Effects of Sowing Date and Sowing Rate on Yield of Rice Developed from Seedlings Dry-raised in Aperture Disk

Shurong XIN[1], Feixiang WANG[2], Wenfan BIAN[1], xinyang LI[3], Bin WU[3], Jili WAN[4], Yan SHI[5], Linlin XU[1], Hui MA[3], Feng CHEN[3], Bing GUO[1], Yunjian SUN[6], Zhuo XU[3]*

1. Institute of Agricultural Resources and Environment, Shandong Academy of Agricultural Sciences/Key Laboratory of Wastes Matrix Utilization, Ministry of Agriculture and Rural Affairs, Jinan 250100, China; 2. Feixian Agricultural Technology Extension Center, Feixian 273400, China; 3. Jinan Hehehe Ecological Technology Co., Ltd, Jinan 250100, China; 4. Qingdao Yuance Group Co., Ltd, Qingdao 2660715, China; 5. Qingdao Agricultural University, Qingdao 266109, China; 6. Hedong District Toyota Rice Planting Professional Cooperative Union, Linyi 276029, China

Abstract [**Objectives**] This study was conducted to find out the best sowing date and sowing rate of rice. [**Methods**] Based on the technique of dry seedling raising in aperture disk, the effects of sowing date and sowing rate on rice yield were studied. [**Results**] Sowing date and sowing rate per hole had obvious effects on tillering dynamics, growth process, number of panicles per unit area, number of filled grains per panicle and yield of rice developed from dry-raised seedlings. The comprehensive analysis showed that the highest yield was 10 285.5 kg/hm^2 with the sowing date of May 20 and sowing rate of 5 grains/hole. [**Conclusions**] This study provides theoretical support and data support for the popularization and application of rice developed from seedlings dry raised in aperture disk.

Key words Rice; Dry seedling raising; Sowing date; Seeding rate; Yield
DOI:10.19759/j.cnki.2164 – 4993.2024.06.003

Sowing date and seeding rate are two important factors affecting rice yield[1-2]. On the one hand, sowing date affects the number of effective tillers in rice, thus affecting the number of effective panicles and rice yield. On the other hand, delaying sowing date will delay maturity and affect yield stability of rice. Seeding rate will affect the growth space of seedlings and the nutritional area of individual plants, and affect the quality of seedlings. The quality of seedlings has obvious effects on seedling survival, tillering and panicles number after subsequent seedlings transplantation, and directly affects the rice yield[3-4]. Dry seedling raising in aperture disk is a new way to raise seedlings. Compared with blanket seedling, it has the advantages of less root injury, faster seedling survival and earlier rooting. In this study, the effects of sowing date and sowing rate on rice yield were studied based on dry seedling raising in aperture disk, in order to find out the best sowing date and sowing rate and provide theoretical support and data support for the popularization and application of dry seedling raising in aperture disk.

Materials and Methods

Experimental location and materials

The experiment was conducted in Hedong District, Linyi City, Shandong Province. The area belongs to Yishu River alluvial plain, having a temperate continental monsoon climate, with an average annual precipitation of 800 mm, an average annual temperature of 13 ℃, and the average frost-free period is 200 d. In the experiment, dry seeding raising in rice bowl was adopted, and the tested variety was Lindao 16. After seedling raising was completed, the seedlings were transplanted into the field for the experiment. The soil quality of the tested field was loam, and the basic fertility parameters were as follows: total nitrogen 1.96 g/kg, alkali-hydrolyzable nitrogen 101.23 mg/kg, available phosphorus 42.6 mg/kg and available potassium 100.4 mg/kg.

Experimental design

Two factors were tested in the experiment: sowing date and sowing rate. There were three sowing dates: May 10, May 20 and May 30. The sowing rate was set with four levels: 3 grains/hole, 4 grains/hole, 5 grains/hole and 6 grains/hole. The experiment adopted randomized block design, with a total of 12 treatments, each with 3 replicates, and each plot was 50 m^2 (5 m × 10 m) in area. Transplanting was carried out in a unified way on June 19, with a row and hill spacing of 30 cm × 12 cm and a density of 277 950 hills/hm^2.

