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Original article

EVALUATION OF QUALITY OF EXPERIMENTAL WHITE-GRAN RICE POPULATIONS IN ACCELERATED BREEDING BY GRAIN SIZE AND VITREOUSITY

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Abstract

Background. In marker-assisted rice breeding, the accelerated development of varieties with superior grain quality traits through advanced biotechnological approaches requires the generation of segregating rice populations followed by phenotyping of genotypes for traits of interest. These segregating populations are used to identify genetic loci (QTLs) associated with complex traits, including rice grain quality, based on phenotypic data.

Purpose. The goal of the work was to evaluate experimental BC_3 populations of rice based on physical characteristics of grain: size, vitreousity, fracturing, in order to carry out work on targeted selection based on phenotyping and genotyping data of promising plants - prototypes of varieties with specified traits in marker-assisted rice breeding.

Materials and methods. The study involved hybrids of 15 combinations of parental forms. The seeds were sown in vessels on the vegetation site of FSBSI Federal Scientific Rice Centre, Pryanishnikov's mixture was used as the main fertilizer; as they ripened, the seeds were harvested manually. High-tech methods of phenotyping the breeding material were used to conduct the research. The grain size was estimated by the mass of 1000 absolutely dry grains using a moisture analyzer, an air-heat unit, and an automatic seed counter; the vitreousity and grain fracturing were estimated in transmitted light using a diaphanoscope.

Results. Genotypes were differentiated and distributed into groups for each trait. As a result of the quality study of the obtained BC_3 samples, lines combining high technological grain quality traits were identified using phenotyping data. The mass of 1000 absolutely dry grains was in the range of 23.2-30.2 g in the group of medium-weight samples, the indices of vitreousity and fracturing were 62-93% and 1-9%, respectively.

Conclusion. As a result of the comparative analysis of hybrids and parental forms, combinations were noted for which the heterosis effect was typical for grain quality traits.

Keywords: rice; physical traits of grain; rice quality; vitreousity; fracturing; grain size

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Научная статья

ОЦЕНКА КАЧЕСТВА ЭКСПЕРИМЕНТАЛЬНЫХ БЕЛОЗЕРНЫХ ПОПУЛЯЦИЙ РИСА В УСКОРЕННОЙ СЕЛЕКЦИИ ПО КРУПНОСТИ И СТЕКЛОВИДНОСТИ ЗЕРНА

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Аннотация

Обоснование. В маркер-обоснованной селекционной практике риса в ускоренном процессе создания сортов с высокими показателями признаков качества зерна на основе новых биотехнологических приемов актуально создание сегрегирующих популяций риса с последующим фенотипированием генотипов по признакам интереса. Сегрегирующие популяции используются для выявления генетических локусов (QTL), связанных со сложными признаками, в том числе качества зерна риса на основе данных фенотипирования.

Цель. В работе была поставлена цель провести оценку экспериментальных популяций риса BC_3 по физическим признакам зерна: крупности, стекловидности, трещиноватости, в целях осуществления работ по прицельному отбору по данным фенотипирования и генотипирования перспективных растений – прототипов сортов с заданными признаками в маркер-опосредованной селекции риса.

Материалы и методы. В исследование были вовлечены гибриды 15-ти комбинаций скрещиваний родительских форм. Семена высевали на вегетационной площадке ФГБНУ ФНЦ риса в сосуды, в качестве основного удобрения использовали смесь Прянишникова; по мере созревания семена убирали вручную. Для проведения исследований были использованы высокотехнологичные методы фенотипирования селекционного материала. Крупность зерна оценивали по массе 1000 абсолютно сухих зерен с использованием анализатора влажности, установки воздушно-тепловой, автоматического счетчика семян; оценку стекловидности и трещиноватости зерна - в проходящем свете с помощью диафаноскопа.

Результаты. Генотипы дифференцировали и распределяли в группы по каждому признаку. В результате проведения исследования качества полученных образцов BC_3 по данным фенотипирования были выделены линии, сочетающие высокие технологические признаки качества зерна. Масса 1000 абсолютно сухих зерен находилась в диапазоне 23,2-30,2 г в группе средних по массе образцов, показатели стекловидности и трещиноватости соответственно: 62-93 % и 1-9 %.

Заключение. В результате сравнительного анализа гибридов и родительских форм были отмечены комбинации, для которых был характерен эффект гетерозиса по признакам качества зерна.

