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Theoretical, methodological, and breeding results of the DIAS program in increasing grain production using the example of creation of a soft spring wheat variety - Kazakhstanskaya rannespelaya (origin, characteristics, economic value)

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Abstract. The selection of parental pairs is carried out considering their genealogical trees and the dynamics of the lim factors of the environment, in the creation area, with further hybridization, and subsequent multiple re-sowing of the population. The Kazakhstanskaya rannespelaya variety was created by selection from the F_5 hybrid combination of Novosibirskaya 67 × Omskaya 9, the Interdepartmental program DIAS. The breeding record of Novosibirskaya 67 consists of 9 and Omskaya 9 – of 37 varieties, of which 19 are of winter origin. The inheritance of ear productivity, in both varieties, followed the type of complementary epistasis, with incomplete dominance and overdominance, with a large proportion, of recessive genes. In conditions of the Northern Trans-Urals, an early-ripening, yielding line was selected in F_5 - Lutescens 1227-8-79, which became the ancestor of the Kazakhstanskaya rannespelaya variety. The variety has successfully passed the State variety testing and is registered in the Qostanay, North Kazakhstan and Kokchetav regions of Kazakhstan, and in the Chelyabinsk region of the Russian Federation, according to the grain quality it is included in the list of strong varieties. In the north of Kazakhstan, Kazakhstanskaya rannespelaya is cultivated on large areas. This variety, as a genetic source, has a good variety-forming ability. With its participation, 6 varieties were created in the Research Institute of the Northern Trans-Urals. Of these, Tyumenskaya 29 and Grenada are registered in 9 and 10 zones of the Russian Federation. It is used in the breeding programs of the Republic of Kazakhstan.

1 Introduction

In the vast Siberian-Kazakhstan region, soft spring wheat is affected by a number of environmental factors: limited vegetation period, early summer drought, July heavy rainfall,

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brown rust and septoria epiphytotics, prolonged autumn rains, early autumn frosts, lack of nitrogen-phosphorus nutrition, acid and alkaline soils. This vast region needs varieties that are maximally adapted to local agro-climatic conditions. Due to limited thermal resources, it needs early-ripening varieties. At the same time, the breeding work success depends on the source material [1,2,3,4]. The selection of parental pairs is carried out on the basis of the analysis of the most extended family trees of parent varieties [5], ecological and geographical origin, and genetic divergence (remoteness) that cause their contrast and distinctiveness [6]. At the same time, the typical dynamics of the environment lim factors for all 12 phases of the ontogenesis of each variety breeding sites are considered [7,8], which makes it possible to assess the adaptability of the variety to the lim factor of each ontogenesis phase [9]. The manifestation of any quantitative trait depends on the combined action of a set of genes and the environment [10,11], which determine the genotype-environmental interaction - a powerful factor in increasing productivity [12]. At the same time, it should be borne in mind that an effective method for creating adaptive, yielding varieties is diallel analysis [13-16]. Due to the fact that selection in early generations is ineffective, which is associated with the effects of dominance, heterosis epistasis [17], and overdominance (according to many traits), which disappear with repeated replanting, due to a decrease in non-additive variances, therefore, the selection of productive genotypes is facilitated in later generations [12,18]. With long-term population replanting, natural selection exerts pressure on them, leaving genotypes more adapted to local conditions with well-expressed synergism in them [19]. In more favorable conditions of the Northern Trans-Urals, productive forms with genetically moderate ear development, good filling, and formation of the completed grain are selected [20]. Here, in a different way than in arid conditions, the genetic systems of assimilant distribution (ATTR and MIC systems) and growth functions in wheat plants work [21]. Conducting ecological breeding, in contrasting agro-climatic zones, using, when interpreted, modern ecological-breeding and mathematical methods allows quite effectively to create productive, plastic varieties adapted to a particular agro-climatic zone [22].

