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Variability of traits and their correlation in different rice genotypes in dynamically changing climate conditions

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Abstract

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The conditions of rice vegetation for four years (2014-2017) were analyzed. It was found that the air temperature and the sum of the effective temperatures above 15 degrees had deviations from the average multiyear in different phases of growth and development. But on the whole they contributed to the normal formation of rice yield. In experiments on rice breeding in a competitive trial, five new rice varieties were studied in comparison with the universal variety Rapan in nine parameters. It is found that VNIIR 10257 significantly exceeded the standard by yield (by 9.9 c/ha). Variability of yields by years was average (CV = 12.9-21.1%). The variability of yield at the level of the standard Rapan (CV = 14%) is noted in VNIIR 10262 and VNIIR 10257. Vegetation period in the studied genotypes was characterized by low variability, both the average by experiment (CV = 3.5-6.6%), and the average annual for each variety (CV = 0.4-6.2%).

The mass of 1000 grains in Rapan and VNIIR 10243 strongly correlated positively with average daily temperatures (r = 0.77 and 0.82, respectively); and in VNIIR 10257 it was negative (r = -0.80). A close high correlation of the content of head rice content with heat supply was found in Rapan and VNIIR 10262 (r = 0.84 and 0.73). The remaining varieties were characterized by moderate and low correlation of the trait. A close positive relation between head rice content and the yield is observed in VNIIR 10243 (r = 0.97). In other varieties, the connection between yield and quality is highly negative. Based on the analysis of the obtained data, VNIIR 10257 (high-yield round-grained) and VNIIR 10262 (large-grained with high technological parameters of grain and milled rice quality) were transferred to the State Variety Test (SVT). New varieties showed high productivity and have a reaction similar to the standard for the variability of the main economic-valuable traits, which gives grounds to talk about their wide adaptive capabilities.

Keywords: rice breeding; new variety; agroclimatic conditions; variability; variability traits; traits; trait-environment; correlation

Introduction

The requirements for increasing the stability of crop yields increase with the increase of the latter, and maintaining it in different weather conditions becomes more and more complicated. The strategy in plant breeding is based on predictable long-term changes in the external environment, i.e. certain agroclimatic features of a particular region (Zhuchenko, 2004). Unfavorable agroclimatic conditions are one of the important reasons for the high variability in crop yields in most of the Russian regions (Zhuchenko, 2009).

The problem of interaction of the genotype with the environment appears already at the level of ontogenesis, which leads to the development of the genotype in a certain direction in the breeding process as a whole. Breeding is a process of microevolution, compressed in time and space (Kadyrov, 1991).

Depending on the tasks assigned to the breeder, the breeding is carried out by individual, several or many traits. One-sided breeding for one or another trait without regard to its connection with other plant characteristics may have negative consequences if as a result of it the physiological coherence of the processes influencing the formation of productivity and yield is disturbed. In order for a new variety to meet high requirements, it is necessary to conduct breeding for a set of traits. The main of them, on which the attention must be paid to during breeding, are yield (productivity), high quality of products, resistance to diseases and pests, and suitability for mechanized cultivation (Gulyaev & Dubinin, 1969).

Materials and Methods

Varieties of competitive testing served as a material for the studies. Sowing of plots was carried out with the help of a seeder with the central seeding machine "Wintersteiger Plotseed". The registration area of the plot is 20 m^2 in a four-fold repetition with a seeding rate of 7 million viable grains per one ha. Plot allocation is a randomized repetition (Ostapenko, 2017). The standard was the medium-ripening universal variety Rapan.

Experiments were laid on rice irrigation system of experimental production department of FSBSI ARRRI for the period 2014-2017. Sowing time – first decade of May.

Seed plots were harvested manually, and the rest – by a small Korean combine DKS-515 directly.

Technological characteristics of grain and milled rice were determined by GOST 10843-76, GOST 10987-76 and "Guidelines for evaluating rice grain quality" (Romanov et al., 1983).

