

Analysis on yield and quality characteristics of new japonica rice lines

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Abstract

Twelve rice lines newly developed from different seed enterprise in Tianjin, Beijing and Hebei and the control Jinyuan 45 were used as experimental materials. The differences of yield, agronomic characters and rice quality characters among different materials were compared and the correlation among characters was analyzed. The results showed that the average actual yield of the new strain was 9.15 tons per hectare and the average theoretical yield was 10.20 tons per hectare. The rice lines with shorter panicle had higher yield, better processing quality, and lower chalkiness rate and degree. The protein of the lines with high culm and full grain was lower than that of the lines with low amylose. The rice with high yield had poor elasticity, better appearance and balance.

Keywords

Rice; Yield; Quality.

1. Introduction

Rice is one of the most important crops in the world. In 2020, the planting area of rice in China reached 30 million hectares. The improvement of rice yield is of great significance to ensure food security. With the improvement of people's living water quality, the demand for rice quality is higher and higher, and rice production is changing from high yield to high quality. The study on the relationship between high yield and high quality of rice is the key issue to guarantee food security and meet the people's demand for a better life.¹

Rice quality was evaluated from processing quality, appearance quality, nutrition quality and cooking and eating quality. Appearance quality is the direct factor that determines whether consumers buy rice or not, and chalkiness is the main factor that affects appearance quality. During the growth and development stage of rice, high temperature or low light will increase the rate and degree of chalkiness, and thus deteriorate the appearance quality and processing quality of rice²⁻⁴. Many studies showed that rice varieties with smaller grain length to width ratio had better processing quality, and the appearance quality and processing quality of rice could be effectively improved by adjusting sowing date and applying nitrogen fertilizer⁵⁻⁷. Amylose and protein contents are closely related to the quality of cooking and eating of rice. The increase of protein and amylose increases the hardness of rice, decreases the viscosity and deteriorates the taste^{8,9}. In recent years, the society has paid more and more attention to Tianjin "Xiaozhan rice", and all breeding units in Tianjin, Beijing and Hebei province have carried out breeding work in order to revitalize "Xiaozhan rice". In this study, 12 new rice lines and Jin yuan 45 from different breeding units in Beijing, Tianjin and Hebei were used as experimental materials to analyze the correlation between yield and quality by comparing yield, agronomic traits and rice quality traits, and to provide theoretical basis for cultivating high quality and high yield rice varieties.

2. Materials and Methods

2.1. Materials

Twelve new rice lines and Jinyuan 45 from different breeding units in Beijing, Tianjin and Hebei were used as experimental materials. In 2021, the plants were planted in 7 test stations in Shunyi, Funing, Tanghai, Kenli, Jinnan, Ninghe and Baodi, with an area of 15m², row spacing of 30.0cm and plant spacing of 13.2cm. The plants were randomly arranged in groups and repeated for 3 times. Adopt local practices of planting and field management.

2.2. Methods

After maturity, the plant height and effective panicle number were investigated in the field. Five rice plants were taken from each plot and dried naturally for seed test in the laboratory to investigate yield components and panicle length. The yield of remaining materials in the plot was measured in turn. The rice quality indexes were determined after one month of indoor storage. The husked rice rate was calculated by sy88-TH test rice huller, the polished rice rate was measured by SY2001-NSART100 test rice mill, the appearance quality of rice was measured by JMWT12 appearance tester produced by Dongfu Jiuhe, and the appearance score of rice was measured by STA1 rice tastometer. Rice hardness, viscosity, balance and elasticity were measured by RHS1A hardness viscosimeter manufactured by Satake, Japan.

2.3. Statistic Analysis

IBM SPSS was used for data analysis, Excel 365 software and Origin 2022 for chart drawing.