Ключевые слова: рис; физические признаки зерна; качество риса; стекловидность; трещиноватость; крупность зерна

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Introduction

In Russia, rice is a valuable cereal crop and is widely used in traditional, baby and dietary nutrition. For most Asian countries, rice is the main source of energy, protein and microelements [1]. The economic value of rice is determined by the profitability of its production, nutritional and culinary advantages (ECQ). The directions of the rice breeding process, as a result of which new varieties are created, are formed by the consumer advantages of genotypes, the tasks of functional and healthy nutrition [10].

The concept of rice quality includes many indicators that form an assessment system. As a result of assessing the quality of rice grains at the stages of breeding and production processes, the indicators meet the requirements of consumers and production.

The main traits of grain that determine consumer merits are morphological, physicochemical and biochemical. Morphological characteristics include shape, color, dimensions, weight, grain size, length, width, thickness, length to width ratio, etc.

In rice production at rice processing plants, grain mass assessment is mandatory when accepting grain, forming and receiving grain shipments for processing according to the parameters of pest infestation and contamination, the content of red, yellow, puny, chalky grains of vitreous and fractured, etc. [1; 10].

In rice breeding, the world's research centers use the latest modern science-intensive technologies to develop varieties with high grain quality. Enrichment of rice germplasm occurs with the involvement of genotypes with different pericarp colors in breeding schemes based on highly effective approaches using post-genomic and cellular technologies [9; 14]. The breeding of rice varieties with high grain quality begins with the selection of parental pairs and the crossing of valuable genotypes. Subsequently, samples with the best agrobiological characteristics and grain quality parameters are selected using phenotyping and biotechnological methods [11]. Much attention is paid to genome-wide association studies of grain appearance (size, shape, flour content, chalky rice content in the total mass) of the world collection of rice germplasm, historical breeding populations [15].

For more than two decades, large-scale genotyping by sequencing (GBS) has been carried out in research centers around the world, the results of which are used in the rice breeding process.

Russian rice varieties are mostly the result of a breeding process based on classical routine techniques [2]. A segregating F_2 rice population obtained by crossing Nipponbare (Oryza sativa ssp. japonica cv.) and wild African (O. Longistaminata). 8,154 informative SNP markers were identified in the analysis of 1,081 F_2 plants. Work has been carried out on the localization of quantitative loci (QTL) that determine the "number of panicles" trait on chromosomes 1, 3, 4 and 8.

The efficiency of GBS for the analysis of a highly heterozygous population was demonstrated [2; 3]. The introduction of genes of interest into the rice genome is used in breeding programs [5].

A number of genes/QTLs have been identified for ECQ properties such as protein content and aromatic properties [5; 8]. Grain filling is accompanied by starch accumulation with the help of enzymes: ADP-glucose pyrophosphorylase (AGPase), starch synthase (SSs), starch branching enzymes (SBEs), and starch splitting enzymes (DBEs) [13].

Functional markers are used for fragrant rice. Marker-assisted breeding has identified high nutritional value alleles in rice varieties. Association mapping using 18,824 high-quality markers yielded 38 QTLs for 10 traits, five of which corresponded to known genes or precisely mapped QTLs. Much attention is paid to genome-wide association studies of grain appearance (size, shape, flour content, chalky rice content in the total mass) of the world collection of rice germplasm, historical selection populations.

Several genes for grain mealyness have been mapped, including Chalk5, which is expressed in the endosperm on chromosome 5 (encodes vacuolar pyrophosphatase), qPGWC-7, qPGWC-8, and qACE-9 [13; 16]. (PCG), qPCG1, was localized in a 139 kb region on the long arm of chromosome 1 [4]. Hundreds of QTLs for flour content trait have been identified. Scientists at Hunan Agricultural University (HUNAU) conducted DAP-seq of multiple rice accessions and showed that overexpression of OsFIF3 inhibited the expression of FLO2 and SUT1, thereby increasing flour content and reducing grain size. In the qPCG1 study, the QTL for mealyness was mapped in an interval with a physical distance of about 139 kb on chromosome 1 [18].

Grain sizes, for which a large number of quantitative trait loci (QTL) have been recorded, are of great interest in connection with the effect on rice yield. Thus, the basic grain size QTL (qTGW3) encodes SHAGGY-like kinase 41; (OsSK41)/OsGSK5, BIG GRAIN1 (BG) encodes a positive regulator of auxin reaction and transport [7].