2 Material and Methods

The research was carried out at the Research Institute of the Northern Trans-Urals (1970-1980, 2010-2022, city of Tyumen) and from 1981 to 1990 – at the Kazakh Research Institute of Agriculture (Alma-Ata region, city of Kaskelen). Intensive, lodging-resistant, strong grain quality varieties of the Interdepartmental Cooperative Program DIAS, (♀) medium-ripening - Novosibirskaya 67, and (♂) medium-late - Omskaya 9 were taken as parental forms. Pollination was carried out – by a freely limited method – through the placement of the ear of the male parent in one insulator with the maternal ear (Lukyanenko method). The selection of the elite plant – variety progenitor was carried out, after stabilizing population replanting, in F_5 in fairly favorable conditions of the Northern Trans-Urals (city of Tyumen) – northern forest-steppe. The experiments of competitive variety testing were laid according to the GSI method (1989) [23] randomized, in 5 sharply contrasting ecological points of Kazakhstan, with technologies adopted in the zones, in four repetitions: Kazakhstan Research Institute of Agriculture – irrigation, dark chestnut soil, forecrop – sugar beet - $N_{45}P_{45}K_{30}$ kg.a.d./ha, the seeding rate is 4.5 million germinating grains/ha; at other ecological points, the forecrop is dead fallow; KazRIA semi-secured bogara - light chestnut soil, 3.0; Semipalatinsk AES – ordinary chernozem, 3.0; Irtysh AES (Pavlodar region) – ordinary chernozem, 3.0; Karabalyk AES (Qostanay region) – ordinary chernozem + $N_{40}P_{40}K_{40}$ kg.a.d./ha, 4.0 million germinating grains/ha . Due to the large diversity of the soil cover, experiments on rain-fed lands and irrigation of the KazRIA were laid by a paired comparison method. Sowing with SSFK-7 seeders. In the irrigated area, irrigation was carried out by dike irrigation in the tillering phase and before earing at the rate of 1000 m^3/ha – each.

In the Research Institute of the Agriculture of the Northern Trans-Urals - northern forest-steppe, Kazakhstanskaya rannespelaya was studied on dark gray soils, on dead, fertilized - $N_{30}P_{45}K_{30}$ kg.a.d./ha fallow, in the nursery "Museum" and in the working collection of the wheat laboratory, of collection nursery type, the area of the plot is 3 m^2, repetition – one-time, the seeding rate is 6000 germ. grains/m^2, sowing with a seeder – SKS-6-10. Accounting and observations according to the GSI methodology (1989) [23]. Experimental data were processed according to B.A. Dospekhov [24].

Immunological assessment, grain quality, resistance to pre-harvest germination of grain in the ear were determined in the laboratories of KazRIA and RIA of the Northern Trans-Urals.

The penetrating ability of the roots was determined by the trench method.

The purpose of the work is to create an early-ripening, productive, locally adapted variety of strong wheat based on the developed theory of ecological and genetic control of quantitative traits, considering the environmental factors of the plant development phases of parental varieties – in the agro-climatic conditions of Northern Kazakhstan and Western Siberia.

3 Results and Discussions

In the period 1973-1984, on the territory of Krasnoufimsk - Ulan-Ude (parallel) and Tyumen - Ust-Kamenogorsk (meridian), 150 employees of two research institutes of the SB RAS (IC&G and CC) and 8 breeding centers of the All-Union Academy of Agricultural Sciences, an Interdepartmental Cooperative Program DIAS (diallel crosses) was carried out. The purpose of the program is to study for the first time the genetics of the productivity traits of spring soft wheat varieties on the main areas of its cultivation in Russia and to give Siberian breeders genetically justified optimal technologies for designing breakthrough new varieties in terms of yields and product quality for each of the 8 geographical zones of spring wheat cultivation [13].

In the process of work, the staff of the DIAS program discovered a new system for regulating the path from genes to a productivity trait ***– changing sets of gene products that "support" the same trait, with a change in the limiting factor of the external environment.*** From 1984 to 2014, members of the staff of the DIAS program and the V.A. Dragavtseva Scientific School (by 2019 there are 35 candidates and 12 doctors of sciences in it) on the basis of this discovery, the ***Theory of ecological and genetic organization of productivity traits*** (TEGO) was developed, from which 24 new ones came out, with strong forecasts of biological consequences and 10 Know-How (they are closed), ahead of the modern level of ecological genetics and breeding plants in the world for 10-15 years. 16 innovative technologies for designing breakthrough crops and product quality of new varieties came out of the TEGO. TEGO is included in the International Encyclopedia “Basic Life Sciences", New York – Boston – London and in three Explanatory dictionaries. Based on the TEGO, three new technologies were developed for identifying the best genotypes during selection with a reliability of recognizing the best genotypes up to 1000 times greater than visual selection by phenotypes. New technologies have been created for the selection of parental pairs for crosses, allowing instead of 1,500 annual crosses at each of the 40 breeding centers of the Russian Federation - to do only 4-5. The proposed 16 innovative breeding technologies have replaced the ancient traditional ones: visual identification of genotypes is more than 2000 years old, the same age of the technology of selection of parental pairs. Unfortunately, neither geneticists nor breeders have been able to improve them over these millennia.