To compare the degree of variability of a number of traits, the coefficient of variation (CV) was used. According to Dospekhov (1979) and Dzyuba (2007), variability is considered to be insignificant if the coefficient of variation does not exceed 10%; average if CV is above 10%, but less than 20%, and significant if the coefficient of variation is more than 20%.

Correlation of economically valuable traits and technological indicators of grain and milled rice quality is determined depending on climatic factors of the environment (Sheudzhen & Bondareva, 2015).

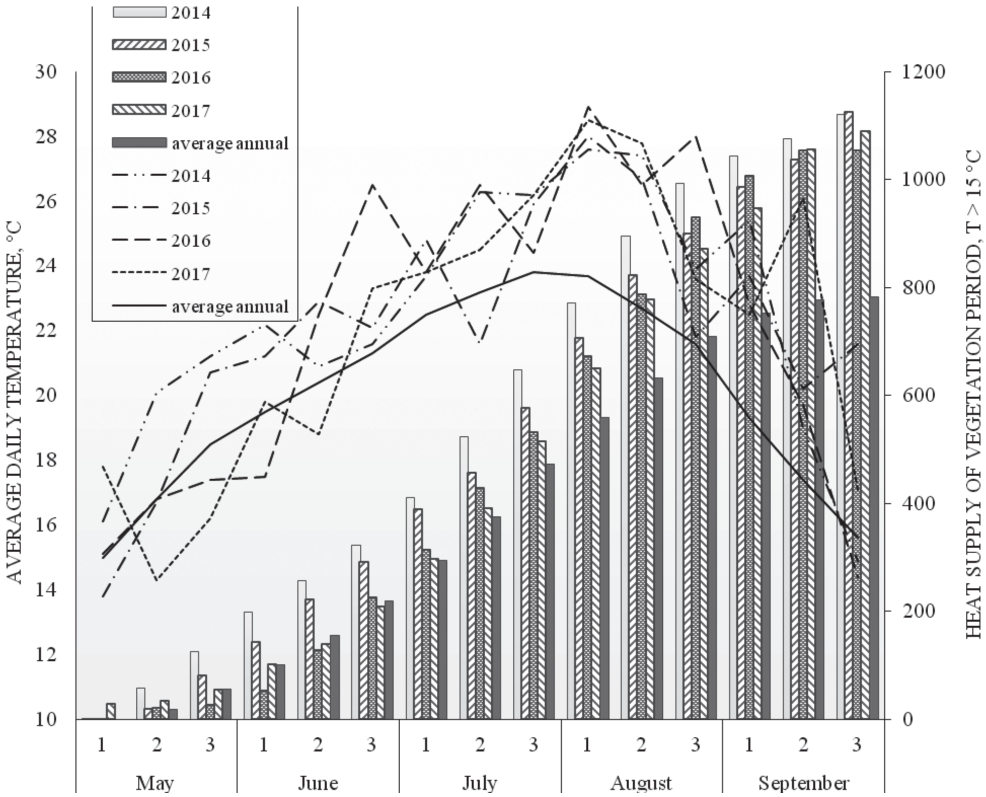

Fig. 1. Temperature regime of rice vegetation period, 2014-2017

Results and Discussion

In the solution of tasks of modern crop production associated with a steady increase in its productivity and profitability, development and widespread use of new varieties takes central place. According to available estimates, the contribution of breeding to the increase in crop yields over the last decades is estimated at 30-70%, and taking into account possible climate changes, the role of breeding will increase (Zhuchenko, 2004).

To further study the nature of relationship between environmental climatic factors and economically valuable traits in the presented rice genotypes, we studied the dynamics of the mean daily air temperatures and the heat supply for the vegetation period during 2014-2017. (Fig. 1).