The high nutritional value of rice products is determined by the breeding process based on the involvement of the widest range of genotypes and the use of the latest breeding methods, with an integrated approach, the use of modern postgenomic and cellular technologies, and the genomic approach. Various traditional approaches in breeding require effective phenotypic screening for the presence of traits of interest in terms of rice grain quality in breeding selection. Scientists attribute the breakthrough in rice breeding to the development of genomic approach mechanisms [12; 15]. However, the genomic approach to rice breeding also requires phenotyping of organisms when developing marking systems for target traits.

Thus, rice breeding based on the use of modern postgenomic and cellular technologies, as well as the genomic approach, is a tool for achieving success in expanding its assortment with valuable grain quality characteristics [12; 15]. The effectiveness of the methodology for assessing traits based on rice genotypes ensures an accelerated breeding process and high information content of the characteristics that are signs of interest.

The aim of the study was the phenotyping of samples of experimental BC_3 populations, the selection of sources of valuable signs of grain quality with further involvement in marker-mediated breeding work.

Purpose. To evaluate experimental populations of BC_3 rice based on physical characteristics of grains: size, vitreousness, and cracking, in order to carry out targeted selection based on phenotyping and genotyping data of promising plants – prototypes of varieties with specified characteristics in marker-assisted rice breeding.

Materials and methods

The material for the study (grain) was grown on the vegetation site of FSBSI "Federal Scientific Rice Centre", Krasnodar. The soil was taken from the experimental plot of Federal Scientific Rice Centre. The material of the study was the grain of the 3^{-rd} generation hybrids, BC_3 backcrosses from crossing white-grained and colored rice varieties with different grain shapes (round, round-oval, oval, elongated-oval, elongated, long). The parental forms were obtained from the Unique Scientific Installation (USI) "Collection of Genetic Resources of Rice, Vegetable and Melon Crops" of Federal Scientific Rice Centre (Russia, Krasnodar) (Table 1).

Table 1.

Rice varieties – parental forms, distribution by grain shape and color of the grain pericarp

Variety	Group of varieties by the grain form	Color of pericarp
Rubin	oval	red
Veles	oval	white
Alliance	oval	white
Mavr	prolonged	purple
Svetlana	long	white
Kurazh	prolonged	white
Gagat	long	purple
Red Blastonik	oval	red
Dihaploid Heibar	oval	red
Dig. lo-2327-10	prolonged	red
VNIIR 10163	oval	red
Khaw-sri-nin	long	red purple

The study involved hybrids from 15 combinations of crosses between parental forms.

Phenotyping of BC_3 samples for grain quality traits was performed on certified equipment in accordance with GOSTs and instructions for scientific instruments. Grain size was estimated by the mass of 1000 absolutely dry grains according to GOST 10842-89 “Grain of cereal and legume crops and oilseeds” using an ELVIZ-2 moisture analyzer, an ASESh-8-2 air-heat unit, an SLY-C automatic seed counter, and a Cas CUW-420H electronic laboratory scale. Grain vitreousity was estimated according to GOST 10987-76 “Grain. Methods for Determining Vitreousity”; grain fracturing in transmitted light using a DSZ-3 and DSZ-2M diaphragm.

The seeds of the previously isolated white-grained BC_3 samples were sown in vessels with 6 kg of soil. The main fertilizer was Pryanishnikov’s mixture: complex and mineral fertilizers: urea (46% active ingredient), nitroammophoska, double superphosphate (46% active ingredient). The harvesting was performed manually. When the grains reached full maturity, they were threshed from the panicles, the grain moisture content was brought to 14% and they were stored.

The heterosis index of hybrids was calculated using the formula of K.P. Svechin. Mathematical and statistical processing of data was carried out using calculations in Microsoft Excel.

Results

On a broad genetic basis, when crossing contrasting forms, new source material was obtained - experimental hybrid populations of BC_3 back-crosses. A significant range of variation in quality indicators allowed for successful selection to improve these traits. Rice grain was obtained by growing plants to full maturity of experimental populations obtained from crossing contrasting forms of BC_2 on a vegetation site. The total number of samples studied was 52 pcs.

The set of grain quality traits is the subject of study in fundamental, theoretical, and applied research in breeding programs. Crossbreeding programs aim to select valuable samples at the stages of the breeding process of varieties with high consumer merits. Traditional and genomic approaches to breeding require effective phenotypic screening with high information content for the presence of traits (genes) of interest in terms of rice grain quality in accelerated breeding selection.

