

# Vector– New Large-Grain Rice Variety of Domestic Breeding

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**Abstract.** Breeding of agricultural plants, rice in particular, is a fundamental factor in providing the country's population with a sufficient amount of high-quality products. Hence, the level of breeding achievements and agricultural technologies determines the food security of the country and the competitiveness of the industry in the international market. The scientifically based introduction of new, better varieties into production contributes to the growth of not only the yield, but also to an increase in the yield of products and an improvement in its quality. Therefore, the role of the variety as a means of agricultural production in modern agriculture is undoubtedly important. The paper presents the results of a breeding program on developing large-grain rice variety Vector, capable of forming a high grain yield - 9.0-10.0 t/ha with high technological indicators - 89.5% of head rice content with 69.8% of the total milling yield, which in conversion is approximately 62.4% of the head rice in the grain mass. At the same time, new rice variety Vector, according to grain size, belongs to the category of large-grain varieties with a mass of 1000 grains - 34.5 g with an average filminess of 17.7% and vitreosity - 83.5%. Also, during the study period (2020-2022) of the new rice variety Vector, resistance to the *Pyricularia* pathogen was found in natural conditions. With artificial infection, the disease development index averaged 37.0%, which corresponds to medium resistance. Based on the results of the work, the Vector variety was submitted for state testing (SVT). A comprehensive and positive assessment of the SVT will allow it to be entered into the State Register and recommend the variety for cultivation in the conditions of Krasnodar region and the Republic of Adygea.

## 1 Introduction

Rice is one of the valuable cereal crops cultivated on all continents, ranking second in terms of sown area after wheat, and in terms of gross grain yields it is equal to or even exceeds it in some years. Asia is the largest rice producer in the world, accounting for about 80% of the world's rice production [1, 6, 10].

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Breeding aimed at developing varieties of functional purpose (long-grain, large-grain, aromatic, glutenous, with colored pericarp, etc.) is the result of an increasing consumer demand of the population for a variety of products obtained from rice. In this regard, the efforts of breeders are aimed at developing and introducing into production rice varieties that allow using the genetic potential of the crop in terms of yield and resistance to stress factors with maximum efficiency, allowing expanding the range of rice cereals for cooking various dishes due to changed tastes of the population [3, 4]. Currently, in the State Register of Breeding Achievements of the Russian Federation, out of 53 rice varieties approved for use, 37 are of Kuban breeding, which occupy more than 80% of the rice sown area in the country [2, 15].

Along with resistance to stress factors, breeders are also working to improve the milled rice quality of new varieties. Priority areas of consumer demand appeared in the rice market. The range of popular rice-based dishes has expanded. Dishes of Asian (pilaf), Japanese (sushi, rolls), Italian (paella, risotto) cuisine require special varieties for their preparation. And the demand for such varieties is growing rapidly [5, 16]. The trend of recent years - a steady increase in demand for large-grain rice is fully satisfied by the results (development and introduction of varieties) of the relevant breeding programs.

In connection with the above, the purpose of our research is a comprehensive assessment of morpho-biological, biometric and technological traits of a new large-grain rice variety Vector for its transfer to the SVT.

## **2 Conditions, materials and methods of research**

The agro-climatic conditions of Krasnodar region allow the cultivation of all rice varieties of domestic breeding and provide the crop with the necessary amount of heat. The sum of effective temperatures  $t^{>15} \text{ }^{\circ}\text{C}$  for the frost-free period is 1000-1200  $^{\circ}\text{C}$  at an average daily temperature of about 23  $^{\circ}\text{C}$  for the summer period. The climate of the region is temperate continental. Precipitation is short-term, showery in nature. During rice growing season, they fall about 350-360 mm. The predominant soil type in the experimental plot of FSBSI "Federal Scientific Rice Centre" is meadow-chernozem, weakly leached, low-humus, heavy loamy on alluvial deposits. The humus content is 2.8-3.4%, gross nitrogen - 0.19%, total phosphorus - 0.16%, easily hydrolysable nitrogen compounds - 6.1 mg / 100 g and exchangeable ammonium - 0.78 mg / 100 g. Absorption capacity is low - 32.0-34.0 mg-eq./100 g of soil. The neutral reaction of the soil solution prevails, rarely weakly alkaline - pH = 7.2-7.6 [12, 13].