Average daily temperature during the study period was different from the long-term data. Thus, in seedling stage (II-III decade of May) in 2014 and 2015, the average daily temperature of air exceeded the long-term values by almost 5°C, which could not but affect seedling vigour. In the same period in 2016-2017, temperature was below the average annual temperature by 2-3°C until the third decade of June.

The average daily temperatures in June 2016-2017 favorably contributed to the tillering stage, but the minimum temperatures of the month below 15°C influenced the increase in the tillering period, but allowed the formation of a larger number of spikelets in the rudimentary panicle during the differentiation of the cone of growth, and determined the density of productive stalk.

The heat supply of rice vegetation in 2014-2017 was significantly higher than the mean long-term values. But the dynamics of average daily air temperatures and the number of precipitation were characterized by unevenness. There were periods of vegetation with a shortage of effective air temperatures, which could not but affect the formation of structural elements of yield and quality indicators of grain and milled rice. Thanks to the timely conducted agrotechnical methods, a sufficiently high crop yield was obtained.

Some economically valuable traits of rice are difficult to combine in one genotype (for example, productivity and grain quality). Therefore, taking into account the importance of a harmonious combination of a complex of such traits, it becomes evident that its practical solution depends entirely on the success of breeding work.

Fluctuations of such climatic factors of environment as the average decadal temperature (DT) and the sum of effective air temperatures above 15°C (SET) inevitably affect the passage of stages of development of rice plants and the duration of the growing season as a whole.

We studied the characteristics of new varieties in many indicators, which later determine their suitability for cultivation in Krasnodar region and Republic of Adygea (Table 1).

The vegetative period in the studied genotypes was characterized by low variability, as the average crop yield (CV = 3.5-6.6%), and the average annual for each variety (CV = 0.4-6.2%). This is evidence of intraparietal homogeneity for this trait, which may be one of the indicators characterizing the homozygous state of genotypes. Varieties in the experiment are clearly subdivided: medium-ripening Rapan (113 days) and other medium-long ripening (125-128 days) with minor fluctuations in years.

The yield of varieties in the experiment was from 80.4 (VNIIR 10262) to 97.2 c/ha (VNIIR 10257). A significant increase of variety Rapan (st) (87.3 c/ha) by 9.9 c/ha was noted in VNIIR 10257 (97.2 c/ha) with LSD_{05} = 7.1 c/ha.

Variability of yields for almost all varieties by years turned out to be average (CV = 12.9-21.1%). Weakly variable yields were noted in KP-15-270 (CV = 7.9%).

Grain content of the agrophytocenosis and the productivity of one day of vegetation are the calculated indices subjectively determining the biological potential of the crop in the accumulation of dry matter per unit area.

An insignificant coefficient of variation in grain content of agrofitocenosis was noted in the varieties VNIIR 10257 and KP-15-270 (CV = 6.5 and 4.5%), while in the others it was medium – 14.5-22.1%. The trait values in physical quantities varied on average from 29.2 to 54.3 thousand pieces/m^2. Variety VNIIR 10257 exceeded the Rapan standard by 14.7 thousand pieces/m^2. This indicates the potential for a new variety VNIIR 10257 to form a larger number of grain per unit area.

Productivity of the vegetation day – characterizes the ability of the variety to synthesize dry matter per unit of time (per 1 day). The ratio of yield to the duration of the growing season determines this ability and is expressed in kg/day/ha. The highest values of the trait were observed in varieties Rapan (st) and VNIIR 10257 – 77.4 and 77.8 kg/day/ha, respectively. In other varieties, the productivity of the vegetation day averaged within 63.1-68.9 kg/day/ha.

The variability of this trait is not significant in KP-15-270 – 7.8%. In the remaining varieties variability was average – 10.4-18.9%.

The number of filled grain, formed on the main panicle, averaged 143.5-168.6 pieces. The average variability of the trait was noted in VNIIR 10262 and VNIIR 10244 (CV = 17.4 and 18.8%); insignificant – in other varieties KP (CV = 4.1-9.4%).