Investigation item

The tillering number of basic seedlings was recorded on the day of transplanting on June 19, and then the tillering dynamics of each treatment were recorded at 10, 20, 30 and 40 d after transplanting. On October 9, 12 and 17, respectively, the number of panicles per hill and filled grains per panicle in each treatment were recorded, and the yield of each treatment was calculated.

Equivalent yield (kg/hm^2) = [Number of panicles (10^4/hm^2) × Number of filled grains per panicle (grains/panicle) × 1 000-grain weight (g) × 10 000 × 0.85]/1 000

Received: September 6, 2024 Accepted: November 9, 2024
Supported by Key R&D Program of Shandong Province (Action Plan for Rural Revitalization, Scientific and Technological Innovation and Boosting) (2023TZXD008); Key R&D Program of Shandong Province (Agricultural Improved Variety Project) (2024LZGCQY007); Innovation Ability Promotion Project of Shandong Province (2024TSGC0841; 2024TSGC0205).
Shurong XIN (1966 –), male, P. R. China, researcher, devoted to research about anti-adversity water saving and agricultural ecological environment.
* Corresponding author.

Data statistics and analysis

Microsoft Excel 2007 software was employed for data processing and analysis.

Results and Analysis

Effects of sowing date and sowing rate on growth period and tillering dynamics of rice developed from seedlings dry-raised in aperture disk

It can be seen from Table 1 that the growth process of various treatment groups with different sowing dates was delayed with the delay of sowing time. Seedlings in the plots sown on May 10 began to head on August 26 and matured on October 9. Seedlings in the plots with the sowing date of May 20 began to head on August 28, 2 d later than those with the sowing date on May 10, and the plants matured on October 12, 3 d later than that with those with the sowing date on May 10. Seedlings in the plots with the sowing date of May 30 began to head on September 1, 5 d later than those with the sowing date on May 10, and the plants matured on October 17, 8 d later than that with those with the sowing date on May 10. It can also be seen from Table 1 that the tillering process of seedlings with different sowing dates was consistent under the same sowing rate. However, under the same sowing date, the number of tillers in each treatment increased with the increase of sowing rate. With the passage of time after transplanting, it increased first and then decreased, and reached a maximum at 30 d after transplanting. Under the same sowing rate, the tiller number of the treatment with the sowing date of May 20 was the most, followed by May 10, with which the tiller number took the second place, and the treatment with the sowing date of May 30 showed fewest tillers.

Table 1 Growth period and tillering dynamics of rice with different sowing dates and sowing rates

Sowing date (month/day)	Sowing rate grains/hole	Transplanting date (month/day)	Heading date (month/day)	Maturation date (month/day)	Tillering dynamics (tillers/5 hill)					
					Basic seedling	10 d after transplanting	20 d after transplanting	30 d after transplanting	40 d after transplanting	Heading stage
5/10	3	Jun. 19	Aug. 26	Oct. 9	15	21	60	84	80	59
	4	Jun. 19	Aug. 26	Oct. 9	20	34	67	91	82	65
	5	Jun. 19	Aug. 26	Oct. 9	25	37	72	101	91	68
	6	Jun. 19	Aug. 26	Oct. 9	30	48	81	110	98	71
5/20	3	Jun. 19	Aug. 28	Oct. 12	15	25	58	87	77	61
	4	Jun. 19	Aug. 28	Oct. 12	20	36	69	96	88	65
	5	Jun. 19	Aug. 28	Oct. 12	25	41	78	108	97	71
	6	Jun. 19	Aug. 28	Oct. 12	30	45	81	117	103	73
5/30	3	Jun. 19	Sept. 1	Oct. 17	15	26	58	85	78	56
	4	Jun. 19	Sept. 1	Oct. 17	20	33	68	96	84	61
	5	Jun. 19	Sept. 1	Oct. 17	25	41	79	108	94	68
	6	Jun. 19	Sept. 1	Oct. 17	30	47	84	115	99	72

Table 2 Effects of different sowing dates and sowing rates on rice yield and its composition

