The Current Breeding Situation and Development Strategies on High-quality Inbred Rice in Guangxi

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Abstract According to the rice quality, production and resistance of 50 high-quality inbred rice varieties bred and examined and approved in Guangxi during the period 2000 - 2011, we analyze the current breeding situation and existing problems concerning high-quality inbred rice variety in Guangxi: the rice quality has been greatly improved, but the amylose content is still low; a series of scented rice varieties with high quality and high yield have been bred, such as Zhongguangxiang No. 1, Sanxiang 628, Guixiang No. 1, Liufengxiangzhan, Jiafuxiang No. 1, Zhaoxiang No. 1; the production of high-quality inbred rice during the period 2009 - 2011 was significantly enhanced, annually more than 66 00 kg/ha, but the disease resistance of rice variety bred was generally poor, and disease-resistant breeding stuck in the mud. Henceforth it is necessary to be oriented by the rice market, and take the rice type with long grain, high adhesive strength, medium-low amylose content and low chalkiness degree as the breeding objectives; introduce the existing high-quality variety resources with medium amylose content at home and abroad, then directly use them or innovate upon them as hybrid strain; take the thick-and-long-grain rice type as breeding objectives, and further improve the yield per unit area of high-quality inbred rice by improving the thousand-grain weight; increase capital investment, improve breeding techniques, strengthen disease-resistant and degeneration-resistant breeding, and improve the application of modern biotechnology in the breeding of high-quality inbred rice.

Key words High-quality inbred rice, Rice quality, Amylose content, Production, Disease resistance, Development strategies

With the continuous improvement of people's living standards, the consumer demand for high-quality rice is increasingly growing, and the demand for high-quality inbred rice is diverse. Meanwhile, with the further adjustment of agricultural planting structure, the cultivation area of high-quality inbred rice in Guangxi is also expanded. Since the mid - 1970s, Guangxi has started to carry out the breeding work of high-quality and high-yield inbred rice. "Temei", "Gui 713" and other varieties early bred by Rice Research Institute, Guangxi Academy of Agricultural Sciences, once became the main varieties for the export in Guangxi (Luo Qunchang *et al*, 2003). Since the twenty-first century, the breeding work of high-quality inbred rice in Guangxi has achieved fruitful results, breeding a number of high-quality varieties. This article analyzes the rice quality, production and resistance of 50 high-quality inbred rice varieties bred and approved in Guangxi during the period 2000 - 2011; probe into the current breeding situation and existing problems, and propose development strategies, to provide reference for the breeding of high-quality inbred rice in Guangxi.

1 The current breeding situation of high-quality inbred rice in Guangxi and results achieved

1.1 Rice quality status

1.1.1 The improvement of overall rice quality makes great strides. With the promulgation of *National High-quality Rice Standards* GB/T17891 - 1999 (GB), from 2000 to 2008, the qualification rate of high-quality inbred rice variety examined and approved in Guangxi was low, but in recent years, the situation has been improved remarkably. As can be seen from Table 1, there were a total of 36 high-quality inbred rice varieties examined and approved in Guangxi during the period 2000 - 2008, but only two varieties reached GB 3, accounting for 5.4%; 12 varieties were examined and approved during the period 2009 - 2011, 8 of which reached more than GB 3, accounting for 66.7%. This shows that in recent three years, the quality of inbred rice bred in Guangxi has been greatly improved, and the overall grain quality has been significantly improved.

Table 1 The high-quality inbred rice variety examined and approved in Guangxi with rice quality reaching GB during the period 2000 - 2011

Year	Number of variety examined and approved	Number of variety reaching GB			Ratio//%
		Class I	Class II	Class III	
2000 - 2008	38	0	0	3	7.9
2009 - 2011	12	0	3	5	66.7

1.1.2 The main indicators on rice quality have been greatly improved, but the amylose content is still low. As can be seen from Table 2, compared with the period 2000 - 2008, in terms of processing quality, appearance quality and cooking quality, the high-quality inbred rice varieties examined and approved in Guangxi have been improved significantly in recent three years. Except the amylose content, other major rice quality indicators all reach GB;

Received: April 1, 2013 Accepted: May 13, 2013
Supported by Guangxi Innovation Team Project, National Modern Agricultural Technology System (nycytxgxcxtd-01); Guangxi Scientific Research and Technological Development Project (10100004-1A); Guangxi Natural Science Foundation (2011GXNSFB018043).
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especially the four indicators of brown rice rate, milled rice rate, grain type and adhesive strength, and more than 90% of varieties reach GB Class I, increasing by 20.3, 31.6, 5.3, 28.5 percentage points, respectively, compared with the period 2000 – 2008. In addition, chalkiness rate, chalkiness degree and amylose content reaching more than GB Class II also increase by 18.5, 28.6, 17.1 percentage points, respectively.