7 genetic and physiological systems (GPS) have been discovered, the positive shifts of which radically raise the yields of new varieties. A method was created to accurately assess the potential for raising wheat yields with new breeding technologies in Siberia and this potential was estimated: it turned out to be 60-80%. But you can take it only by building a Breeding phytotron in St. Petersburg worth (from scratch) about 5 billion rubles.

As of today, members of the DIAS program headquarters and the V.A. Dragavtseva Scientific school based on innovative breeding technologies that came out of the DIAS program created and zoned 17 breakthrough varieties in yields. Breeding technologies created during the implementation of the DIAS program can, by controlling the phenomena of "genotype-environment interaction", increase grain yields by 40-70% (when breeding in the field) without using the currently popular, but very risky "genetic engineering" and "genomic editing".

Varieties that came out of the DIAS program, daughter varieties descended from the DIAS varieties and grandchild varieties of the DIAS program were cultivated and are being cultivated in the Urals, Northern Trans-Urals, Middle Urals, Western Siberia, Kazakhstan, Altai Krai, Altai Republic, Buryatia, Khakassia, Tyva, and Mongolia on areas of about 10 million hectares with an economic effect of hundreds of billion rubles annually.

In Siberia and the Trans-Urals, intensive innovative breeding technologies developed on the basis of TEGO have been used in the breeding of grain, leguminous, and forest woody plants since 1984. Features of these technologies: selection of parental pairs based on the family trees of parents, considering the dynamics of limiting environmental factors in the zones of creation of fathers, mothers, grandmothers, grandfathers, etc.; assessment of contributions to the harvest of each of the seven genetic and physiological systems (GPS) discovered during TEGO development; further hybridization, stabilizing replanting and selection. The use of new breeding technologies has had a positive impact on the creation of a high-yielding variety of Kazakhstanskaya rannespelaya.

The Kazakhstanskaya rannespelaya variety (KR) was obtained by individual selection from the F_5 hybrid combination of Novosibirskaya 67 × Omskaya 9, as a result of the implementation of the Interdepartmental Program on the genetics of spring wheat productivity traits in Siberia - DIAS [13]. The family trees of both parents of the KR penetrate deeply into past generations and cover 46 varieties (Fig. 1). Of these, the maternal form – Novosibirskaya 67 has 9 varieties, and 37 – the paternal Omskaya 9, of which 19 are of winter origin. The genealogy of the Novosibirskaya 67 is from the NOE variety of French origin, selected from the population – "Sinyaya", exported from Odessa, and widespread in France and neighboring Morocco. In Omsk, line 2486 was selected from the variety – population of NOE, this line in the pre-war years gave the Lutescens 956 variety, which became the paternal form of Novosibirskaya 7, which was distinguished by drought resistance, tendency to lodging, affection with loose smut, and grain germination in the ear. The Lutescens 1487 from the Volga region was taken as maternal form, obtained from crossing the local Yakutskaya (ferrugineum) with the Gordieforme (local Volga region). From this combination, a line was selected that became the ancestor of the variety - Lutescens 7, later called Novosibirskaya 7. This variety, along with good productivity and a number of other positive qualities and properties, had weak resistance to lodging and low grain baking qualities. The seeds of Novosibirskaya 7 were irradiated with different doses of gamma rays, fast thermal neutrons, X-rays, and were treated with solutions of some chemical mutagens. The study of a number of obtained mutants allowed to identify the best of them - No. 1656 – the ancestor of a new variety – Novosibirskaya 67 (r.-v. albidum) - (Novosibirskaya 7 + γ 5000r) (IC&G SB RAS). The created variety is mid-ripening, yielding, with a fairly strong straw, with good responsiveness to agricultural background improvement, forms a strong wheat grain. The disadvantages of the variety include – low resistance to early summer drought and pronounced germination of grain in the ear – under wet autumn conditions. Novosibirskaya 67 is characterized by active grain filling and ripening. It has been cultivated in the Tyumen region for more than 20 years – since 1994. As the paternal form of the variety, the middle-late, intensive Omskaya 9 was taken, obtained from a hybrid combination 1210 from crossing the spring line of Bezostaya 1 (transformation ("alteration") winter, followed by selection) and Saratovskaya 29, and further single saturation of Saratovskaya 29, linear selection, and the union of six agronomically homogeneous lines. The distinctive features of Omskaya 9 are late ripening, with an extended tillering period, which makes it possible to tolerate the Siberian type of drought well, resistance to lodging, pronounced intensity, responsiveness to high agricultural background, good ear wateriness, coarse grain, resistance to pre-harvest germination of grain in the ear and to loose smut. Both parental components form a strong wheat grain.