The mass of 1000 grains is a slightly variable trait. Its insignificant variability under different growing conditions

(CV = 0.2-3.2%) characterizes the genetic nature of the trait and the homozygosity of the varieties. Two large-grain varieties (VNIIR 10243 and VNIIR 10262) with a mass of 1000 grains – 30.9 g were studied in our experiment; and four medium-grained ones with a mass of 1000 grains – 26-29 g.

The average filminess of the studied rice varieties was 17.2-19.4%, showing a coefficient of variation of 0.6-3.6%. The average variability of the trait was 3.68-5.59%.

Vitreousity (or the structure of endosperm) affects total milled rice, its presentation and largely determines its technological and cooking properties. The value of the trait in the varieties in the experiment is high (89-98.3%). The coefficient of variation by varieties was insignificant – 0-10.4%. Absolute consistency of the trait was distinguished in KP-15-270 (CV = 0%).

Head rice content is one of the main technological indicators of milled rice quality, which characterizes the economic efficiency of rice varieties during grain processing. The value of the trait for the years of study averaged 84.0-91.4%, and its variability ranged between 1.7-8.2% and was insignificant. High values of head rice content indicate the ability of new varieties to form a full-fledged, high-quality and filled grain, despite weather fluctuations.

According to researchers, rice productivity (yield) is dependent on agroclimatic conditions (Galkin & Zaytsev, 1982; Sheudzhen, 2005; Sheudzhen et al., 2007). But it should be noted that it is not always possible to catch this connection, since it is difficult to establish this relationship between all the interacting factors of the environment and the individual traits of the genotypes under study, given their diversity. In our studies, we tried to determine the relationship of traits in different rice varieties and their relationship to heat supply and average daily air temperature (Table 2).

The presented correlation analysis indicates the heterogeneity of relationships. During the period of research (2014-2017) in variety Rapan there was a close but negative correlation (r = -0.75), in KP-15-270 a positive relationship

Table 1. Variability of economically-valuable traits of new rice varieties, CV, %

Variety	Trait	Year				Mean value	CV, %
		2014	2015	2016	2017		
Rapan (st)	Duration, days.	103	119	116	113	112.7	6.2
	Yield, c/ha	73.1	86	102.9	87.3	87.3	14.0
	Grain content in agrophytocenosis, thous.pcs./m^2	31.0	36.5	51.7	39.2	39.6	22.1
	Productivity of vegetation day, kg/day/ha	71.0	72.3	88.7	77.5	77.4	10.4
	Number of filled grain from main panicle, pcs.	140.3	176.5	155.2	157.3	157.3	9.4
	Mass of 1000 grains, g	28.5	26.4	27.1	27.3	27.3	3.2
	Filminess, %	19.4	19.2	19.5	19.4	19.4	0.6
	Vitreousity, %	98	97	96	97	97.0	0.8
	Head rice content, %	95.2	96.9	82.0	91.4	91.4	7.3
VNIIR 10243	Duration, days.	125	131	128	128	128.0	1.9
	Yield, c/ha	58	91.5	93.3	80.9	80.9	20.1
	Grain content in agrophytocenosis, thous.pcs./m^2	21.4	32.1	32.7	30.6	29.2	18.1
	Productivity of vegetation day, kg/day/ha	46.4	69.8	72.9	63.2	63.1	18.8
	Number of filled grain from main panicle, pcs.	150.3	141.7	167.2	153.1	153.1	6.9
	Mass of 1000 grains, g	31	30.9	30.9	30.9	30.9	0.2
	Filminess, %	18.3	17.2	17.8	17.8	17.8	2.5
	Vitreousity, %	99	98	98	98	98.3	0.5
	Head rice content, %	84.6	92.9	91.2	89.6	89.6	4.0
VNIIR 10244	Duration, days.	122	128	129	126	126.3	2.5
	Yield, c/ha	67.2	99.9	101.4	72.4	85.2	21.1
	Grain content in agrophytocenosis, thous.pcs./m^2	26.1	38.4	41.2	31.6	34.3	19.9
	Productivity of vegetation day, kg/day/ha	55.1	78.0	78.6	57.5	67.3	18.9
	Number of filled grain from main panicle, pcs.	179	115.2	147.6	172.7	153.6	18.8
	Mass of 1000 grains, g	28.4	30.2	28.3	28.5	28.9	3.1
	Filminess, %	18.3	17.5	18.1	17.4	17.8	2.5
	Vitreousity, %	97	78	94	92	90.3	9.3
	Head rice content, %	93.8	78.3	81.7	85.7	84.9	7.9