The rice grain quality traits “size”, “vitreosity”, “fracturing” characterize both the consumer qualities of rice and the physical properties of the grain. In order to accelerate the breeding process using marker-mediated backcrossing for further molecular marking in experimental populations, an assessment of the samples was carried out according to grain quality traits (vitreosity, fracturing, size).

Previously, the authors proposed an algorithm for assessing experimental populations, including sequential determination of moisture, size, shape, vitreousity, fracturing with differentiation of samples into groups depending on the indicators of the traits. The work was carried out in accordance with the recommendations [10].

Due to the selection of parent forms with different quality traits, the BC_3 combination samples also differed in grain quality parameters. The results of the study of the grain size of the BC_3 samples are presented in Table 2.

Table 2.

Quality of BC_3 rice samples by the grain size

BC_3	Mass of 1000 a. d. grains, g			
	high ≥30,1		medium 20,3-30,0	
	min-max	number, pcs.	min-max	number, pcs.
1. Rubin/Veles//Veles/// Veles	-	-	22,4	1
2. Rubin /Alliance//Alliance///Alliance	-	-	22,6-25,1	13
3. Mavr/Svetlana//Svetlana///Svetlana	-	-	25,0-25,6	2
4. Mavr/Kurazh//Kurazh///Kurazh	-	-	24,8	1
5. Gagat/Svetlana//Svetlana///Svetlana	-	-	23,4	1
6. Red Blastonik/Veles//Veles///Veles	-	-	26,9-28,1	2
7. Red Blastonik/Alliance //Alliance///Alliance	-	-	24,4-27,1	2
8. Dihaploid Heibar/Veles//Veles///Veles	-	-	24,6-25,7	3
9. Dihaploid Heibar/Alliance//Alliance/// Alliance	-	-	25,6-25,8	2
10. Dihaploid k.2327/Veles// Veles///Veles	-	-	26,2	1
11. Dihaploid k.2327/Alliance//Alliance	30,3	1	23,8-30,0	12
12. VNIIR10163/Veles//Veles///Veles	-	-	24,8-27,3	4
13.VNIIR10163/Alliance//Alliance/// Alliance	-	-	25,6	2
14.Khaw-sri-nsn/Svetlana//Svetlana/// Svetlana	-	-	22,4-27,3	4
15. Khaw-sri-nsn/Kurazh//Kurazh///Kurazh	-	-	22,7-27,5	2

The grain size was low (medium) for all combinations. The variation range of the trait was insignificant in the combinations Mavr/Svetlana//Svetlana/// Svetlana (0.6 g), Dihaploid Heibar/Veles//Veles///Veles (1.1 g), Dihaploid Heibar/Alliance//Alliance///Alliance (0.2 g). For the remaining combinations, the variation of the values of the trait "mass of 1000 a.d. grains" was 2.2-4.9 g. In this group, the upper limit of grain size was represented by the samples of the following combinations: Red Blastonik/Veles//Veles///Veles (26.9-28.1 g), Dihaploid k.2327/Alliance//Alliance///Alliance (23.8-30.0 g). The last combination had one plant with a high mass of 1000 a.d. grains (30.3 g). Such samples are considered promising and are used for reseeding.

Based on the results of the evaluation of BC_3 samples, the best samples in terms of grain size were identified (Table 3). The range of variation of the trait was insignificant in the combinations Dihaploid Heibar/Veles//Veles///Veles (0.4 g), Dihaploid Heibar/Alliance//Alliance///Alliance (0.2 g), Rubin /Alliance//Alliance///Alliance (1.3 g) (Table 3); significant in combinatioms: Mavr/Svetlana//Svetlana///Svetlana (2.8 g), Red Blastonik/Veles//Veles///Veles (4.1 g), Dihaploid k.2327/Alliance//Alliance///Alliance (6.1 g), VNIIR10163/Veles//Veles///Veles (1.5 g).

Table 3.