The object of research was rice initial material, developed and studied in all stages of the breeding process at FSBSI "Federal Scientific Rice Centre". Variety VNIIR 10281 was selected from a variety of genotypes based on the results of previous years of research and studied in more detail in the period 2020-2022 under the conditions of competitive variety testing (CVT) on the rice irrigation system of Federal Scientific Rice Centre. Research work was carried out in accordance with the methods of experimental work on breeding developed at Federal Scientific Rice Centre and GOST 15.101.98 - "Procedure for the implementation of research work" [7, 11].

For sowing experimental plots of competitive variety testing (CVT), a seeder with a Wintersteiger "Plotseed" central seeding machine was used. The plot area is 20 m<sup>2</sup> (length 15 m, width 1.4 m), four times repetition, placement - randomized repetitions, standard variety - Favorit. The number of rows in a plot is eight, the distance between rows is 15 cm, the distance between plots is 40 and 50 cm. Mineral fertilizers N120P60K40 were applied to the soil before sowing, one dressing in the tillering phase with N46 urea. Predecessors by years of research are soybean, winter wheat and black fallow, respectively. Sowing dates - I-II decades of May.

Plants in the amount of 10 pieces from each repetition of all varieties were selected at full maturity to determine morphological characteristics and biometric analysis.

The results obtained were processed by the methods of variance and covariance analyzes [14].

### 3 Results and discussion

The most important traits characterizing new rice genotypes are grain yield and quality of final product (milled rice). However, it should be noted that they are quite complex, since they are due to a large number of simpler traits and properties that determine them, the variability of which largely depends on the agroclimatic and agrotechnical conditions of crop cultivation. Therefore, with the help of variance and covariance analyzes of the data, we revealed significant differences between the variants of our experiment in developing the large-grain rice variety Vector. The low variability of the main economically valuable traits indicates the high adaptability of the variety and the reliability of the results obtained (Table 1).

**Table 1.** Comparative characteristic of rice varieties Vector (VNIIR 10281) and Favorit (standard), 2020-2022.

№	Trait	Vector					Favorit (st)					+/- to the standard on average
		2020	2021	2022	mean value	Cv, %	2020	2021	2022	mean value	Cv, %	
1	Yield, c/ha	8,8	9,4	9,2	9,13	3,3	8,1	9,0	9,2	8,70	6,0	0,43
2	LSD <sub>05</sub>	0,56	0,42	0,75								
3	Duration, days	130	121	122	124,3	4,0	123	116	120	119,6	2,9	4,7
4	Productivity of one growing day, kg/days/ha	60,4	77,7	75,6	71,2	13,3	66,3	78,0	76,7	73,6	8,7	-2,4
5	Grain content of agrophytocenosis, thous.pcs./m <sup>2</sup>	34,5	43,4	42,2	40,04	12,1	38,4	43,4	47,8	43,20	10,9	-3,2
6	Productive density, pcs./m <sup>2</sup>	58	108	92	86,0	29,7	91	107	133	110,3	19,2	-24,3
7	Plant height, cm	90,5	100,0	107,9	99,4	8,8	98,9	97,1	111,9	102,6	7,9	-3,2
8	Panicle length, cm	16,5	17,3	18,0	17,3	4,3	15,8	16,9	16,2	16,3	3,4	1,0
9	Total number of spikelets, pcs	148	177	127	150,7	16,6	125	166	82	124,4	33,7	26,3
10	Panicle density, pcs./cm	11,2	12,3	8,3	10,6	19,5	9,2	12,0	6,7	9,3	28,5	1,3
11	Grain sterility, %	20,2	16,4	14,6	17,1	16,8	14,4	18,2	23,9	18,8	25,4	-1,8
12	Grain length-to-width ratio (l/b)	2,3	2,2	2,3	2,27	2,5	2,3	2,2	2,3	2,27	2,5	0
13	Mass of 1000 grains at 14% moisture, g	32,5	35,3	35,8	34,5	4,8	34,0	35,5	35,7	35,0	2,6	-0,5
14	Filminess, %	17,4	16,8	17,1	17,1	1,8	17,6	18,4	18,4	18,1	2,5	-1,1
15	Vitreosity, %	82	85	86	84,3	2,5	81	90	88	86,3	5,5	-2,0
16	Total milling yield, %	69,4	72,2	69,6	70,4	2,2	68,8	70,2	65,4	68,1	3,6	2,3
17	Head rice content, %	91,9	85	84,7	87,2	4,7	77,3	81,2	81,3	79,9	2,9	7,3
18	Head rice content in grain according to ISO, %	63,8	61,4	59,7	61,6	3,9	53,2	57,0	53,2	54,4	4,0	7,2