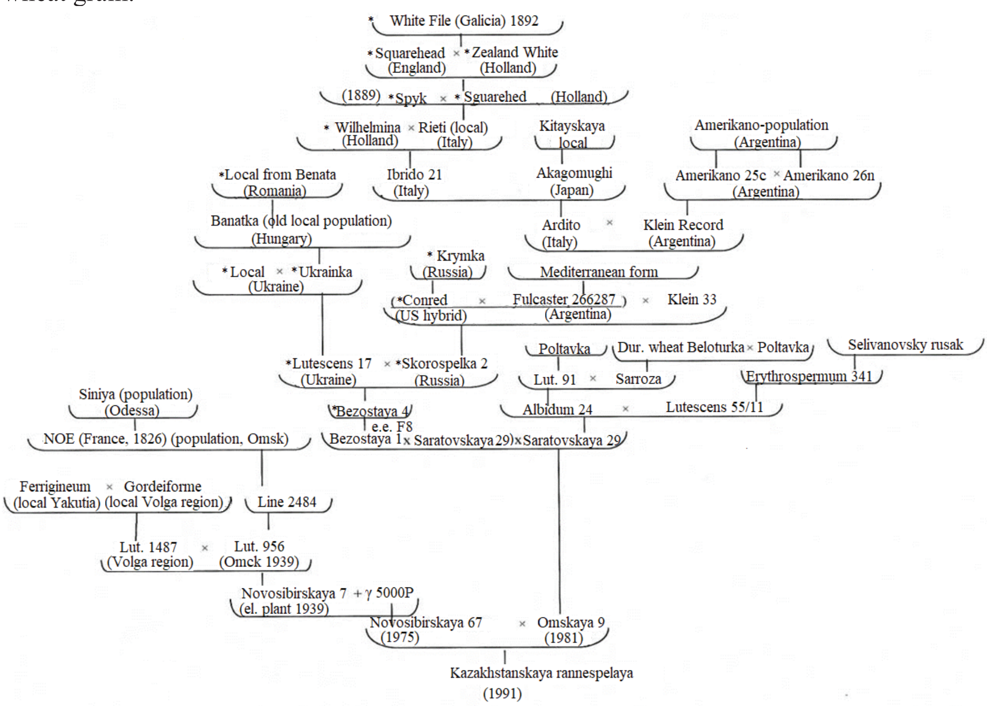

Fig. 1. Genealogy of the Kazakhstanskaya rannespelaya variety (KR).

The genetics of both parental varieties were studied during the implementation of the Interdepartmental program DIAS. According to the Tyumen ecological point of the program, the inheritance of ear productivity over the years went by the type of complementary epistasis, with incomplete dominance and overdominance, with a large proportion of recessive genes. This provided these varieties with a good combinational ability according to the main quantitative characteristics of ear productivity. Combining the genomes of these varieties and the subsequent transgressive splitting of the population, with its multiple stabilizing replantings, made it possible to obtain a whole range of different ripening, lodging-resistant, yielding biotypes. Selected from them, in the conditions of Tyumen, an early-ripening, productive line - Lutescens 1227-8-79 became the ancestor of the variety - Kazakhstanskaya rannespelaya (KR).