Distribution of best BC_3 rice samples by grain size

BC_3	**Mass of 1000 a. d. grains, g**	
	medium 20,3-30,0	
	min-max	**number, pcs.**
2. Rubin /Alliance//Alliance///Alliance	23,2-24,5	3
3. Mavr/Svetlana//Svetlana///Svetlana	25,0-27,8	3
4. Mavr/Kurazh//Kurazh///Kurazh	24,8	1
5. Gagat/Svetlana//Svetlana///Svetlana	23,7	1
6. Red Blastonik/Veles//Veles///Veles	24,1-28,2	3
7. Red Blastonik/Alliance//Alliance///Alliance	27,3	1
8. Dihaploid Heibar/Veles//Veles/// Veles	25,5-25,9	2
9.Dihaploid Heibar/Alliance//Alliance///Alliance	25,7-25,9	2
10. Dihaploid k.2327/Veles// Veles///Veles	23,7	1
11. Dihaploid k.2327/Alliance//Alliance	23,9-30,0	9
12. VNIIR10163/Veles//Veles///Veles	24,7-26,2	2
13. VNIIR10163/Alliance//Alliance ///Alliance	25,9	1

According to the upper limit of grain vitreousity, promising samples were identified in the combinations Mavr/Svetlana//Svetlana///Svetlana with a mass of 1000 a.d. grains of 25.0, 25.8 and 27.8 g; Red Blastonik/Veles//Veles///Veles - 24.1, 24.3 and 28.2 g; Red Blastonik/Alliance//Alliance///Alliance - 27.3 g; Dihaploid k.2327 /Alliance//Alliance///Alliance - 23.9, 24.6, 25.0, 25.8, 27.0 and 30.0 g; VNIIR10163/Veles//Veles///Veles – 24.7, 26.2 g.

Vitreousity in samples of most combinations in the experiment was low (≤85%). In this group, at the upper limit of grain vitreousity, samples of combinations were distinguished: Khaw-sri-nsn/Svetlana//Svetlana///Svetlana (78-86%) and Khaw-sri-nsn/Kurazh //Kurazh///Kurazh (82-84%). In the remaining combinations, the values of the trait were average (85-93%). The range of variation of the trait was insignificant in the combinations Dihaploid Heibar/Alliance//Alliance///Alliance (2%), Dihaploid k.2327/Alliance//Alliance///Alliance (5%), VNIIR10163/Veles//Veles///Veles (3%), Khaw-srinsn/Kurazh //Kurazh///Kurazh (2%). In the remaining combinations, the variation of the values of the trait "vitreousity" was 7.0-19%.

Grain fracturing in most of the studied samples of combinations was noted as low (0.0-10.0%). Average values of the trait were typical for the samples of combinations

Rubin/Alliance//Alliance///Alliance (11-17%), Dihaploid Heibar/Veles//Veles///Veles (12%), Dihaploid k.2327/Alliance//Alliance///Alliance (14-15%), VNIIR10163/Veles//Veles///Veles (12-20%) (Table 4).

Table 4.

Quality of BC_3 rice samples by the traits of grain vitreousity and fracturing

BC_3	Vitreousity				Fracturing, %			
	medium 85-93		low ≤85		medium 10,1-30,0		low 0,0-10,0	
	min-max	number, pcs.	min-max	number, pcs.	min-max	number, pcs.	min-max	number, pcs.
1. Rubin/Veles//Veles///Veles	-	-	70	1	-	-	4	1
2.Rubin /Alliance//Alliance///Alliance	-	-	63-81	13	11-17	5	6-9	8
3. Mavr/Svetlana//Svetlana///Svetlana	86	2	-	-	-	-	5-8	2
4. Mavr/Kurazh//Kurazh///Kurazh	-	-	62	1	-	-	5	1
5. Gagat/Svetlana//Svetlana///Svetlana	91	1	-	-	-	-	5	1
6. Red Blastonik/Veles//Veles///Veles	87	1	77	1	-	-	3-8	2
7.Red Blastonik/Alliance//Alliance/// Alliance	-	-	74-81	2	-	-	6-8	2
8. Dihaploid Heibar/Veles//Veles///Veles	-	-	64-83	3	12	1	7-9	2
9. Dihaploid Heibar/Alliance//Alliance/// Alliance	91-93	2	-	-	-	-	5-9	2
10. Dihaploid k.2327/Veles// Veles///Veles	-	-	73	1	-	-	5	1
11. Dihaploid k.2327/Alliance//Alliance	87-92	11	71-82	2	14-15	3	4-8	10
12. VNIIR10163/Veles//Veles///Veles	89-92	2	77-80	2	12-20	2	5-9	2
13.VNIIR10163/Alliance//Alliance/// Alliance	-	-	77	2	-	-	4-7	2