It is well known that yield is the most important quantitative trait, prevailing over all others in its continuous methodological and analytical improvement. The table shows that the variety Vector during the years of study formed a yield higher than or equal to the standard, i.e. in 2020, a significant excess was revealed - 8.8 t/ha. On average, over three years, the yield of the new variety was 9.13 t/ha with a low variability of the trait - 3.3%. This is due to the maximum realization of the potential of panicle grain capacity, the number of productive stems with the duration of the growing season - 124 days.

The calculation of the integral indicators that determine the yield - the productivity of one growing day and the grain content of agrophytocenosis, showed that the Vector accumulated 71.23 kg of dry matter / days / ha during the growing season, which is within the standard with an average grain content of agrophytocenosis - 40.04 thous. pcs./m<sup>2</sup>. The variability of these traits is average - 13.3 and 12.1%, respectively, due to the dynamism of the constituent elements (the duration of growing season, grain content of panicles, productive density and yield).

The total number of grains per panicle characterizes the yield potential of varieties and possible ways of its realization. The grain content of the variety Vector for three years averaged 150.7 pieces, which is 26.3 pieces higher than that of the standard. Hence, with almost the same grain sterility - 17-18%, the new variety forms a larger number of grains. The average degree of variability of this trait - 16.6% indicates the high adaptability of the variety Vector. It should be noted that the high grain content is a consequence of the increased panicle density. The density of the main panicle of variety Vector was 10.6 grains per 1 cm of the panicle, with an average length of 17.3 cm.

The mass of 1000 grains is one of the most important traits that characterize a variety, and is also a reliable criterion for belonging to a certain group according to grain size (short-grain, medium-grain and large-grain) [1, 8]. In terms of grain size, the variety Vector should be attributed to the group of large-grain varieties with a mass of 1000 grains - 34.5 g. The trait is slightly variable over the years - 4.8%.

Total milling yield and head rice content are the main technological quality indicators that characterize economic efficiency of rice varieties during grain processing [9]. The variety Vector has high indicators of total milling yield and head rice content in the grain (according to ISO) – 70,40 и 61,63 % respectively with a similar filminess and vitreosity. Low variability (< 10 %) of technological indicators of grain and mulled rice quality of new variety shows their stability.

An important aspect of the optimal combination of traits in one plant is the nature and closeness of their correlations. It is known that the relationship of economically valuable traits in different genotypes has its own specifics (Table 2).