Sowing date (month/day)	Sowing rate grains/hole	Number of panicles 10^4 panicles/hm^2	Filled grains per panicle grains/panicles	1 000-grain weight//g	Equivalent yield per unit area//kg/hm^2
5/10	3	328.5	124.0	26.8	9 264.0
	4	361.5	121.9	26.8	10 033.5
	5	378.0	116.1	26.8	9 997.5
	6	394.5	105.3	26.8	9 468.0
5/20	3	339.0	122.5	26.8	9 462.0
	4	361.5	119.8	26.8	9 861.0
	5	394.5	114.4	26.8	10 285.5
	6	406.5	110.3	26.8	10 197.0
5/30	3	312.0	97.5	26.2	6 759.0
	4	339.0	96.5	26.2	7 287.0
	5	378.0	94.4	26.2	7 947.0
	6	400.5	92.3	26.2	8 227.5

Effects of different sowing dates and sowing rates on yield of rice developed from seedlings dry-raised in aperture disk

It can be seen from Table 2 that under the same sowing date, the number of panicles per unit area of each treatment increased with the sowing rate increasing, while the number of filled grains per panicle decreased with the sowing rate increasing. Under the condition of the same sowing rate, the number of panicles in the treatment with the sowing date of May 20 was the most, followed by treatment with the sowing date of May 10, and that with the sowing date of May 30, which showed fewest panicles. In terms of the number of grains per panicle, the treatment of sowing on May 10 exhibited most grains, followed by the treatment of sowing on May

20, and the treatment sown on May 30, which showed fewest grains. The 1 000-grain weights of the treatments sown on May 10 and 20 were the same, both at 26.8 g, and the value of the treatment sown on May 30 was smaller than other two treatments, at 26.2 g. In terms of yield, the treatments sown on May 10 and 20 both show a trend of first increasing and then decreasing with the sowing rate increasing, while the yield of the treatment sown on May 30 gradually increased with the sowing rate increasing. Among the various treatments, the treatments sown on May 10 showed the highest yield of 10 033.5 kg/hm^2, when the sowing rate was 4 seeds/hole, and the lowest yield of 9 264 kg/hm^2 was observed when the sowing rate was 3 seeds/hole. The treatments sown on May 20 showed the highest yield of 10 285.5 kg/hm^2 at a sowing rate of 5 seeds/hole, and the lowest yield of 9 462 kg/hm^2 at a sowing rate of 3 seeds/hole. For the treatments sown on May 30, the yield was highest at 8 227.5 kg/hm^2 when the sowing rate was 6 seeds/hole, and lowest at 6 759 kg/hm^2 when the sowing rate was 3 seeds/hole. From the above analysis, it can be seen that the sowing rate achieving the highest yield increased with the delay of sowing date, that is, the yield reduction effect caused by the delay of sowing date could be alleviated by increasing the number of basic seedlings. Generally speaking, the yield was highest with the sowing date of May 20 and the sowing rate of 5 grains/hole.

Conclusions and Discussion

Sowing date and sowing rate are two important factors that affect the yield of rice under the condition of dry seedling raising in aperture disk. Appropriate sowing date can ensure that the seedlings can keep their vigor as much as possible under the premise of sufficient growth period, while appropriate sowing rate can coordinate the growth and development of individual plants with the total population, and keep as many basic seedlings as possible under the premise of ensuring the quality of seedlings, so as to increase rice yield[5-6].