The amylose content of rice is one of the most important indicators determining the rice taste, and high-quality edible rice requires moderate amylose content. If the content is high, the rice will be more rigid; if the content is low, the rice will be adhesive, with poor palatability (Chen Yuanmeng *et al*, 2004). Based on years of breeding experience of high-quality inbred rice, it is found that the rice with 18% of amylose content is tasted better, so we should put 18% of amylose content as the key indicator for the improvement of rice quality in the breeding, but this is the difficulty in the breeding.

Low amylose content is the primary factor long affecting the attainment rate of high-quality inbred rice variety in Guangxi. In the 50 high-quality inbred rice varieties bred in Guangxi during the period 2000 – 2011, 35 varieties with too high or too low amylose content did not reach GB, and 73.0% of varieties had very low amylose content (<15%). After the efforts of breeders, the amylose content of high-quality inbred rice variety bred in recent three years has been greatly improved, but there are still 33.3% of varieties not reaching GB due to too low amylose content.

Table 2 The attainment rate of major rice quality indicators on high-quality inbred rice variety in Guangxi Unit: %

Year	Number of variety examined and approved	Class of GB	Brown rice rate	Milled rice rate	Grain type	Chalkiness rate	Chalkiness degree	Adhesive strength	Amylose content
2000 – 2011	50	Class I	76.6	76.0	96.0	58.0	32.0	70.0	2.0
		Class II	19.1	4.0	0	28.0	38.0	16.0	10.0
		Class III	4.3	4.0	0	10.0	22.0	6.0	18.0
		Substandard	0.0	16.0	4.0	4.0	8.0	8.0	70.0
2000 – 2008	38	Class I	71.4	68.4	94.7	52.6	26.3	63.2	2.6
		Class II	22.9	5.3	0	28.9	36.8	18.4	5.3
		Class III	5.7	5.3	0	13.2	26.3	7.9	10.5
		Substandard	0	21.1	5.3	5.3	10.5	10.5	81.6
2009 – 2011	12	Class I	91.7	100.0	100.0	75.0	50.0	91.7	0
		Class II	8.3	0	0	25.0	41.7	8.3	25.0
		Class III	0	0	0	0	8.3	0	41.7
		Substandard	0	0	0	0	0	0	33.3

Except the too low amylose content, other major rice quality indicators of some varieties all reach GB Class I, such as Guijing No. 1, Guixiang No. 1, Keyu 03, Yalin No. 3 and Guiyu No. 7. We can know that overcoming the problem of low amylose content is still the focus of rice quality improvement of high-quality inbred rice for a comparatively long time.

1.1.3 The breeding of scented rice variety is impressive. The scented rice not only overflows with aroma after cooking, but also has good nutritional quality, rich in amino acids, proteins and trace elements (Chen Yuanmeng *et al*, 2007). With the improvement of people's living standards and health awareness, the production and consumption of scented rice, especially high-quality scented rice, are increasing (Chen Yuanmeng *et al*, 2006). In this context, breeders in Guangxi have achieved impressive results in the breeding work of high-quality scented rice variety through unremitting efforts.

During the period 2000 – 2011, 19 high-quality inbred scented rice varieties were bred successively, accounting for 38.8% of the high-quality inbred rice varieties bred. Due to good rice quality, scent and good taste, Baguixiang, Tiandongxiang, Zaoxiang No. 1, Xinxiang and other scented rice varieties are famous across the whole province. The newly bred Zhongguangxiang No. 1, Sanxiang 628, Guixiang No. 1, Liufengxiangzhan, Jiafuxiang No. 1, Zhaoxiang No. 1 and other scented rice varieties have high rice quality and yield, with great prospects for promotion.

1.2 Increasingly improved production level and breakthrough in both high quality and high yield The conditions of relatively closed rice market and vast population but limited farmland in China determine that the breeding of high-quality rice should pay equal attention to rice quality and high yield (Cheng Yongsheng *et al*, 2005). For a long time, compared with the hybrid rice, the yield of high-quality inbred rice variety bred in Guangxi is very low, to a large extent restricting the further expansion of cultivation area of high-quality inbred rice. According to the average annual regional tested yield of high-quality inbred rice variety examined and approved (Table 3), we see that the average regional tested yield before 2009 hovered around 6 300 kg/ha, while during the period 2009 – 2011, the yield was steadily improved, over 6 600 kg/ha every year. Especially in 2011, the contradiction between high quality and high yield was eased, achieving a qualitative leap; 3 high-quality inbred rice varieties were examined and approved, the average regional tested yield exceeded 6 750 kg/ha, and the rice quality was up to GB Class 3 or more. The yield of Guiyu No. 7 was the highest, reaching 7 233 kg/ha, and the rice quality reached GB Class 2 (Table 4). In 2011, Guiyu No. 7 was planted in Naman Town as demonstration, and the average yield reached 7 729.5 kg/ha according to the testing by experts. High-quality and high-yield breeding made a new

breakthrough.