3. Results and Analysis

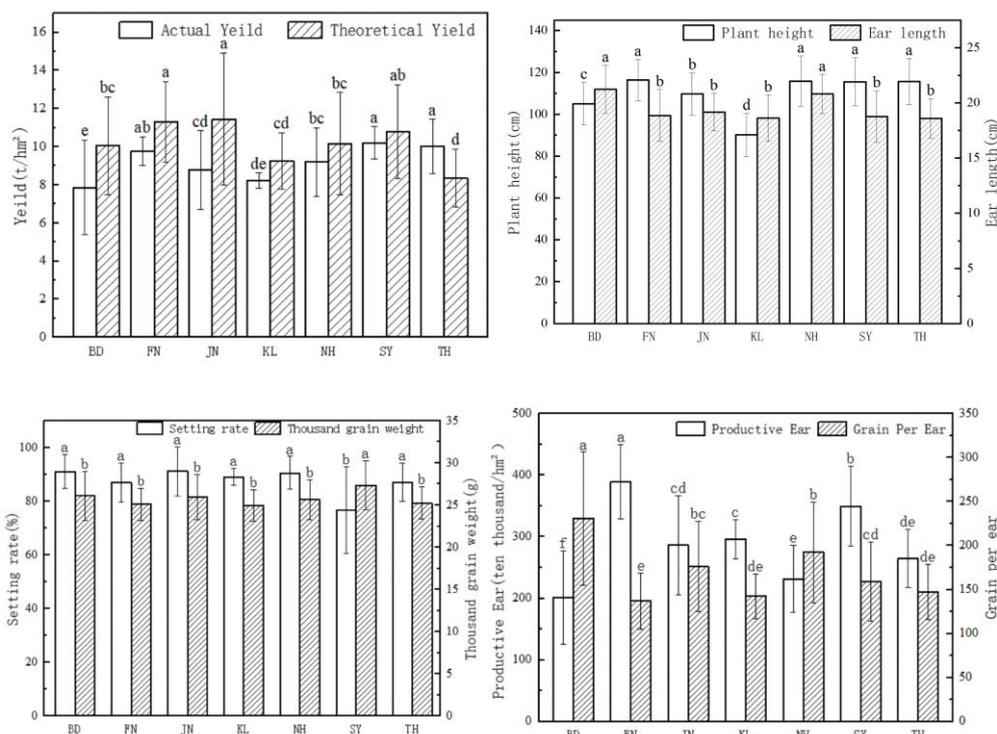
3.1. Yield and agronomic traits

Table1 Yield and agronomic traits of 12 new japonica rice lines

Traits	Average	Max	Min	Coefficient variation (Varieties)	Coefficient variation (Region)
Actual Yield (t/hm ²)	9.15	10.47	7.13	15.70%	15.76%
Theoretical Yield (t/hm ²)	10.20	11.70	7.74	24.11%	20.85%
Productive ear	283.47	385.74	220.49	21.71%	25.09%
Number of grain per ear	168.00	227.18	112.65	25.46%	20.05%
Setting rate(%)	86.49	93.28	69.18	9.27%	7.03%
Thousand seed weight(g)	26.30	29.2	23.01	9.13%	4.91%
Ear length (cm)	19.40	22.14	16.28	10.50%	7.61%
Plant height(cm)	109.56	123.65	92.40	8.94%	9.25%

As can be seen from Table 1, the coefficient of variation of actual yield, theoretical yield, effective panicle number and grain number per panicle were large in the newly developed lines, the coefficient of variation among varieties were 15.70%, 24.11%, 21.71% and 25.46%, respectively, and the coefficient of variation among regions were 15.76%, 20.86%, 25.09% and

20.05%, respectively. The actual yield, effective panicle number and plant height of the new strain were greatly affected by the regions, and the differences of other traits were mainly among varieties. The actual yield of the new strain ranged from 7.13 to 10.47 t/hm², with an average of 9.15 t/hm²; The effective panicle number ranged from 220.49 to 3.8574 million panicle per hectare, with an average of 2.8347 million panicle per hectare and grains per panicle ranging from 112.65 to 227.18; The seed setting rate ranged from 69.18 to 93.28%, with an average of 86.49%; The 1000-grain weight ranged from 23.01 g to 29.20 g, with an average of 26.30g.



Graph 1 Yield and agronomic characters in different areas

According to Graph 1, the yield and agronomic traits of the new strain differed greatly in different regions. The optimal actual yield of Tanghai and Shunyi was 10.02 and 10.21 tons per hectare, respectively; The highest theoretical yields in Funing and Jinnan were 11.30 tons and 11.45 tons per hectare, respectively; The number of effective panicles per hectare in Funing was 3.8906 million, which was significantly higher than that in other areas, and 9 strains had the best performance in Funing; Baodi had 230.56 grains per spike, which was significantly higher than that of other areas, and 6 strains had the best performance in Baodi; The 1000-grain weight of Shunyi was 27.35g higher than that of other areas, but the seed-setting rate was 76.72% lower than that of other areas.

3.2. Quality traits of new strains

Table 2 Characterization of rice quality characters of new rice lines

Trait	Average	Max	Min	coefficient variation (Varieties)	coefficient variation (Reigon)
Brown Rice Rate(%)	83.15	84.53	81.26	1.60%	1.03%
Milled Rice Rate(%)	71.98	74.53	67.41	3.61%	3.89%
Head Rice Rate(%)	63.01	69.92	51.77	10.70%	6.68%

Chalk White Rate(%)	9.99	23.36	0.62	85.94%	52.04%
Chalkiness Degree(%)	2.95	7.86	0.13	92.22%	54.43%
Whiteness	34.55	36.52	31.97	5.34%	5.02%
Length-Width ratio	2.02	2.67	1.65	9.52%	9.61%
Protein(%)	9.75	10.99	8.87	6.99%	6.12%
Amylose(%)	17.15	18.33	15.09	18.78%	2.96%
Hardness	5.28	5.96	4.66	13.77%	13.18%
Viscosity	0.36	0.46	0.25	35.79%	38.61%
Balance	0.34	0.36	0.32	34.45%	86.72%
Elastic	0.44	0.46	0.40	18.59%	71.01%
Appearance	3.29	4.52	1.66	31.21%	29.54%

As shown in Table 2, the average milled rice rate of the new line was 71.98%, and the average milled rice rate was 63.01% from 51.77 to 69.92%. Amylose content ranged from 15.09 to 18.33% with an average of 17.15%. The chalkiness rate and chalkiness degree were 85.94% and 92.22%, respectively. The coefficients of regional variation were 86.72%, 52.04% and 54.43%, respectively. In general, rice texture characteristics were significantly affected by different regions, while chalkiness rate and chalkiness degree were significantly affected by different varieties.