14.Khaw-sri-nsn/ Svetlana//Svetlana/// Svetlana	-	-	78-86	4	-	-	8-10	4
15. Khaw-sri-nsn/Kurazh//Kurazh///Kurazh	-	-	82-84	2	-	-	7-8	2

The best samples by the traits of vitreousity and fracturing were selected (Table 5). The variation range of the “vitreousity” was 1-5%, “fracturing” - 1-6%, which was insignificant. According to the upper limit of grain vitreousity, promising samples were selected in the combinations Dihaploid Heibar/Alliance//Alliance///Alliance with vitreousity of 91, 93%; Dihaploid k.2327/Alliance//Alliance///Alliance - 88, 90, 93%; Gagat/Svetlana//Svetlana///Svetlana - 92%. According to the upper limit of grain fracturing, promising samples were identified in the combinations Rubin/Alliance//Alliance///Alliance, where fracturing was 4 and 5%, VNIIR10163/Alliance//Alliance ///Alliance – 5%; Mavr/Kurazh//Kurazh///Kurazh, Gagat/Svetlana//Svetlana///Svetlana; Dihaploid k.2327/Veles//Veles///Veles, where the value of the trait was 3%.

Table 5.

Distribution of best BC_3 rice samples by the traits of grain vitreousity and fracturing

BC_3	Vitreousity, %				Fracturing	
	medium, 85-93		low, ≤85		low, 0,0-10,0	
	min-max.	number, pcs.	min-max	number, pcs.	min-max	number, pcs.
1. Rubin/Veles//Veles///Veles	-	-	-	-	-	-
2. Rubin /Alliance//Alliance///Alliance	-	-	79-81	3	4-5	3
3. Mavr/Svetlana//Svetlana///Svetlana	86	2	82	1	3-7	3
4. Mavr/Kurazh//Kurazh///Kurazh	-	-	62	1	3	1
5. Gagat /Svetlana//Svetlana///Svetlana	92	1	-	-	3	1
6. Red Blastonik/Veles//Veles///Veles	88-89	2	77	1	3-9	3
7. Red Blastonik/Alliance//Alliance///Alliance	-	-	77	1	9	1
8. Dihaploid Heibar/Veles//Veles///Veles	-	-	83-85	2	9	2
9. Dihaploid Heibar/ Alliance//Alliance///Alliance			-	-	3-7	2
10. Dihaploid k.2327/Veles// Veles///Veles	-	-	85	1	3	1
11. Dihaploid k.2327/Alliance//Alliance	88-93	9	-	-	2-8	8
12. VNIIR10163/Veles//Veles///Veles	87	1	82	1	4-9	2
13. VNIIR10163/Alliance//Alliance///Alliance	-	-	77	1	5	1

The best (large grain size, vitreousity and low grain fracturing) were samples from the combinations Mavr/Svetlana//Svetlana///Svetlana and Dihaploid k.2327/Alliance//Alliance///Alliance.

The study examined the effect of the hybrid trait exceeding the trait value of the parental forms (Fig. 1-3). Heterotic effects in grain size were noted for the samples of the combinations Dihaploid k.2327/Alliance//Alliance – 114.0%, Red Blastonik/Veles//Veles///Veles - 104.5%, Mavr/Svetlana//Svetlana///Svetlana – 106.7%.

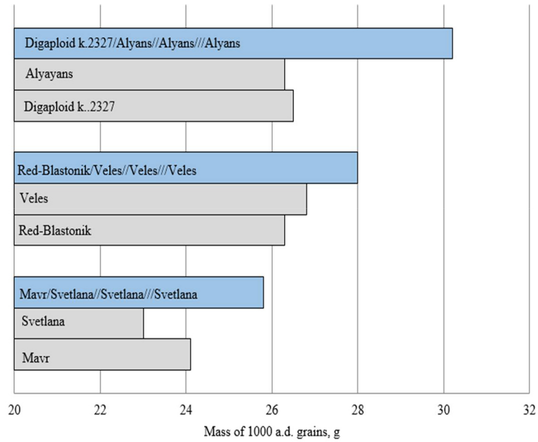

Fig. 1. Size of parental forms and BC_3 with heterotic effect to both parents (3.2.2, 6.1.4, 11.4.1).