Table 3 The average annual regional tested yield of high-quality inbred rice variety examined and approved

Year	Average yield//kg/ha	Year	Average yield//kg/ha
2000	5 752.5	2006	6 676.5
2001	5 799.0	2007	6 319.5
2002	/	2008	6 393.0
2003	6 021.0	2009	6 630.0
2004	6 349.5	2010	6 631.5
2005	6 186.0	2011	7 062.0

Table 4 High-quality inbred rice varieties examined and approved in Guangxi in 2011

Variety	Average yield//kg/ha	Class of GB
Guiyu No. 7	7233.6	II
Zhaoxiang No. 1	7127.5	III
Sanxiang 628	6824.1	III

1.3 Generally poor disease resistance of rice variety bred and stagnant disease-resistant breeding Rice blast is the most important disease affecting the safe production of high-quality inbred rice in Guangxi, and the selection of disease-resistant variety is the most effective way to prevent and control this disease. From the statistical results on the resistance of the high-quality inbred rice variety bred in Guangxi to rice blast (Table 5), the resistance of the bred variety to rice blast has been basically in the sense of medium and high level since 2000, and more than two thirds are in the sense of high level. In recent three years, the resistance of high-quality inbred rice variety bred has not yet been improved. In terms of the resistance to bacterial blight, Table 6 shows that most of the varieties bred during the period 2000 – 2008 were at the medium level of resistance and sense, while the varieties bred in recent three years are in the sense or high level sense to bacterial blight, and even there is the phenomenon of degeneration. In the future, it is necessary to further strengthen the disease-resistant breeding of high-quality inbred rice.

Table 5 The resistance of the high-quality inbred rice variety bred in Guangxi to rice blast

Year	Number of varieties	High resistance		Resistance		Medium resistance		Medium sense		Sense		High sense	
		Number of varieties	Proportion//%	Number of varieties	Proportion//%	Number of varieties	Proportion//%	Number of varieties	Proportion//%	Number of varieties	Proportion//%	Number of varieties	Proportion//%
2000 – 2008	35	0	0	0	0	0	0	3	8.6	8	22.9	24	68.6
2009 – 2011	12	0	0	0	0	0	0	0	0	4	33.3	8	66.7

Note: It lacks the resistance data on the three varieties of Guiyinzhan, Tiandongxiang and Hexixiang, not included in the statistics; for that in between two levels, the statistics are collected based on the higher level.

Table 6 The resistance of high-quality inbred rice variety in Guangxi to bacterial blight

Year	Number of varieties	High resistance		Resistance		Medium resistance		Medium sense		Sense		High sense	
		Number of varieties	Proportion//%	Number of varieties	Proportion//%	Number of varieties	Proportion//%	Number of varieties	Proportion//%	Number of varieties	Proportion//%	Number of varieties	Proportion//%
2000 – 2008	35	0	0	0	0	11	31.4	15	42.9	4	11.4	5	14.3
2009 – 2011	12	0	0	0	0	0	0	0	0	6	50.0	6	50.0

Note: It lacks the resistance data on the three varieties of Guiyinzhan, Tiandongxiang and Hexixiang, not included in the statistics; for that in between two levels, the statistics are collected based on the higher level.

1.4 Weak degeneration-resistant breeding In recent years, with the frequent occurrence of abnormal climate change, rice chilling injury or drought damage also occurs sometimes, resulting in significant reduction of rice or even total crop failure, seriously affecting the safe production of high-quality inbred rice. The cold tolerance and drought resistance are not included in regional test evaluation indicators, so the breeders pay insufficient attention to the input to degeneration-resistant breeding, and do not attack a key problem in the degeneration-resistant breeding, resulting in the poor degeneration-resistance of most varieties bred, difficult to withstand severe weather damage. Therefore, the breeding of cold-resistant and drought-resistant varieties is imminent.