The results of this study showed that with the delay of sowing date, the heading and maturity of each treatment were delayed accordingly. The treatments with the sowing date of May 20 showed heading and maturity delayed by 2 and 3 d respectively compared with the treatments with the sowing date of May 10, and there was little difference between them. However, the treatments with the sowing date of May 30 exhibited heading and maturity delayed by 5 and 8 d respectively compared with the treatments with the sowing date of May 10, showing quite great differences. Under the condition of the same sowing date, the number of tillers in each treatment increased with the increase of sowing rate per hole, and increased first and then decreased with the number of days after transplanting, reaching a maximum at 30 d after transplanting. The number of tillers was largest in the treatment with the sowing date of May 20 and the sowing rate of 6 grains/hole. In terms of yield, under the same sowing date, the number of panicles per unit area in each treatment increased with the sowing rate increasing, while the number of filled grains per panicle decreased with the sowing rate increasing. Under the condition of the same sowing rate, the treatment sown on May 20 showed most panicles per unit area, followed by the treatment sown on May 10, and that sown on May 30 exhibited fewest panicles. From the perspective of the number of filled grains per panicle, the treatment of sowing on May 10 was the most, followed by the treatment of sowing on May 20, and the treatment of sowing on May 30 showed the smallest value. Overall, the yield of the treatment with the sowing date of May 20 and sowing rate of 5 seeds/hole was the highest, at 10 285.5 kg/hm^2, and that with the sowing date of May 30 and sowing rate of 3 seeds/hole was the lowest, which was 6 759 kg/hm^2, exhibiting a significant difference.

References

[1] JIANG YW, LIU XL, HUANG LX, *et al.* Effects of sowing date and seedling nursery methods on seedling quality and yield of Xin-rongyou 6307[J/OL]. China Rice, 2020(2): 1-4. (in Chinese).
[2] HE AP, PENG XR, HE YM, *et al.* Effects of different sowing dates and sowing rates on rice yield[J]. Anhui Agricultural Science Bulletin, 2017, 23(17): 34-35, 43. (in Chinese).
[3] XIN SR, YU XY, ZHAO ZC, *et al.* Effects of sowing time and sowing rate on quality of rice seedlings raised in aperture disk[J]. Shandong Agricultural Sciences, 2019, 51(12): 40-42. (in chinese).
[4] XU XC, DAI QZ, JIANG QG, *et al.* Effects of sowing date and sowing rate on yield and its components of new rice variety "Qingjiao 22"[J]. Shanghai Agricultural Science and Technology, 2019(5): 44-46. (in Chinese).
[5] LU ZR, WANG GZ, TANG JP, *et al.* Regulating effect of density on yield and population quality of direct-seeded rice[J]. Acta Agriculturae Shanghai, 1999, 15(2): 61-64. (in Chinese).
[6] HUANG X, YE ZH, CHEN G. Effects of sowing date and sowing rate on agronomic characters and yield of late japonica rice Ning 84[J]. Journal of Zhejiang Agricultural Sciences, 2016, 57(11): 1774-1776. (in Chinese).
[7] LIU J, SONG YJ. Effects of different seedling raising methods on growth period and yield of rice[J]. Agricultural Technical Services, 2023, 40(5): 1-3. (in Chinese).
[8] LI ZX, TANG JC, WU ZH, *et al.* Seedling quality and grain yield of rice to optimized seedling raising methods [J]. Hubei Agricultural Sciences, 2020(23): 41-45, 62. (in Chinese).
[9] XIAO CL, WANG AD, LI J, *et al.* Effects of different sowing dates on yields and quality of rice in cold region[J]. Heilongjiang Agricultural Sciences, 2018(9): 37-40. (in Chinese).
[10] YAO Y, HUO ZY, ZHANG HC, *et al.* Effects of sowing date on the growth characteristics of direct seeding rice[J]. Chinese Journal of Ecology, 2010, 29(11): 2131-2138. (in Chinese).
[11] WU DX, LI LZ, XU DY, *et al.* Effects of different seedling rearing methods on agronomic characters and yield of Taifengyou79 high-quality rice[J]. Tillage and Cultivation, 2024 ,44(5): 64-67. (in Chinese).
[12] QIN SH, YANG WB, LI FJ, *et al.* Preliminary study on the feasibility of simplified technique for dry seedling raising of one-season middle rice [J]. Modern Agricultural Science and Technology, 2010(4): 61, 64. (in Chinese).
[13] WEI GQ. Analysis on centralized dry seedling raising mode of rice [J]. Agriculture and Technology, 2016, 36(4): 93. (in Chinese).
[14] TANG TL. Analysis on dry seedling raising techniques and its mechanism of increasing yield and income[J]. Agriculture and Technology, 2018, 38(23): 107-108. (in Chinese).

Editor: Yingzhi GUANG Proofreader: Xinxiu ZHU