**Table 2.** Correlation of main traits of rice varieties Vector and Favorit (st), 2020-2022

Q	Mean	Standard	Q
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	value	deviation	1	2	3	4	5	6	7	8	9	10
Vector (VNIIR 10281)												
1	9,13	0,31										
2	71,23	9,44	0,975									
3	40,04	4,83	0,978	0,999								
4	99,5	8,71	0,694	0,835	0,829							
5	10,6	2,07	0,079	-0,142	-0,130	-0,663						
6	150,7	25,06	0,414	0,203	0,215	-0,368	0,940					
7	34,53	1,78	0,890	0,968	0,965	0,946	-0,385	-0,048				
8	84,3	2,08	0,839	0,938	0,934	0,974	-0,477	-0,149	0,995			
9	17,1	0,31	-0,999	-0,975	-0,978	-0,694	-0,079	-0,414	-0,890	-0,839		
10	70,40	1,56	0,796	0,644	0,653	0,117	0,666	0,880	0,432	0,338	-0,796	
11	61,63	2,06	-0,726	-0,859	-0,853	-0,999	0,628	0,326	-0,960	-0,983	0,726	-0,162
Favorit (st)												
1	8,77	0,59										
2	73,67	6,41	0,963									
3	43,22	4,73	0,950	0,830								
4	102,6	8,11	0,546	0,300	0,781							
5	9,3	2,65	-0,138	0,134	-0,442	-0,905						
6	124,4	41,90	-0,182	0,090	-0,481	-0,923	0,999					
7	35,07	0,93	0,998	0,978	0,928	0,492	-0,075	-0,119				
8	86,3	4,73	0,927	0,994	0,762	0,192	0,243	0,201	0,949			
9	18,1	0,46	0,985	0,995	0,882	0,395	0,033	-0,011	0,994	0,977		
10	68,13	2,47	-0,396	-0,134	-0,664	-0,986	0,964	0,975	-0,337	-0,023	-0,234	
11	54,47	2,19	0,345	0,585	0,033	-0,598	0,882	0,860	0,404	0,672	0,500	0,725

Note: Q – trait;  
 1 – yield, t/ha;  
 2 – productivity of one growing day, kg/days/ha;  
 3 – grain content of agrophytocenosis, thous.pcs./m<sup>2</sup>;  
 4 – plant height, cm;  
 5 – main panicle density, pcs./cm;  
 6 – total number of spikelets, pcs;  
 7 – mass of 1000 grains, g;  
 8 – vitreousity, %;  
 9 – filminess, %;  
 10 – total milling yield, %;  
 11 – head rice content (according to ISO), %.

Correlation analysis of the data revealed that the yield of variety Vector has a positive and close relationship with the productivity of one growing day of vegetation, grain content of agrophytocenosis, mass of 1000 grains, vitreousity and the total milling yield - 0.975, 0.978, 0.890, 0.839 and 0.796, respectively. Hence, it should be assumed that in 95-63% of cases, conjugate traits are genetically determined. A similar picture is observed in the standard variety Favorit. Negative high correlation of yield with filminess and head rice content in the grain (ISO) - -0.999 and -0.726, respectively, should be noted. From this it follows that an increase in yield above the optimum (8-9 t/ha) in 99 and 53% may lead to a

decrease in grain and milled rice quality. Here, in variety Favorit, we observe a positive, but weak correlation with the head rice content - 0.345.

Table 2 shows that the plant height of new variety positively and closely correlates with the mass of 1000 grains and vitreousity - 0.946 and 0.974. However, there was a close negative relationship with the head rice content - -0.999, which may be a consequence of a similar correlation between plant height and grain filminess, but to a lesser extent - -0.694, since the relationship of these quality indicators in 53% of cases is of a genetic nature. In the standard, the relationship of these traits is expressed weakly and in a different way.

It should be noted that in variety Vector, with a positive average degree of correlation of the total milling yield with the productivity of one growing day of and the grain content of agrophytocenosis - 0.644 and 0.653, there is a negative close relationship of the latter with the head rice content - -0.859 and -0.853. A close negative relationship of these integral yield indicators with filminess was also noted - -0.975 and -0.978.

It has been established that the grain size of variety Vector closely and negatively correlates with filminess (-0.890) and head rice content in the grain (-0.960), and positively with vitreousity (0.995). This indicates a high degree of genetic determination of conjugated traits - 79, 92 and 99%. In variety Favorit, the opposite nature of the relationship of these traits was noted.

Filminess has a close negative relationship with the total milling yield - -0.796 and positive with the head rice content in the grain - 0.726. In the standard variety, the nature of the relationship is similar.

Based on the results of a multi-year comprehensive assessment of new rice genotypes under the conditions of competitive variety testing, we have identified a promising large-grain variety Vector (VNIIR 10281), which was characterized in detail and transferred to SVT in 2022. Below is a description of a new rice variety, according to the generally accepted form of description.

