The source material of soft spring wheat for improving the quality of grain and resistance to lodging

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Abstract. The Northern Trans-Urals is a region of intensive agriculture that needs high-yielding varieties that are resistant to lodging and a-biotic environmental factors, forming high-quality grain. In this respect, as a starting material for breeding, Canadian varieties with good technological indicators of grain and Norwegian varieties with high resistance to lodging and well-expressed economic and valuable characteristics are of interest. An important indicator when creating wheat varieties is the resistance to pre-harvest germination of grain on the root. The conjugacy of this feature with the yield is high and is expressed negatively - r = -0.922. Among the studied cultivars, Demonstrant (Norway) and 5603HR (Canada) stand out for their resistance to grain germination in the ear. Norwegian varieties are characterized by multi-grain ear, fine grain and compacted ear. Marker traits of drought resistance – the length of the upper internode and the removal of the ear, are better expressed in the standard of Omskaya 36, varieties of local selection and varietals - Laban and GN 06600 (Norway). In arid conditions, these varieties have a more pronounced yield. The best in this respect is Kazakhstan one - Astana (2.27 t/ha). The intensity was highlighted by the variety - GN 06600 (Norway) - 5.05 t/ha. The revealed conjugate relationships in the studied traits allow to purposefully conduct breeding work.

1 Introduction

The success and effectiveness of breeding is largely determined by the source material. At the same time, the wide use of the genetic diversity of the world gene pool and local material is important [1-5]. At the same time, intraspecific hybridization is one of the main sources of creating hereditary diversity, which should be based on the correct selection of pairs for crosses. The justification for this is the theoretically justified by N.I. Vavilov method of their ecological and geographical origin. Later, it was supplemented by genetic divergence (remoteness), which causes their contrast and sharp distinctness [1]. This formulation of the source material creation gives a frequent manifestation of transgressive forms with well-expressed adaptability [6]. The basis for the creation of varieties is the genotypes of local

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breeding [7], which, due to long-term natural selection, are better adapted to these conditions [2]. Nevertheless, it is hopeless to conduct breeding on the use of zoned and old local varieties, while improving certain characteristics. Therefore, it is necessary to include the world genetic material of the VIR collection in the breeding. At the same time, it should be borne in mind that in most non-district varieties, the traits are closely linked, the manifestation of which is undesirable under these conditions. Therefore, hybrids with their participation, in splitting generations, are unlikely to obtain the desired recombinants. Consequently, the samples included in the hybridization should, if possible, have a large set of positive economically valuable traits and properties [8,9]. At the same time, the quality of grain is one of the main variety indicators and, in this regard, Canadian varieties deserve attention [10,11].

Along with this, in the Northern Trans-Urals, much attention is paid to resistance to lodging [12] and pre-harvest germination of grain in the ear [13]. The marker indicators of the manifestation of productivity in arid conditions are the length of the upper internode [14,15] and especially the removal of the ear [15]. The conjugacy of these characteristics allows to purposefully conduct the breeding process.

The purpose of the research: to study the varietal characteristics of Canadian and Swedish varietals, in comparison with the varieties common in the Northern Trans-Urals - in terms of yield, economically valuable, technological and morphological characteristics. To identify the conjugate connections that appear in this case.

2 Materials and methods

The object of research was 15 varieties of the "SIMMYT" program, of various ecological and geographical origin, with a complex of economically valuable traits and properties. Six Norwegian varieties were obtained from them in 2011: Berserk, Demonstrant, Krabat, Laban, GN 04526, GN 06600 and one Kazakhstan variety - Astana. In 2012, four Canadian varieties were received: Freir, Kuntz, 5603 HR, Jenna and three Russian ones: Omsk 35, Tertsia, Pamyati Azieva. For comparison with them, four varieties of our breeding are included in the experiment: Lutescens 70, Riks, Tyumenskaya 25, AVIADa. The Omskaya 36 variety is taken as the standard. This set of varieties was studied in 2011-2013 on the experimental field of the Research Institute of Agriculte of the Northern Trans-Urals – on dark gray soil. The predecessor is black, fertilized fallow - N_{30} $P_{30}K_{45}$ kg r.a./ha. The plot area is 5 m^2, the repetition is three or four times. The seeding rate is 650 germinating grains/1 m^2. Sowing with a SKS-6-10 seeder. Accounting and observations according to the SSEUM methodology (1989). The elements of the crop structure and stem morphology were determined in 20 plants taken from test sites. The pre-harvest germination of grain in the ear was determined under provocative laboratory conditions [16]. Technological assessment of grain quality was carried out according to the Methodological Guidelines for grain quality assessment (1977). The experiments were conducted in 2012-2013. At the same time, 2012 was dry, 2013 was arid and 2011 was favorable in terms of climate support. The experimental data were processed according to the basic methods of basic statistics (Dospekhov, 1978; Rokitsky, 1978).