Morphological description: the bush is semi-sprawling; the stem is thickened, durable, with the lower internodes shortened by 1.3-2.5 cm (compared to Saratovskaya 29); the ear is cylindrical, of medium length – 8.1 cm, compacted – 23 spikelets per 10 cm of the stem, with no spikes on the ear top; the gluma is ovoid in shape, length – 8,6 mm, width – 3,7 mm, with slightly pronounced nervation; gluma tooth – short, beak-shaped, mature; gluma shoulder – slightly oblique, of medium size; keel – strongly pronounced along the entire length; grain – large, semicircular, red in color, grain groove is not deep; at the upper internode there is a purple hue, turning into gray when ripe; flag leaf is slightly curling, medium-sized, hairy, with a waxy coating.

Kazakhstanskaya rannespelaya has a high percentage of plants with 5 germinal roots – 79.6% and 6.3% - with 6 roots. The length of all the roots of 1 seedling on day 10 is 36.2 cm, which is slightly higher than that of the drought-resistant Saratovskaya 29 and indicates a pronounced adaptability of the variety. This is confirmed by the peculiarities of the growth of the KR root system. Since, on a semi-secured boghara, its roots penetrate into the soil to a depth of 180 cm, for comparison - in Saratovskaya 29 to 172 cm. The activity of daily root growth, during the "shoots-tillering" period - 3.89 cm/day, "tillering-tubing" - 4.45 cm/day, which is 0.4 and 07 cm/day more than that of the compared variety. At the same time, the KR roots close to tillering deepen by 74 cm, tubing – 131, and earing – 159 cm, in Saratovskaya 29, respectively: by 69 cm, 119, and 139 cm. During irrigation, the KR roots penetrate to a depth of 217 cm, which is at the level of the other seven studied intensive medium-ripened varieties.

According to the results of competitive and environmental tests, KR at most ecological points turned out to be more productive than Saratovskaya 29 by 0.32-0.52 t/ha (+10...+24%) (Table 1). The potential yield of the variety at the irrigated KazRIA stationary is 5.4 t/ha, with good lodging resistance.

The KR in the north of Kazakhstan is cultivated 2 days earlier, it is 4 days more precocious than Saratovskaya 29, forms a medium-sized, productive, lodging-resistant cenosis. The variety, like Saratovskaya 29, has a limited productive bushiness. In contrast to the compared variety, it has a grained, denser ear and an almost equal absolute weight of grain with the standard. According to the technological indicators of grain (Table. 1) KR surpasses the strong Saratovskaya 29. KR has a high percentage of hardness – up to 96% [IT 76-127], which allows double technological use of the variety – for bread and pasta [25].

Table 1. Economic and biological characteristics of the Kazakhstanskaya rannespelaya soft spring wheat variety. (KSI, ESI, 1984-1986).

Environmental point, indicator	Meas. unit	Kazakhstanskaya rannespelaya	Saratovskaya 29, st.	+, - to st.	In % to st.
Karabalyk AES	t/ha	3.70	3.18	+0.52	116
LSD_{05}	t/ha	0.20			
Semipalatinsk AES	t/ha	2.28	2.21	+0.07	101
LSD_{05}	t/ha	0.20			
KazRIA - irrigation	t/ha	5.00	4.56	+0.44	110
LSD_{05}	t/ha	0.35			
KazRIA s/s boghara	t/ha	2.88	2.50	+0.38	113
LSD_{05}	t/ha	0.24			
KazRIA unsec. boghara	t/ha	1.66	1,34	+0.32	124
LSD_{05}	t/ha	0.15			
Karabalyk AES					
Vegetation period	days	81	85	-4	95
Plant height	cm	89	91	-2	98

Resistance to lodging	score	4	2-3	+2-1	
Productive bushiness	-	1,50	1.51	-0.01	100
Ear grain content	pcs.	23.2	21.9	+1.3	106
Weight of 1000 grains	g	35.9	36.8	-0.9	98
Raw protein	%	16.7	15.5	+1.2	108
Raw gluten	%	34.3	32.0	+2.3	107
Alveograph (W)	u.a.	634	441	+193	144
Bread volume	ml	1140	1100	+40	104
General evaluation of bread	score	4.5	4.4	+0.1	102