2 Development strategies

2.1 Oriented by the rice market, breeding marketable variety Taste and appearance are the two factors determining whether the rice is sold well, and different regions have different requirements on the rice taste. The rice in Guangxi is mainly sold in the province or to Guangdong, Hong Kong, Macao and other regions, so breeders must pay close attention to the consumer demand for rice in the region, with marketable rice type as the breeding goals of rice quality. In general, the rice type with long grain, high adhesive strength, medium – low amylose content and low chalkiness degree is welcomed by consumers.

2.2 Improving the breeding technology and increasing capital investment For a long time, due to the orientation issues of the seed market, the breeding technology input and capital investment of high-quality inbred rice are far less than that of the hybrid rice. It is necessary to strengthen exchanges and cooperation with the counterparts at home and abroad, learn from their advanced concepts and methods for the breeding of high-quality inbred rice; for existing problems, organize the breeding units for joint re-

search, and increase capital investment to ensure that the breeding and related research work on high-quality inbred rice in the region is carried out smoothly.

2.3 Focusing on solving the problem of low amylose content in the improvement of rice quality In recent years, the rice quality of high-quality inbred rice variety in the region has been greatly improved, but the low amylose content is still the region's primary issue to be solved in the improvement of rice quality of high-quality inbred rice. In breeding practice, it is necessary to fully explore the high-quality inbred rice germplasm resources with medium amylose content, such as Baguixiang 713, Guixiang No. 1, Yalin No. 3, Guiyu No. 7 and Guizhan No. 4 that have been examined and approved. In addition, there is a need to introduce the existing high-quality variety resources with medium amylose content at home and abroad, then directly use them or innovate upon them as hybrid strain.

2.4 Further improving the yield per unit area of high-quality inbred rice by improving the thousand-grain weight The production of inbred rice is lower than that of hybrid rice, which is always an obstacle to the development of high-quality inbred rice in the region. Through statistical analysis on the relationship between the regional tested production of variety bred in Guangxi and thousand-grain weight, it is found that in the varieties with production higher than 6300 kg/ha, the varieties with thousand-grain weight higher than 20 g account for 90.0%, while in the varieties with production lower than 6300 kg/ha, the varieties with thousand-grain weight higher than 20 g only account for 42.9%, indicating that increasing thousand-grain weight can greatly improve yield per unit area. In the future, it is necessary to take the thick-and-long-grain rice type as breeding objectives, and without reducing the quality of rice, increase thousand-grain weight to further improve the yield per unit area of high-quality inbred rice, in order to achieve a higher level of harmonization of high quality and high yield.

2.5 Strengthening disease-resistant and degeneration-resistant breeding Guangxi is the region severely hit by rice blast, so the use of disease-resistant variety is the most direct, most economic and most effective measure to prevent this disease, but currently the breeding of high-quality inbred rice in Guangxi resistant to rice blast still has not make a breakthrough. In the future, on the one hand, it is necessary to further strengthen the disease-resistant breeding, introduce from abroad or explore the excellent germplasm resources with high rice quality and high resistance to rice blast; take the currently promoted high-yield and high-quality inbred rice variety as the recurrent parent to crossbreed it with disease-resistant germplasm resources, then backcross it with the recurrent parent 1 or 2 times, and arrange the backcrossed progeny in the blast zone to be planted; directly select high-yield, high-quality disease-resistant strains in the disease zones, to breed new high-yield, high-quality and high-resistance varieties. On the other hand, it is necessary to strengthen exchanges and cooperation between breeders and plant protection experts, to conduct joint research and accelerate the process of disease-resistant breeding.

Agro-meteorological disasters occur frequently, seriously threatening the safe production of high-quality inbred rice in Guangxi. Improving the degeneration-resistance of variety is a fundamental way to solve this problem. It is necessary to increase the personnel and capital input to the research on degeneration-resistant breeding of high-quality inbred rice, introduce high-quality degeneration-resistant parent for the use, attack key problems in degeneration-resistant breeding, and breed high-yield, high-quality and high-resistance variety as quickly as possible, to ensure the safe production of high-quality inbred rice in Guangxi.

2.6 Improving the application of modern biotechnology in the breeding of high-quality inbred rice The high bio-technology has incomparable advantages, laying a strong technical foundation for the improvement and selection of individual genetic traits. The high bio-technology is still at the auxiliary stage of breeding, but it has shown a strong supporting role. Molecular marker-assisted selection breeding technique effectively improves the selection efficiency of target gene, which has been widely used in the screening of important disease-resistant, insect-resistant genes (Cheng Yongsheng *et al*, 2005). In the future, it is necessary to strengthen the combining of conventional breeding methods and molecular marker-assisted selection breeding technique, to accelerate the disease-resistant and degeneration-resistant breeding process.

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