3 Research results

A distinctive feature of the studied foreign varieties (Table 1) is the lower plant height (62-75 cm) – by 16-29 cm compared to the Omskaya 36 standard. The Astana variety and varieties of local breeding are below the standard within 9 cm. In the dry conditions of 2012, the height of plants decreased to 49-59 cm in Norwegian varieties, 60-65 – Canadian,

standard and domestic - to 70-75 cm. A sharp decrease in plant height in ontogenesis is the result of a paradigm of severe depression of the modification variability of genotype-environment interaction leading to low yields. This is especially true for Tertsia and foreign varieties, except for GN 06600. According to the growing season, most of the studied varieties belong to the medium-ripening group, with a period of "sprouting-earing" – 38-42 days and a growing season – 88-91 days, which is confirmed by low coefficients of variation - 5.0% and 2.8%. Early-ripening varieties include: GN 06600 (Norway); Freir (Canada) and local – Tyumenskaya 25, which are 3-5 days more precocious than most other varieties compared. In late-ripening varieties: Tertsia and Omskaya 35, the period of "sprouting-earing" is 42-43 days, and wax ripeness came on 92-93 days.

One of the important indicators of wheat varieties in the Trans-Urals is the resistance to pre-harvest germination of grain on the root, which is a varietal, genetically determined trait. Under provocative, laboratory conditions, this feature showed a strong variation in the varieties – 113.6%, from the minimum - 0.0% to the maximum value - 57.4% (**Table 1**). It was revealed that there is a high negative correlation between the germination of grain in the ear and the harvest – r = -0.922 (R=0.404) and a significant determination coefficient - d = -0.850. The conjugacy between this trait and the technological indicators of grain is also significantly negative – r = -0.614...-0.918 (d =-0.377...-0.842). This convincingly shows the importance of this trait for the crop breeding. Among the varieties resistant to pre-harvest germination of grain in the ear are the following: Demonstrant (Norway) and 5603 HR (Canada), endurance is characteristic for the following: Laban, Berserk, Krabat (Norway), Kuntz (Canada) and Omskaya 35 (2.4-3.8%). The varieties of local breeding and Astana (Kazakhstan) are tolerant to the pre-harvest germination of grain on the root, thanks to which they have become widespread in production. All the selected genotypes are recommended as a starting material for breeding for resistance to pre-harvest germination of grain in the ear. With their participation, a topcross scheme of crosses (6×4) and directed pair crosses were performed to create a breeding material tolerant to late summer-autumn wet weather. The cultivars: GN 06600, GN 04526 (Norway); Freir, Jenna (Canada), Tertsia and Pamyati Azieva (Russia), with strongly sprouting grain, in provocative conditions (36.7-57.4% and 21.2-29.5% - in the last two) are not advisable to use as initial forms when creating varieties that are resistant and tolerant to pre-harvest germination of grain in the ear.

Norwegian varieties, for the most part, are distinguished by a more grained ear - 30-33 pcs. and small grain, with an absolute weight of 31.3-33.5 g. Fine grain (28.1-33.2 g) in three of the four Canadian varieties. GN 06600, GN 04526 (Norway) and Jenna (Canada) have a fairly large grain, the weight of 1000 grains of which is 38.0-39.6 g, it is slightly larger in the varieties Omskaya 36 and Omskaya 35 (41.2 and 39.1 g). Such varietal differences, in the marked varieties, are consistently manifested over the years, which should be considered in breeding practice.

Sharply contrasting climatic conditions and biological features of the varieties affected the manifestation of their productivity. So, in the sharply dry 2012, when only 97 mm of precipitation fell during the growing season, which is 2.5 times less than the norm (243 mm), all varieties showed an average yield in the experiment - 1.62 t/ha, which is 2.2-2.3 times less than in more favorable years (Table 1). At the same time, the variation of yields in varieties this year is the highest – 25.6%, which indicates quite pronounced varietal differences.

Table 1. Yield and economically valuable characteristics of varieties of soft spring wheat, by year.