### **Characteristic of new rice variety Vector (VNIIR 10281)**

Rice variety Vector (VNIIR 10281) was developed by hybridization method and multiple individual selections from hybrid combination KP-08-153/SP-08-1555.

Species – *Oryza sativa* L., subspecies – subsp. Japonica kato, botanical variety – var. italica Alef.

Belongs to medium-late ripening group with a duration of growing period - 121-124 days.

Plant height - 95-97 cm. Bush is compact, erect, productive tillering - 2,0-2,5 shoots. The stem is strong, hollow, of medium thickness, resistant to lodging (8-10 points) and shedding. Suitable for mechanized harvesting.

The leaves are medium dark green, intermediate in size, slightly pubescent. The flag leaf is of medium length and width, departing from the axis of the stem by 30-40°.

The panicle is compact, vertical, slightly spreading in the phase of full ripeness, 16-18 cm long, with a grain content of 185-195 spikelets and a density of 10-12 spikelets per 1 cm of length. The stalk of the panicle is of medium thickness, strong, protruding from the leaf sheath by 3-5 cm. The lemmas are straw-yellow in color, medium pubescent, without awns (Fig. 1).

The grain is large, elongated. The mass of 1000 grains at 14% moisture is 34.0-35.0 g. Grain length-to-width ratio (l/b) is 2.2. Milled rice is white, vitreousity - 80-86%, filminess - 17.0-18.8%; the total milling yield is 70.0-72.2%, head rice content is 91.0-92.0%.

Cooked rice is white, crumbly, the taste is good, water-uptake coefficient is 4.9-5.0, water absorption coefficient is 2.9. Grain is recommended for cooking garnishes, dishes of the Spanish and Italian cuisine (risotto, paella).



**Fig. 1.** Large-grain rice variety Vector (VNIIR 10281).

The variety is moderately resistant to blast (IDD 35-37%) with artificial infection. Cold tolerance is average (3.5 points out of 5).

Yield potential – 8-10 t/ha.

Distinctive feature of variety: medium-late ripening, large-grain variety, resistant to lodging, increased head rice content.

Mineral fertilizers are applied at the rate of:

- seed fallow - N130-140 P50.

The optimal sowing-flooding period is the I-II decade of May.

The seeding rate is 6.0-7.0 million germinating grains per 1 ha (200-230 kg/ha).

## 4 Conclusion

During the development of a new initial material and its further study, a promising large-grain rice variety Vector (VNIIR 10281) was identified, which has a high yield of 9.13 t/ha with its low variability of 3.3%. This is due to the ability of the variety to maximize the potential of the grain content of agrophytocenosis - 40.01 thousand pieces / m<sup>2</sup> with the optimal duration of the growing season - 124 days. The probability of genetic determination of these traits is 96%, with the degree of their positive correlation being 0.978.

The high level of stability and breeding value of variety Vector is ensured by its resistance to the main bio- and abiotic factors, and it also has a number of advantages in terms of some economically valuable traits. The new variety is characterized by a combination of relatively high indicators of the total milling yield and the head rice content in both milled rice and grains (70.4, 87.2 and 61.1%, respectively) with a mass of 1000 grains - 34.5 g. However, a negative close relationship between grain size and the head rice content (ISO) - -0.960 is due to its similar correlation with filminess - -0.890, since the probability of genetic determination of the last traits is 53% with their positive relationship - 0.726.

Slight variability of the technological indicators of grain and milled rice quality of variety Vector - 1.8-4.7% with a stable high yield is an important adaptive property both for its cultivation in various agro-climatic zones of Krasnodar region and neighboring Republics (Adygea, Dagestan, Chechnya) in order to increase gross yields, and for use in breeding programs as an initial material for development of large-grain forms (lines) with excellent taste and valuable culinary qualities.

According to the results of a multi-year comprehensive assessment, the medium-late ripening large-grain rice variety Vector, which optimally combines biometric and technological traits, was submitted in 2022 to the State Variety Test.

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