Table 1. Continued

VNIIR 10257	Duration, days.	122	128	125	125	125.0	2.0
	Yield, c/ha	82	112.8	96.7	97.2	97.2	12.9
	Grain content in agrophytocenosis, thous.pcs./m^2	50.6	58.8	52.6	55.3	54.3	6.5
	Productivity of vegetation day, kg/day/ha	67.2	88.1	77.4	77.8	77.8	10.9
	Number of filled grain from main panicle, pcs.	151.2	183.5	171.2	168.6	168.6	7.9
	Mass of 1000 grains, g	25.6	26	26.1	25.9	25.9	0.8
	Filminess, %	20.1	18.8	18.5	19.1	19.1	3.6
	Vitreousity, %	94	75	95	92	89.0	10.6
	Head rice content, %	91.8	86.9	90.3	89.7	89.7	2.3
VNIIR 10262	Duration, days.	125	120	128	126	124.8	2.7
	Yield, c/ha	64.4	92.1	91.3	73.7	80.4	16.9
	Grain content in agrophytocenosis, thous.pcs./m^2	25.3	38.7	33.9	33.8	32.9	14.5
	Productivity of vegetation day, kg/day/ha	51.5	76.8	71.3	58.5	64.5	17.9
	Number of filled grain from main panicle, pcs.	178.3	119.6	142	134.2	143.5	17.4
	Mass of 1000 grains, g	30.5	31.8	30.7	30.7	30.9	1.9
	Filminess, %	17.2	16.6	17.7	17.1	17.2	2.6
	Vitreousity, %	98	96	97	98	97.3	1.0
	Head rice content, %	90.1	86.4	74.1	85.5	84.0	8.2
KP-15-270	Duration, days.	125	125	126	125	125.3	0.4
	Yield, c/ha	86.3	92.9	89	76.9	86.3	7.9
	Grain content in agrophytocenosis, thous.pcs./m^2	39.7	46.9	40.3	36.3	40.8	4.5
	Productivity of vegetation day, kg/day/ha	69.0	74.3	70.6	61.5	68.9	7.8
	Number of filled grain from main panicle, pcs.	155.2	150	151.5	164.1	155.2	4.1
	Mass of 1000 grains, g	27.9	28.1	28.3	27.4	27.9	1.4
	Filminess, %	19.3	19.1	19.2	19.6	19.3	1.1
	Vitreousity, %	98	98	98	98	98.0	0.0
	Head rice content, %	90.4	89.8	92.6	88.9	90.4	1.7
Mean value	Duration, days.	120.4	125.2	125.3	123.8	123.7	
	Yield, c/ha	71.83	95.87	95.77	81.41	86.22	
	Grain content in agrophytocenosis, thous.pcs./m^2	32.35	41.90	42.07	37.80	38.53	
	Productivity of vegetation day, kg/day/ha	60.03	76.55	76.58	66.00	69.79	
	Number of filled grain from main panicle, pcs.	159.05	147.75	155.78	158.34	155.23	
	Mass of 1000 grains, g	28.66	28.90	28.57	28.46	28.65	
	Filminess, %	18.77	18.07	18.47	18.39	18.42	
	Vitreousity, %	97.33	90.33	96.33	95.33	95.00	
	Head rice content, %	90.99	88.53	85.32	88.45	88.32	
CV, %	Duration, days.	6.56	3.50	3.50	4.09		
	Yield, c/ha	13.70	8.96	5.31	10.57		
	Grain content in agrophytocenosis, thous.pcs./m^2	30.85	21.64	18.44	22.05		
	Productivity of vegetation day, kg/day/ha	15.73	7.62	8.06	12.80		
	Number of filled grain from main panicle, pcs.	9.16	17.47	6.65	7.98		
	Mass of 1000 grains, g	6.18	7.66	6.13	6.43		
	Filminess, %	5.03	5.59	3.68	5.44		
	Vitreousity, %	1.62	10.90	1.55	2.85		
	Head rice content, %	3.71	6.56	7.75	2.43		