No.	Variety	Origin	Plant height, cm	Vegetation period, day		Grain germination, %	Weight of 1000 grains, g	Number of grains in the ear, pcs.	Grain yield, t/ha		
				sprouting-earing	sprouting-wax ripening				2011	2012	2013
1	Omskaya 36, st.	Russia	91	39	88	8.0	41.2	26	3.98	2.03	4.26
2	Demonstrant	Norway	66	41	90	0.7	31.4	35	3.37	1.09	3.56

3	Laban	Norway	72	42	90	2.4	33.5	32	3.97	1.96	3.87
4	Berserk	Norway	62	41	91	3.2	32.0	30	4.17	1.35	3.04
5	GN 06600	Norway	80	37	85	36.7	37.8	28	3.69	1.94	3.98
6	Krabat	Norway	68	40	89	3.8	31.3	26	2.87	1.39	2.60
7	GN 04526	Norway	73	41	88	44.5	39.6	32	3.33	1.67	5.05
8	Freyr	Canada	75	36	85	39.1	33.2	29	-	1.41	3.30
9	Kuntz	Canada	67	37	86	2.4	30.8	28	-	1.10	3.56
10	5603HK	Canada	73	39	86	0.0	28.1	26	-	1.28	3.95
11	Jenna	Canada	69	40	89	57.4	38.0	27	-	1.59	4.12
12	Astana 2	Kazakhstan	85	40	88	4.6	36.8	24	3.63	2.27	3.67
13	Omskaya 35	Russia	91	43	93	2.8	39.1	28	-	1.90	4.01
14	Tertsia	Russia	90	42	92	29.5	34.1	26	-	0.81	2.87
15	P. Azieva	Russia	89	38	87	21.2	35.2	24	-	1.61	3.24
16	Lutesc. 70	Russia	87	38	87	8.9	33.3	25	4.17	1.69	3.46
17	Riks	Russia	89	41	91	9.6	36.6	31	3.58	1.91	4.02
18	Tyumensk. 25	Russia	82	37	85	11.0	35.0	25	3.86	1.92	4.06
19	AVIADa	Russia	87	40	89	5.4	36.0	27	3.14	2.04	4.22
	$\bar{x}$		79	40	89	15.3	34.9	28	3.65	1.62	3.72
	min		62	36	85	0.0	28.1	24	2.87	0.61	2.60
	max		91	43	93	57.4	41.2	35	4.17	2.27	5.05
	$S\bar{x}$		2.3	0.5	0.6	4.0	0.8	0.93	0.12	0.09	0.13
	V,%		12.5	5.0	2.8	113.6	9.8	11.6	5.2	25.6	15.3
	LSD_{05}								0.23	0.29	0.20

* - provocative conditions; data of traits with the maximum manifestation in the years of research.

The lowest productivity, in arid conditions in the Tertsia (0.81 t/ha), many Norwegian varieties: Demonstrant, Berserk, Krabat and Canadian: Kuntz, 5603 HR, Freir (1.09-1.41 t/ha). Under these conditions, Kazakhstan Astana 2 (2.27 t/ha), Norwegian: Laban, GN 06600, varieties of local breeding and standard – Omskaya 36 (1.91-2.04 t/ha) are distinguished by higher yields. These varieties are the most adapted to arid environmental conditions, which should be considered when including them in hybridization. Poorly adapted to the contrasting conditions of the Northern Trans-Urals are Krabat, Berserk (Norway), Tertsia and, due to late maturity, Omskaya 35 (Russia), which reduces their breeding significance. The Norwegian variety GN 04526 has a potentially high productivity – 5.05 t/ha, in 2013

Evaluation of varieties according to technological indicators of grain, for a number of years (Table 2) shows that their physical properties: the absolute mass, micronature, and vitreousness are not unambiguously expressed. The absolute weight of grain is one of the indicators of the adaptability of a particular variety, which, along with genetic features, is largely determined by modification variability, which is confirmed by a fairly pronounced variation, as mentioned above, four Norwegian varieties out of six and three Canadian varieties out of four are characterized by fine grain. Large grains are characterized by: GN 06600, GN 04526 (Norway), Jenna (Canada) and Omskaya 35 (39.3-39.7 g). The largest absolute weight of grain (41.2 g) in the standard variety - Omskaya 36. The micronature of the grain depends both on its size and is largely determined by its shape. In this regard, Canadian varieties are distinguished, as well as Lutescens 70, AVIADa and Astana 2 (7.27-7.47 g/cm^3). Low grain nature in Norwegian and Omsk varieties (7.01-7.10 g/cm^3) and especially in Tertsia (6.88 g/cm^3). The vitreousness of the grain, despite the fact that it is an indirect indicator of its protein content, showed practically no varietal differences. It should be noted that all Canadian varieties consistently form an increased protein and gluten content over the years. Among the Norwegian varieties in this regard, the following ones stand out: Berserk and Krabat. Balanced, high-quality gluten in: Pamyati Azieva, Laban (FDM = 75 units) and, to some extent, in GN 04526, Kuntz and Omskaya 35 (FDM = 77-80 units), which significantly increases their importance as a source material for grain quality breeding. A distinctive feature of the indicators of grain technological characteristics in this set of