The early maturity of the variety is explained by the combination of certain biological properties of the parental components in its genotype. Thus, the Novosibirskaya 67 variety at the early stages of its development reacts sharply to extreme environmental conditions. After earing, KR is characterized by accelerated maturation. Omskaya 9, in the genealogy of which 75% of the genome is from Saratovskaya 29, gave the new variety unpretentiousness to external conditions in the early stages of development and a weak reaction of Bezostaya I to changes in photoperiodism. The ability of KR to develop without delay at the early stages of organogenesis and to ear at the same time 2 days earlier than Saratovskaya 29, as well as to actively carry out filling, seems to be due to the presence of genes of the Vrn-1 and Vrn-3 groups [26, 27]. The weak reaction of the variety to the growing conditions and day length allows it to ripen, in the north of Kazakhstan, 4 days earlier than Saratovskaya 29, which is very important for a region with a limited temperature regime.

For KR (Lutescens 1227-8-79), as it was noted earlier, rain conditions are more acceptable, as well as the northern steppe and forest-steppe regions of Kazakhstan, which is confirmed by the indicators of the reaction of varieties to environmental conditions – Er, the values of which are positive (0.99...4.37) in the first case and neutral in the second [22].

KR successfully passed State variety tests in 1987-1989 in the Kokchetav region, where it was more productive than the mid-early Irtyshanka 10 by 0.12-0.47 t/ha and showed an equal vegetation period with it (Table 2).

Table 2. Results of the variety testing of the Kazakhstan early-ripening soft spring wheat variety at the variety test plots of the Kokchetav region (1987-1989).

Variety test plot	Predecessor	Grain yield, t/ha		Vegetation period, days	
		total	+, - to st.	total	+, - to st.
Arykbalaksky	fallow	2.40	+0.12	75	-1
	wheat	1.41	+0.22	74	+2
Ruzaevsky	fallow	2.96	+0.47	81	+1
	wheat	1.92	+0.36	76	0
Shchuchinsky	fallow	1.98	+0.30	77	+1
	wheat	1.70	+0.28	75	+1
Kazansky	fallow	2.51	+0.15	74	-2
	wheat	2.16	+0.19	76	+2
	Standard – Irtyshanka 10				

Similar results were obtained for the Qostanay region (Table 3), where the KR, with equal or higher productivity relative to the standard - Saratovskaya 29 and the compared variety - Irtyshanka 10, had a growing season 3 days less than the standard, and equal to the compared variety. At the same time, KR is more resistant to lodging than the compared varieties.

On the variety stages of the Chelyabinsk region, the KR is more productive than the early-ripening standard – Druzhina - by 0.31-1.08 t/ha with an equal vegetation period, lodging resistance, absolute grain weight and more pronounced drought resistance (Table 3).

By the State Commission the KR was included in the list of strong varieties. Since 1990, it has been zoned in the Kokchetav and Qostanay regions, since 1992 – in the North Kazakhstan region.

In these regions, within 5-7 years, it displaced Irtyshanka 10, which was sown annually on an area of 1.0-1.2 million hectares, and also pushed Saratovskaya 29. The KR is still being cultivated in this region. The original and elite seed production of the KR variety is carried out in the Karabalyk AES, the Qostanay region.

Table 3. Results of the variety testing of the Kazakhstanskaya rannespelaya soft spring wheat variety at the variety test plots of the Qostanay region (1987-1989).