Note: CV – Coefficient of variation, %.

Table 2. Correlation analysis of rice varieties in competitive testing, 2014-2017

Variety	Q	Mean value	Disper-sion	1	2	3	4	5	6	7	8	9	10
Rapan (st)	1	22.2	0.2										
	2	1090.0	38.8	0.63									
	3	112.7	6.9	-0.80	-0.26								
	4	87.3	12.2	-0.67	-0.75	0.71							
	5	39.6	7.6	-0.70	-0.72	0.76	0.99						
	6	77.4	8.1	-0.46	-0.85	0.40	0.93	0.90					
	7	157.3	14.9	-0.66	0.12	0.90	0.34	0.40	-0.04				
	8	27.3	0.9	0.77	0.13	-0.99	-0.59	-0.65	-0.25	-0.96			
	9	19.4	0.1	0.15	-0.66	-0.36	0.40	0.33	0.71	-0.73	0.50		
	10	97.0	0.8	0.71	0.72	-0.76	-0.99	-0.99	-0.90	-0.41	0.65	-0.33	
	11	91.4	6.7	0.33	0.84	-0.24	-0.85	-0.81	-0.99	0.20	0.09	-0.82	0.81
VNIIR 10243	1	22.2	0.2										
	2	1090.0	38.8	0.63									
	3	128.0	2.4	-0.71	0.03								
	4	80.9	16.2	-0.82	-0.43	0.84							
	5	29.2	4.2	-0.81	-0.32	0.91	0.99						
	6	63.1	11.8	-0.82	-0.48	0.81	0.99	0.98					
	7	153.1	10.6	-0.15	-0.81	-0.33	0.23	0.09	0.29				
	8	30.9	0.0	0.82	0.40	-0.87	-0.99	-0.99	-0.99	-0.18			
	9	17.8	0.4	0.68	-0.08	-0.99	-0.81	-0.89	-0.78	0.38	0.84		
	10	98.3	0.5	0.82	0.40	-0.87	-0.99	-0.99	-0.99	-0.18	0.99	0.84	
	11	89.6	3.6	-0.80	-0.24	0.95	0.97	0.99	0.96	-0.01	-0.98	-0.93	-0.98
VNIIR 10244	1	22.2	0.2										
	2	1090.0	38.8	0.63									
	3	126.3	3.1	-0.78	-0.46								
	4	85.2	17.9	-0.44	-0.12	0.90							
	5	34.3	13.1	-0.41	0.09	0.83	0.97						
	6	67.3	12.8	-0.40	-0.08	0.88	0.99	0.97					
	7	153.6	29.0	0.38	-0.27	-0.73	-0.87	-0.97	-0.88				
	8	28.9	0.9	-0.21	0.60	0.34	0.48	0.69	0.50	-0.85			
	9	17.8	0.4	0.80	0.14	-0.42	-0.14	-0.26	-0.12	0.38	-0.55		
	10	88.8	7.3	0.09	-0.70	-0.22	-0.40	-0.62	-0.41	0.79	-0.99	0.48	
	11	84.9	6.7	0.75	0.19	-0.94	-0.89	-0.91	-0.87	0.89	-0.63	0.58	0.53
VNIIR 10257	1	22.2	0.2										
	2	1090.0	38.8	0.63									
	3	125.0	2.4	-0.71	0.03								
	4	97.2	12.6	-0.70	0.05	0.99							
	5	54.3	4.4	-0.28	0.57	0.76	0.78						
	6	77.6	8.5	-0.71	0.04	0.99	0.99	0.77					
	7	168.6	13.3	-0.76	-0.08	0.99	0.99	0.67	0.99				
	8	25.9	0.2	-0.80	-0.53	0.76	0.74	0.15	0.74	0.84			
	9	19.1	0.7	0.82	0.53	-0.76	-0.75	-0.17	-0.75	-0.84	-0.99		
	10	89.0	9.4	0.25	-0.58	-0.82	-0.84	-0.97	-0.83	-0.74	-0.28	0.29	
	11	90.2	2.3	0.27	-0.44	-0.87	-0.87	-0.79	-0.86	-0.83	-0.53	0.53	0.91