varieties is that they have a low variation, due to the great similarity of their manifestations in many of them.

For intensive agriculture in the Northern Trans-Urals, varieties are needed that combine high productivity (6.5-7.0 t/ha) with resistance to lodging. Therefore, in a region with a limited growing season and a fairly good moisture supply, due attention is paid to Northern European varieties and especially to the Scandinavian group. Here, Rang was widely cultivated, Rollo and Pompe were widespread. The Rang variety was included in the regional program "DIAS", with its participation we created common varieties: Lutescens 70 (Novosibirskaya 67 × Rang) and Kazakhstanskaya 17 (Rang × Grekum 114).

Table 2. Technological indicators of grain, by year.

No.	Variety	Origin	Weight of 1000 grains, g	Micro nature of grain, g/10 cm^3	Vitreousness, %	Protein, %		Gluten, %		FDM, un.
						2011	2012-2013	2011	2012-2013	
1	Omskaya 36, st.	Russia	41.2	7.08	62	14.5	15.6	26.8	35.8	85
2	Demonstrant	Norway	31.4	7.10	54	12.0	16.0	23.1	37.2	85
3	Laban	Norway	33.5	7.06	60	12.0	16.0	22.8	36.8	75
4	Berserk	Norway	32.0	7.10	56	14.5	17.3	32.6	42.9	100
5	GN 06600	Norway	39.3	7.05	63	11.9	16.8	29.8	39.1	85
6	Krabat	Norway	31.3	7.01	56	14.8	16.6	33.2	41.5	95
7	GN 04526	Norway	39.7	7.14	57	13.1	15.8	29.0	37.8	77
8	Freyr	Canada	33.2	7.30	60	-	17.6	-	44.4	87
9	Kuntz	Canada	30.6	7.29	60	-	17.9	-	41.0	80
10	5603HK	Canada	28.1	7.27	71	-	17.3	-	42.3	90
11	Jenna	Canada	39.3	7.18	57	-	16.5	-	42.0	92
12	Astana 2	Kazakhstan	36.8	7.29	58	12.0	14.6	23.2	33.5	82
13	Omskaya 35	Russia	39.2	7.03	61	-	14.8	-	35.1	80
14	Tertsia	Russia	37.2	6.88	62	-	16.8	-	40.6	95
15	Pamyati Azieva	Russia	35.2	7.16	56	-	15.4	-	36.8	75
16	Lutescens 70	Russia	33.7	7.30	59	12.8	16.2	26.0	39.6	85
17	Riks	Russia	37.9	7.20	58	12.5	16.4	25.9	40.1	90
18	Tyumenskaya 25	Russia	35.4	7.10	59	13.1	15.6	27.9	38.1	83
19	AVIADa	Russia	35.9	7.47	58	12.3	15.7	28.4	37.4	92
	$\bar{x}$		34.9	7.16	59	13.0	16.2	27.4	39.1	86
	min		28.1	6.88	54	11.9	14.6	22.8	33.5	75
	max		41.2	7.47	71	14.8	17.9	33.2	44.4	100
	$S\bar{x}$		0.78	0.03	0.85	0.31	0.21	1.00	0.67	1.61
	V,%		9.8	1.9	6.2	8.3	5.5	12.6	7.4	8.2

Tyumenskaya early was obtained by selection from Rollo. In different years, in the working collection of the wheat laboratory of the Research Institute of the Northern Trans-Urals, there were varieties obtained from the VIR collection: Rang (k-47098), Perso (k-45101), Troll (k-47096). Svalöf 01320 (k-45133), Rex (k-45644), Peko (k-38429), Rokicka (k-42693), Phoebus (k-45773). With their participation, a fairly extensive breeding material was obtained, the best forms selected from it are included in further breeding work. In this regard, the elements of stem morphology were studied in the new Norwegian varieties, along with economically valuable traits.