3.3. Relationship between yield, agronomic traits and rice quality

Table 3 Correlation between yield, agronomic traits and rice quality traits of new rice lines

Trait	Actual Yield	Theoretical Yield	Productive ear	Plant height	Ear length	Grains per spike	Setting rate	Thousand seed weight
Brown Rice Rate	.233**	.162**	.223**	-.040	-.315**	.130*	-.202**	-.403**
Brown Rice Rate(%)	.050	-.004	.077	-.222**	-.205**	.065	-.054	-.306**
Milled Rice Rate(%)	.183**	.123*	.254**	.069	-.341**	.127*	-.266**	-.510**
Head Rice Rate(%)	-.104	-.174**	-.031	-.125*	.133*	-.097	.063	-.050
Chalk White Rate(%)	-.091	-.138*	-.088	-.085	.166**	-.040	.058	.048
Chalkiness Degree(%)	.048	.019	-.047	.209**	.155*	-.080	.109	.299**
Protein(%)	-.506**	-.209**	-.106	-.615**	-.092	-.060	.181**	-.170**
Amylose(%)	.405**	.255**	.155*	.565**	-.005	.097	-.271**	.153*
Length-Width ratio	-.357**	-.270**	-.053	-.458**	.308**	-.398**	.330**	.321**
Hardness	.070	-.019	.112	.135*	.010	-.181**	.070	.126*
Viscosity	-.089	.022	-.035	-.054	.100	-.036	.186**	.034
Balance	.395**	-.004	.450**	.418**	-.225**	-.331**	-.308**	.025
Elastic	-.393**	.010	-.451**	-.426**	.212**	.330**	.335**	-.047
Appearance	.275**	.121*	.100	.175**	.138*	-.168**	.186**	.249**

As can be seen from Table 3, yield was significantly positively correlated with brown rice rate and whole rice rate, negatively correlated with chalkiness rate and chalkiness degree, and extremely significantly negatively correlated with aspect ratio, that is, the shorter grain type, the higher yield, the smaller chalkiness rate and whole rice rate, and the higher brown rice rate and whole rice rate. Panicle length was significantly negatively correlated with brown rice rate, milled rice rate and milled rice rate, significantly positively correlated with chalkiness and chalkiness rate, and significantly positively correlated with length-width ratio, that is, the longer panicle length, the longer grain type, the more chalkiness, and the lower brown rice rate, milled rice rate and milled rice rate. Plant height was significantly negatively correlated with milled rice rate, chalkiness rate and length-width ratio, that is, the higher plant height was, the lower grain type was and the higher milled rice rate was. Grain number per panicle was significantly positively correlated with brown rice rate and milled rice rate, and significantly negatively correlated with length-width ratio. Seed setting rate was significantly negatively correlated with brown rice rate and milled rice rate, and significantly positively correlated with length-width ratio. In general, the lines with more yield, panicle number and grains per panicle, lower plant height, seed setting rate, 1000-grain weight and length-width ratio had better processing quality. The lines with high yield, short panicle and short grain shape had better appearance.

Protein content was negatively correlated with yield, plant height and 1000-seed weight, and positively correlated with seed setting rate. That is, the protein content of the lines with high stem and full grains was lower than that of the lines with low amylose. Rice yield was significantly positively correlated with balance and appearance, and significantly negatively correlated with elasticity. Rice with high yield had poor elasticity and better appearance and balance.

4. Discussion and Conclusion

In this study, 12 newly developed rice strains and a control variety were planted in 7 regions of 3 provinces to comprehensively analyze the yield and quality traits of rice. Many studies believe that amylose has a significant effect on rice varieties^{10, 11}, the increase of amylose content will make rice hardness, viscosity and taste worse^{9, 11}. In this study, yield was significantly positively correlated with amylose content, but not with hardness and viscosity of rice, but balance degree was significantly positively correlated with yield, suggesting that the increase of yield might not necessarily reduce the eating quality of rice. Rice grain shape is a quantitative character, which is an important character controlling rice yield and quality¹². In this study, rice lines with short panicle and grain shape had higher yield, better processing quality, and lower chalkiness rate and degree. It was found that the effective panicle number, 1000-grain weight, balance and elasticity of 12 rice lines were significantly affected by the environment, while the differences of grain number per panicle, panicle length, plant height, chalkiness rate and chalkiness degree were mainly found in varieties.

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