Table 2. Continued

VNIIR 10262	1	22.2	0.2										
	2	1090.0	38.8	0.63									
	3	124.8	3.4	-0.03	-0.79								
	4	80.4	13.6	-0.58	-0.18	-0.23							
	5	32.9	11.5	-0.83	-0.50	0.00	0.05						
	6	64.5	11.6	-0.55	-0.03	-0.40	0.99	0.06					
	7	143.5	25.0	0.88	0.21	0.41	-0.77	-0.62	-0.81				
	8	30.9	0.6	-0.34	0.47	-0.87	0.67	0.12	0.78	-0.75			
	9	17.2	0.5	0.09	-0.68	0.94	-0.05	-0.26	-0.21	0.43	-0.77		
	10	97.3	1.0	0.30	-0.31	0.64	-0.88	0.13	-0.94	0.69	-0.90	0.42	
	11	84.0	6.9	0.47	0.73	-0.57	-0.66	0.01	-0.53	0.30	0.11	-0.70	0.26
KP-15-270	1	22.2	0.2										
	2	1090.0	38.8	0.63									
	3	125.3	0.5	-0.19	-0.62								
	4	86.3	6.8	0.27	0.54	0.27							
	5	40.8	4.4	0.22	0.75	-0.12	0.91						
	6	68.9	5.4	0.28	0.58	0.22	0.99	0.93					
	7	155.2	6.3	-0.27	-0.44	-0.39	-0.99	-0.85	-0.98				
	8	27.9	0.4	0.22	0.18	0.65	0.90	0.65	0.88	-0.95			
	9	19.3	0.2	-0.27	-0.51	-0.31	-0.99	-0.89	-0.99	0.99	-0.92		
	10	98.0	0.0	–	–	–	–	–	–	–	–	–	
	11	90.4	1.6	0.18	-0.29	0.92	0.50	0.11	0.46	-0.61	0.83	-0.54	–

Note: Q – trait, factor: 1 – average daily temperature, °C; 2 – heat supply of vegetation period, $\Sigma t > 15°C$; 3 – duration of vegetation period, days; 4 – yield, c/ha; 5 – grain content in agrophytocenosis, thous. pcs/m^2; 6 – productivity of vegetation day, kg/days/ha; 7 – number of filled grains from main panicle, pcs; 8 – mass of 1000 grains, g; 9 – filminess, %; 10 – vitreousity, %; 11 – head rice content, %.

of medium degree (r = 0.54) between yield and amount temperatures above 15°C. The other varieties have a weak interrelation of heat supply with their yield (r = -0.12 – -0.43).

A positive close correlation of yield with the duration of vegetation period was found in most varieties: Rapan, VNIIR 10243, VNIIR 10244 and VNIIR 10257 (r = 0.71, 0.84, 0.90 and 0.99, respectively). The influence of average daily temperatures and the sum of temperatures on milled rice quality traits is also ambiguous.