A distinctive feature of Norwegian varieties is average height (70-76-90 cm) and good resistance to lodging, which was manifest in a rather favourable 2011, when standard lodging plant height was 111 cm, and is quite resistant to lodging local varieties – 91-101 cm **(Table 3**), so the variation coefficient is quite high - 16,2%. The plant height in Norwegian varieties: No. 2,6,7 in arid conditions decreased by 9-13 cm (-14...-20%) – to 60-65 cm, in No. 3 and 5 - by 16-23 cm (-28...-34%) and reached the same levels, and the Berserk variety was the lowest – 55 cm. Plants of tall, compared varieties are reduced by almost the same height (68-76 cm), which is why the variation coefficient of the trait is low this year - V = 6.6%. At the

same time, in standard and Lutescens 70, the plant height, in arid conditions, decreased quite significantly by 35 and 32 cm (-46%), and in other tall varieties – by 23-26 cm (-34...-37%). Norwegian varieties are distinguished by a shortened 3-5 cm length of the second lower, supporting internode, compared to the standard and it is somewhat smaller than that of other fairly resistant to lodging varieties. The length of the upper internode and the removal of the ear are marker traits of drought resistance. At the same time, the length of the upper internode, under favorable conditions, is more pronounced in tall varieties – 41-49 cm, which is much more than in Norwegian varieties - 27-31-38 cm, V = 22.9%. The variation coefficient of the trait decreases to 15.7% - in arid conditions. At the same time, the length of this internode in the first ones decreases by 11-15 cm, and in the low-stemmed ones by 5-8 cm, which is why the differences are somewhat leveled. The actual length of the upper internode in tall ones was 31-37 cm, and in short ones - 22-26 cm. At the same time, in this variant, there is a rather high inverse correlation, the length of the upper internode with the yield is r = -0.918 (R = 0.576) and d = 0.843. It follows from this that tall varieties with an elongated upper internode are more drought-resistant, so a decrease in this trait leads to a decrease in yield. A highly varying trait, regardless of the conditions of the year, is the length of the ear yield - from the vagina of the upper leaf to its base – 39.0% and 36.2%.

Table 3. Morphological traits, by year.

No.	Variety	Plant length, cm		Length of the II lower int.-node, cm		Length of the upper int.-node, cm		Ear yield, cm		Diameter of the II lower int.-node, mm	
		2011	2013	2011	2013	2011	2013	2011	2013	2011	2013
1	Omskaya 36, st.	111	76	14.7	11.8	48	37	28.1	19.2	3.33	2.53
2	Demonstrant	76	63	10.3	7.7	30	26	11.4	8.7	3.65	2.67
3	Laban	83	65	10.7	7.3	38	27	20.2	10.5	3.51	2.65
4	Berserk	71	55	8.5	6.4	29	23	11.1	5.4	3.09	2.72
5	GN 06600	90	67	10.8	8.6	36	29	17.3	13.7	3.56	2.77
6	Krabat	70	60	8.1	7.4	27	22	9.9	5.6	3.31	2.58
7	GN 04526	74	65	7.9	8.9	31	23	14.8	8.7	3.30	2.63
8	Lutescens 70, st.	102	70	11.8	8.3	45	34	25.5	18.1	3.09	2.41
9	Riks	99	73	8.8	7.9	44	31	25.3	17.6	3.34	2.69
10	Tyumenskaya 25	91	68	10.4	8.8	39	27	22.1	12.5	3.35	2.61
11	AVIADa	101	75	9.9	10.3	49	34	30.0	17.7	3.46	2.77
12	Astana 2	97	71	10.7	9.1	41	33	24.7	15.8	2.84	2.36
	$x_{\cdot}$ —	88	68	10.2	8.5	34	29.5	19.5	13.3	3.32	2.60
	min	69	55	7.9	6.4	23	22.0	8.7	5.4	2.84	2.36
	max	111	76	14.7	11.8	49	37.0	30.0	19.2	3.65	2.77
	$Sx_{\cdot}$ —	4.1	1.9	0.5	0.4	2.4	1.4	2.2	1.4	0.06	0.04
	V,%	16.2	6.6	18.3	16.9	22.9	15.7	39.0	36.2	6.8	5.3

Continuation of Table 3.

