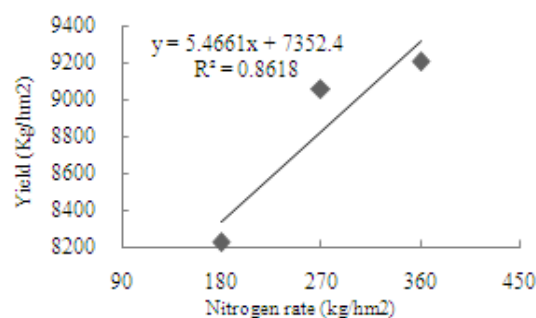


Fig. 4: Relationship between nitrogen rate and yield

2009 was very significant. The yield of 2011 was 917607 kg/hm², the yield of 2010 was 8698.2 kg/hm² and the yield of 2009 was 8609.85 kg/hm².

The correlation between sowing date and yield (Fig. 3) showed that the yield of A₂ was the highest and A₁ and A₃ are roughly in the same level. And it shows a positively correlation between nitrogen rate and yield (Fig. 4). Yield increases with the increase of nitrogen rate. Under the experimental conditions, the yield increases 82 kg/hm² as the nitrogen rate increases for every 15 kg/hm²:

$$y = 5.4661x + 7352.4, R = 0.9283$$

Variance analysis showed that the climatic conditions of different years has highly significant (F = 114.49 > F_{0.01} = 6.23) effects on the yield of middle-season rice, the effect of sowing date on the yield of middle-season rice is significant (F = 129.96 > F_{0.01} = 6.23), nitrogen rate effects the yield of middle-season

Table 4: Comparison of yield in different years

Season	Average yield (kg/hm ²)	Significant difference	
		0.05	0.01
2011	9176.70	a	A
2010	8698.20	b	B
2009	8609.85	b	b

Table 5: Range analysis of orthogonal test

Factor	Mean				
	Level 1	Level 2	Level 3	Range	Adjusted R'
Sowing date	8643.77	9203.48	8637.60	565.88	509.67
Basic seeding	8767.23	8867.87	8849.75	100.63	90.64
Nitrogen rates	8222.58	9055.78	9206.48	983.90	886.17
Water	8842.67	8799.68	8842.50	42.98	38.71

rice very significantly ($F = 345.64 > F_{0.01} = 6.23$) and water depth and basic seedling number have no significant impact on the yield of middle-season rice. This shows that sowing date and nitrogen rate are the main factors and have more significant effects on the yield of middle-season rice than water depth and basic seedling number under the experimental conditions.

The results of further analysis on the four factors were shown in Table 4. The ranges of sowing date, basic seedling number, nitrogen rate, water depth were respectively, 509.67, 90.64, 886.17 and 38.71 (Table 5). Since the impact of nitrogen rate reaches a very significant level, the nitrogen rate in the optimization is a preference factor and C₃ was the optimum, combining with range analysis. The effect of sowing date also reaches a very significant level and is regarded as the second considered factor. Combining with range analysis, A₂ was the optimum. Taking water depth, basic seedling number into consideration, combining with range analysis, it can be concluded that the best combination of the four factors is A₂B₂C₃D₁, which is unanimous with the combination of treatment 5's highest yield.

CONCLUSION

Conclusion can be made through the three consecutive year experiment in the same location:

- Climatic conditions in different years have significant effects on growth duration and yield of middle-season rice.
- The effect of sowing date on growth duration and yield is very significant. The rice growth duration

reduces with the delay of sowing date under these experimental conditions ($y = -0.2222x + 132.98$; $R = 0.9983^*$, y-growth duration; x-sowing date). The yield reached the highest when the sowing date was May 1.

- Nitrogen rate has a significant effect on growth duration and yield. The growth duration shows an increasing trend with the increase of nitrogen rate.
- The best combination of the test is A₂B₂C₃D₁, namely treatment 5.

The experiment was carried out under the condition of moderate fertility, its reaction under the condition of high and low fertility need to be discussed. The experiment factors and levels were less than normal, which was unfavorable to accurately determine the real law of rice growth. Meanwhile, the yield in different years reached a significant level in the 3-year experiment, the relationship between which and climate factors needs to be studied in future experiment.

REFERENCES

- Cheng, W.D. and G.P. Zhang, 2003. Variation in rice quality of different cultivars and grain position as affected by water management. *Field Crop Res.*, 80(3): 245-252.
- Gao, R.S. and S.P. Zhang, 1994. *Climatic and Ecological Base of Rice Quality*. Shaanxi Science and Technology Press, Xi'an (in Chinese).
- Hiroyuki, S., T. Hasegawa and K. Iwama, 2002. Response of growth and yield in paddy rice to cool water at different growth stages. *Field Crop Res.*, 73(23): 67-79.
- Wang, Y.L., L.Y. Liu, B.Y. Yao *et al.*, 1997. Impact of different growth stages, the level of nitrogen supply on root growth and vigor of hybrid rice. *Crop J.*, 23(6): 699-706.
- Wang, S.H., W.X. Cao, Y.F. Ding *et al.*, 2003. Impact of planting basic seeding and nitrogen fertilizer on absorption and utilization of rice nitrogen. *Nanjing Agric. Univ.*, 26(4): 1-4.
- Zhang, J.N., 2007. Discussion about the problems and strategies to the safe production of rice in China. *North Rice*, 4: 1-7.