Thus, the mass of 1000 grains in varieties Rapan and VNIIR 10243 strongly correlated positively with average daily temperatures (r = 0.77 and 0.82, respectively); but negatively (r = -0.80) in VNIIR 10257. The correlation of the mass of 1000 grains with the heat supply was average and multidirectional in VNIIR 10244 and VNIIR 10257 (r = 0.60 and -0.53, respectively), and in the remaining cases it was moderate.

The filminess index correlated closely with the air temperature in three varieties – VNIIR 10243, VNIIR 10244 and VNIIR 10257 (r = 0.68, 0.80 and 0.82, respectively). The average positive correlation between filminess and heat supply was found in VNIIR 10257 (r = 0.53); in the varieties Rapan and VNIIR 10262 it was negative (r = -0.66 and -0.68).

A close positive relationship between head rice content and the heat supply was found in varieties Rapan and VNIIR 10262 (r = 0.84 and 0.73). Also, a close multidirectional relationship of the trait with the average daily temperature was established in the varieties VNIIR 10244 and VNIIR 10243 (r = 0.75 and -0.80). The remaining varieties were characterized by moderate to moderate correlation of the trait.

A close positive relationship between head rice content and the yield is observed in VNIIR 10243 (r = 0.97). In other varieties, the connection between yield and quality is highly negati ve.

The analyzed data testify to the nonlinearity of the correlation of traits of new rice genotypes with the abiotic factors of environment considered. This is a consequence of the specific reaction of each variety in the formation of individual elements of the crop and the yield as a whole, depending on the temperature fluctuations.

It should be noted that the obtained interrelations are reliable only within the analyzed period (2014-2017) and in the studied varieties. Critical deviations of the temperature regime from the mean annual data during the passage of the main ontogenetic phases (initiation and formation of generative organs) in a rice plant will ultimately lead to a redistribution of correlation links. Genotypes will react differently to the constantly changing environmental conditions, as a consequence of which there can also be a redistribution of the trait-factor relationships.

Conclusions

According to the results of a competitive test of rice varieties, it can be concluded that the heat supply during the vegetation period had an ambiguous effect on the formation of yield. The insignificant and average variability of traits during the period of research (2014-2017) and the weak relationship of weather fluctuations with the yield of some varieties make them highly adaptable.

The yield of rice varieties in the experiment ranged from 80.4 to 97.2 c/ha. VNIIR 10257 significantly exceeded Rapan by 9.9 c/ha (with LSD_{05} = 7.1 c/ha). The variability of trait was almost average for all varieties by year (CV = 12.9-21.1%), in KP-15-270 – weak (CV = 7.9%). The variability of yield at the level of standard Rapan (CV = 14%) is noted in VNIIR 10262 and VNIIR 10257. The varieties Rapan and KP-15-270 have an average multidirectional relationship of yields with a sum of temperatures above 15°C (r = -0.75 and 0.54, respectively). The other varieties have a weak interrelation of heat supply with their yield (r = -0.12 – -0.43).

The vegetation period in the studied genotypes was characterized by low variability, as the average varietal in the experiment (CV = 3.5-6.6%), and the average annual for each variety (CV = 0.4-6.2%).

The mass of 1000 grains in Rapan and VNIIR 10243 strongly correlated positively with average daily temperatures (r = 0.77 and 0.82, respectively); and in VNIIR 10257 it was negative (r = -0.80).

A close high correlation of head rice content with heat supply was found in Rapan and VNIIR 10262 (r = 0.84 and 0.73). The remaining varieties were characterized by average and moderate correlation of the trait.

A close positive relationship between head rice content and the yield is observed in VNIIR 10243 (r = 0.97). In other varieties, the connection between yield and quality is high negative.

Basing on the data obtained, rice varieties VNIIR 10257 (high-yielding round-grain) and VNIIR 10262 (large-grain with high technological parameters of grain and milled rice quality) were transferred to the State Variety Test.

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