No.	Variety	Weight of 1 cm of the lower int.-node, mg		Ear length, cm		Ear density, cm	
		2011	2013	2011	2013	2011	2013
1	Omskaya 36, st.	17.8	11.4	10.3	8.4	16.6	19.5
2	Demonstrant	24.7	14.1	10.5	7.9	17.3	21.1
3	Laban	14.9	12.3	8.9	7.5	18.6	19.9
4	Berserk	16.1	9.5	7.9	7.2	25.1	26.0
5	GN 06600	17.0	15.5	9.9	8.0	20.0	21.4
6	Krabat	23.3	16.7	9.1	7.0	21.0	25.8
7	GN 04526	19.6	10.4	9.5	8.5	20.1	20.7
8	Lutescens 70, st.	16.1	10.6	8.9	7.1	21.1	20.7

9	Riks	21.6	11.0	10.9	9.2	19.4	19.2
10	Tyumenskaya 25	19.0	10.2	9.1	7.1	21.5	21.3
11	AVIADa	18.3	11.1	11.2	8.4	17.7	20.3
12	Astana 2	15.6	8.9	8.1	7.3	20.7	21.4
	$\bar{x}$	18.7	11.8	9.5	7.8	19.9	21.4
	min	14.9	8.9	7.9	7.0	16.6	19.2
	max	24.7	16.7	11.2	9.2	25.1	26.0
	$S\bar{x}$	0.9	0.7	0.30	0.21	0.66	0.64
	V,%	16.8	20.5	11.1	9.1	11.5	10.3

The value of the trait in low-stem varieties No. 2,4,6 – 9,9-11,4 cm, that is 2 times lower than other taller Norwegian varieties - No. 3.5 and three times less than that of the standard and other compared genotypes. In arid conditions, the length of the ear yield in low-stemmed varieties decreased to 5.4-8.6 cm, which is 2-3 times less than in tall varieties. With the grain yield, in this variant, the length of the ear yield shows a positively significant correlation - r = 0.815 and d = 0.664, that is, an increase in the yield is possible only with an increase in the length of the ear yield. The inverse, significant correlation - r = -0.765, at d = 0.585 of the length of the ear yield, in arid conditions, with its ear grain content indicates that a decrease in one attribute leads to a decrease in the second one. The above explains the low yield, in the dry conditions of 2012, of low-stem varieties: Demonstrant, Berserk, Krabat (Norway) and the entire Canadian group.

The diameter of the second lower internode differs slightly in the varieties, which is clearly visible over the years - V = 6.8% and 5.3%. It is most developed in Demonstrant, GN 06600 and AVIADa (3.46-3.65 mm and 2.67-2.77 mm). The trait is less pronounced in those prone to lodging: Astana and Lutescence 70 (2.84-3.09 mm and 2.30-2.41 mm). In other varieties, the diameter of the second internode is well manifested (3.35-3.56 mm), which largely determines their resistance to lodging. In arid conditions, the diameter decreases to - 2.45-2.69 mm. In this case, due to the presence of a significantly negative correlation between the diameter of the second internode and the yield - r = -0.701 (d = 0.491), it follows that the created varieties should have an optimal value.

The weight of 1 cm of the stem, the two lower internodes, is a complex indicator of resistance to lodging, variously expressed in varieties, which is confirmed by a fairly significant variation over the years – 16.8% and 20.5%. Demonstrant and Krabat varieties have the densest straw of the lower internodes, which is noted both in humid conditions (24.7 and 23.0. Dense-columned forms, as a rule, are distinguished by high-grain and medium-sized grain. At the same time, the correlation between the ear density and yield is quite significant, positive - r = 0.742 (d = 0.549), and with the absolute grain weight it is negative - r = -0.537, this explains the absence of large-grained forms in dense-grained forms. It is also necessary to consider the presence of negative correlations between grain size and yield - r = -0.586 and ear grain content - r = -0.612. Therefore, the created varieties should have an average density, a well-grained ear and an optimal grain size. Genotypes with such ear indicators and productive cenosis - 500-550 pcs./m^2 form grain yields – 6.0-6.7 t/ha.

4 Conclusion

Thus, in the breeding for grain quality, it is recommended to use Canadian varietals, as well as Omskaya 35 and Pamyati Azieva; Norwegian varieties are of interest for increasing resistance to lodging. Cultivars: Demonstrant (Norway) and 5603 HR (Canada) resistant to pre-harvest germination of grain in the ear. The identified conjugate relations allow to purposefully conduct the breeding process.

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