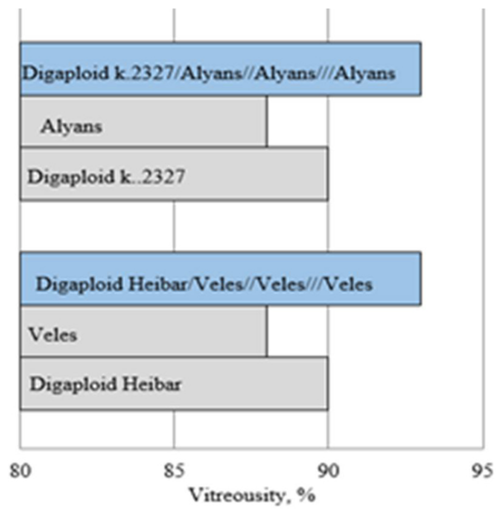

Fig. 2. Vitreousity of parental forms and BC_3 with heterotic effect to both parents (9.1.2, 11.8.3)

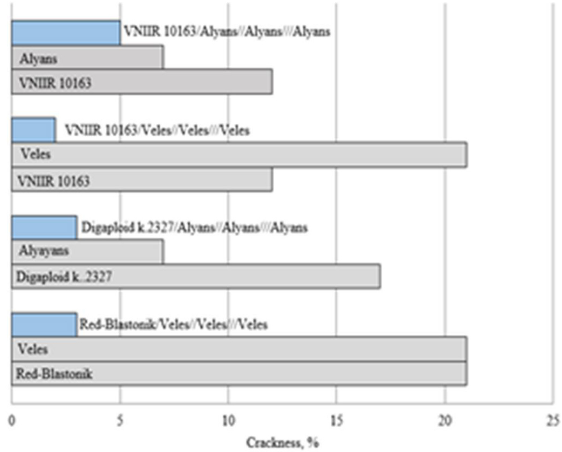

Fig. 3. Fracturing of parental forms and BC_3 with heterotic effect to both parents (6.1.4, 11.1.3, 12.3.2, 13.6.1)

In terms of grain vitreousity and fracturing, the following combinations showed excess values: Vitreousity: Dihaploid Heibar/Veles//Veles///Veles 105.7%; Dihaploid k.2327/Alliance//Alliance///Alliance % 105.7%; fracturing: Red Blastonik/Veles//Veles///Veles 700.0%; Dihaploid k.2327/Alliance//Alliance///Alliance 567.0%; VNIIR10163/Veles//Veles///Veles 1000%; VNIIR10163/Alliance//Alliance ///Alliance 2400%.

Identification of heterotic forms of rice hybrids with significant improvement in quality traits compared to parental forms allows optimizing breeding work.

Conclusions

In the study under conditions of phenotyping for grain quality traits within the framework of rice marker-assisted breeding, the differentiation of samples of experimental populations by grain size, vitreousity and fracturing was carried out. Promising samples of segregating BC_3 populations of 15 combinations with parental forms contrasting by quality traits, selected in a short period of highly effective phenotyping, were identified. The samples were divided into groups by mass of 1000 a.d. grains with a mass of ≥30.1 g (high), 20.3-30.0 g (medium); by vitreousity - 85-93% (medium), ≤85 (low); by fracturing - 10.1-30.0% (medium), 0.0-10.0% (low). The best samples were identified for 12 out of 15 combinations, the mass of 1000 absolutely dry grains was in the range of 23.2-30.2 g in the group of medium-weight samples, vitreousity and fracturing indices were 62-93% and 1-9%, respectively. The most promising samples were recognized as samples of BC_3 segregating populations: Mavr/Svetlana//Svetlana///Svetlana, Red Blastonik/Veles//Veles///Veles, Red Blastonik/Alliance//Alliance///Alliance, Dihaploid k.2327/Alliance//Alliance///Alliance, VNIIR10163/Veles//Veles///Veles. The samples were characterized by high indicators of grain size, vitreousity and fracturing.

The heterotic effect in terms of grain quality traits was noted in terms of grain size, vitreousity and fracturing in the following combinations: Dihaploid k.2327/Alliance//Alliance, Red Blastonik/Veles//Veles///Veles, Mavr/Svetlana//Svetlana///Svetlana in terms of grain size (IG=106-114%).

The results of the study will be used in accelerated breeding work to develop rice varieties with high indicators of grain size on new biotechnological methods in marker-assisted breeding practice of rice.

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