Variety	Karabalyksky	Fedorovsky	Uzun-kolsky	Uritsky	Kustanaysky zernovoy	
	Grain yield, t/ha					
Kazakhstanskaya rannespelaya	1.81	2.87	2.19	2.12	1.38	
Saratovskaya 29, st.	1.82	2.82	1.92	2.15	1.39	
Irtyshanka 10	1.38	2.90	2.10	2.22	-	
LSD_{05}	0.11	0.16	0,14	0.16	0.14	
	Vegetation period, days					
Kazakhstanskaya rannespelaya	69-70	75	78	84	72	
Saratovskaya 29, st.	72-73	77	81	86	75	
Irtyshanka 10	71	75	79	86	72	
Chelyabinsk region						
	Argayashsky	Uysky	Yemanzhelinsky	Troitsky	Argayashsky	Uysky
	Grain yield, t/ha					
Forecrop	fallow	fallow	fallow	fallow	kuk.	kuk.
Druzhina, st.	1.89	1.96	1.41	0.71	1.39	1.54
Kazakhstanskaya rannespelaya	2.50	2.39	1.72	1.79	2.17	2.20
Deviation	+0.61	+0.43	+0.31	+1.08	+0.78	+0.66
LSD_{05}	0.19	0.14	0.14	0.29	0.06	0.12
	Vegetation period, days				Resistance to lodging, score	
Druzhina, st.	72	69	75	73	5	5
Kazakhstanskaya rannespelaya	74	69	76	73	4	5
	Weight of 1000 grains, g				Drought resistance, score	
Druzhina, st.	36.4	36.6	35.2	24.3	3.8	4
Kazakhstanskaya rannespelaya	36.2	38.6	36.8	27.2	4.5	4

In these regions, within 5-7 years, it displaced Irtyshanka 10, which was sown annually on an area of 1.0-1.2 million hectares, and also pushed Saratovskaya 29. The KR is still

being cultivated in this region. The original and elite seed production of the KR variety is carried out in the Karabalyk AES, the Qostanay region.

Since 1991, the KR has been zoned in the Chelyabinsk region, where it has been cultivated for 15 years.

Since 2010, Kazakhstanskaya rannespelaya has been included in the nursery "Museum" of the Northern Trans-Urals Research Institute of Agriculture, where, along with previously cultivated, promising varieties in the Trans-Urals, V.V. Novokhatin breeding varieties are also studied. The results of the study over the past five years (2018-2022) show (Table 4), that in terms of yield and the main economically valuable characteristics, the KR is not inferior to the new intensive varieties. At the same time, it consistently forms high-quality grain over the years. Kazakhstanskaya rannespelaya, as a genetic source, is used in crosses of the wheat laboratory of the Northern Trans-Urals RIA. With its participation, 6 varieties were created and transferred to the State variety testing: SURENTa-5, Annette, Tyumenskaya 29, Tyumenskaya 32, Tyumenskaya 33, and Grenada. Of these, Tyumenskaya 29 and Grenada are registered by the State Commission for 9 and 10 zones of the Russian Federation. It is also used in the breeding programs of the Republic of Kazakhstan, which is reflected in the thematic reports of the Republic National Research University.

Conclusions

The use of innovative technologies for the creation of high-yielding varieties, based on the multidirectional selection of parental pairs, the genetics of their quantitative characteristics, multiple, stabilizing replanting of created populations and selection, under favorable conditions, allows to increase the breeding process effectiveness.

On the example of the creation of the Kazakhstanskaya rannespelaya variety by ecological breeding methods, various manifestations of genotype-environmental interaction – an important factor in increasing yields – are shown.

Table 4. Economically valuable characteristics of the Kazakhstanskaya rannespelaya wheat variety (RIA of the Northern Trans-Urals, 2018-2022).

Variety	Plant height, cm	Lodging, score	Length of II in-node, cm	Diameter of II in-node, mm	*Brown rust, type/%	Number of grains per ear, pcs	Weight of 1000 grains, g	*Grain germination in the ear, %	Protein, %	Gluten, %	Grain yield, g/m^2
Kazakhstanskaya rannespelaya	92	4	12.8	3.4	3/60	30	40.2	11.9-39.3	15.0	34	340-444-460
Omskaya 36	100	3	15.9	3.3	3/60	27	42.4	5.6-27.5	15.1	33	365-480-500
Lutescens 70	93	3	14.4	3.2	3/40	30	38.4	2.6-7.4	14.6	31	359-397-440
Tyumenskaya 29	97	4	14.9	3.4	2/40	29	40.2	5.6-7.8	15.0	33	385-499-517
Tulunskaya 12	87	4	12.3	3.2	3/60	28	36.4	15.2-46.4	15.4	34	333-417-503
Grenada	90	4	12.1	3.3	1/10	32	41.2	1.2-9.4	14.5	31	376-453-553
Saratovskaya 29	100	3	15.8	2.7	3/60	26	41.9	6.1-12.4	14.9	30	300-360-412
$S\bar{x}$											9-20

*- provocative conditions

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