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ВЕСТНИК

НАЦИОНАЛЬНОЙ АКАДЕМИИ НАУК
РЕСПУБЛИКИ КАЗАХСТАН

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NAS RK is pleased to announce that Bulletin of NAS RK scientific journal has been accepted for indexing in the Emerging Sources Citation Index, a new edition of Web of Science. Content in this index is under consideration by Clarivate Analytics to be accepted in the Science Citation Index Expanded, the Social Sciences Citation Index, and the Arts & Humanities Citation Index. The quality and depth of content Web of Science offers to researchers, authors, publishers, and institutions sets it apart from other research databases. The inclusion of Bulletin of NAS RK in the Emerging Sources Citation Index demonstrates our dedication to providing the most relevant and influential multidiscipline content to our community.

Қазақстан Республикасы Ұлттық ғылым академиясы "ҚР ҰҒА Хабаршысы" ғылыми журналының Web of Science-тің жаңаланған нұсқасы Emerging Sources Citation Index-те индекстелуге қабылданғанын хабарлайды. Бұл индекстелу барысында Clarivate Analytics компаниясы журналды одан әрі the Science Citation Index Expanded, the Social Sciences Citation Index және the Arts & Humanities Citation Index-ке қабылдау мәселесін қарастыруда. Web of Science зерттеушілер, авторлар, баспашылар мен мекемелерге контент тереңдігі мен сапасын ұсынады. ҚР ҰҒА Хабаршысының Emerging Sources Citation Index-ке енуі біздің қоғамдастық үшін ең өзекті және беделді мультидисциплинарлы контентке адалдығымызды білдіреді.

НАН РК сообщает, что научный журнал «Вестник НАН РК» был принят для индексирования в Emerging Sources Citation Index, обновленной версии Web of Science. Содержание в этом индексировании находится в стадии рассмотрения компанией Clarivate Analytics для дальнейшего принятия журнала в the Science Citation Index Expanded, the Social Sciences Citation Index и the Arts & Humanities Citation Index. Web of Science предлагает качество и глубину контента для исследователей, авторов, издателей и учреждений. Включение Вестника НАН РК в Emerging Sources Citation Index демонстрирует нашу приверженность к наиболее актуальному и влиятельному мультидисциплинарному контенту для нашего сообщества.

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GRAIN MINERAL COMPOSITION OF INTROGRESSIVE WHEAT-WILD FORMS IN BREEDING OF SPRING WHEAT ON THE NUTRITIONAL PROPERTIES

Abstract. One of the most important problems of our time is providing people with balanced diet by adding all of the essential factors necessary for the health. A convenient and perspective object is interspecific and intergeneric wheat-wild hybrids that can combine nutritional, technological properties and agronomic suitability. From this point of view, introgressive forms from interspecific and intergeneric hybrids with systematic breeding of wheat type up to the F6-F8 generation are valuable with permanent forms of cytological control of 42-chromosome forms in the early generations. To use this material for practical purposes, it is necessary to characterize the mineral composition, both the metabolic potential and the biochemical composition of the grain, against a background of productivity.

The content of macro- and microelements in the grain was determined by inductively-plasma-atomic emission spectrometry.

The genotypes Ilinskaya x *T.timopheevii* (N, K, P, Zn) and Kazakhstanskaya 10 x *T.dicoccum* (Mg, Mn, Fe, Zn) showed stably increased level of mineral composition in the North. The genotype Kazakhstanskaya 10 x *T.dicoccum* in both the south and the north were characterized by a stable increase in the content of N, Mg and Fe, as well as the genotype Ilinskaya x *T.timopheevii* according to Zn content.

It was noted the predominance of spring introgressive forms over wild and cultivated forms on the content of P, K, Mg, Fe and Ca. The obtained results indicate that in the breeding for a high level of metabolism, the use of transitional wheat-wild spring-type forms is promising for extreme continental conditions.

Key words: spring wheat, wild relatives and hybrids, macro- and microelements of grain, breeding.

Introduction. One of the most important problems of our time is providing people with balanced diet by adding all of the essential factors necessary for the body.

The biological approach of the natural enhancement of microelements in plants has been termed "biofortification". One of the most important factors of stable production of spring wheat high-quality products as an export crop is breeding and early introduction into agricultural production of new varieties, combining high economically valuable traits with a genetically determined high content of microelements and adapted to the agroclimatic conditions of the region.

Recently, interest in natural and organic products has increased, which led to the reopening of ancient wheat as a source of grain for healthy nutrition. A number of wheat species are used and adapted for cultivation on an industrial scale, for example, *T.turgidum* (khorosan), *T.spelta, T.compactum*. However, these wheat have drawbacks (shedding, difficult threshing, etc.) that prevent their widespread using. In this regard, the constant interspecific and intergeneric wheat-wild hybrids are a convenient and promising object, which ideally can combine nutritional, technological properties and agronomic suitability.

It is known that wild and primitive wheat (T.*monococcum, T.dicoccum* and *T.dicoccoides*) are identified as more promising genetic sources of microelements, in comparison with modern wheat varieties and breeding lines. The species *T.dicoccoides* is a resource of genetic diversity for agronomic properties, amino acid composition and protein content. Similar studies are developing on phosphorus [1] and nitrogen, the assimilation of nutrients (N, P, K) by di-, tetra- and hexaploid wheat [2]. The increase in ploidy of wheat is accompanied by an increase in the efficiency of the use of N for the growth of biomass and grain yield. The influence of N and P on biomass is maximally effective in *T.boeoticum*, minimally in *Ae.speltoides*. The influence of N, P and K on productivity is most effective in *Ae.speltoides* and least in *T.estivum*. According to the content of mineral elements in the grain, in particular Fe and Zn, *T.diccocoides'* accessions , T. durum fore crops are most studied, characterized by an increased content of Fe in the grain.

Other types of wheat were characterized sporadically by mineral composition of the grain [3], as well as samples of Aegilops [4]. A number of works are devoted to the search for sources of not only a high content of microelements, but also their bioavailability [5].

Wheat has long been used by mankind for food, according to the high value of grain. Problems of nutrition and health are being addressed with success in wheat breeding, which allow to obtain high yields and successes in processing allowing to obtain high-quality white flour.

One way to overcome these problems is to return or resynthesis to ancient wheat as more nutritious and digestible.

Another approach considers it necessary to develop modern wheat on the basis of new technological methods of breeding and processing.

Thus, in order to enhance signs of resistance to diseases, stresses and increase of protein content it was created a new material as a result of successful hybridization of Triticum and Aegilops species with modern commercial varieties at the breeding center of KazSRIA&PG under a program of remote crossing [6].

From this point of view valuable are introgressive forms from interspecific and intergeneric hybrids with systematic of wheat type up to the F6-F8 generation and with constant cytological control of 42-chromosome forms in the early generations [7-9], characterized by resistance to disease [10, 11] and productivity at the level of 8-9 t/ha, including in the CIMMYT experiments.

To use this material for practical purposes, it is necessary to characterize the mineral composition, both the metabolic potential and the biochemical composition of the grain, against a background of productivity. Detailed phenotyping of the material for grain quality is promising for further genetic analysis of introgressive forms involving different species [12-16]. In addition, transitional forms are the most optimal approach for the evaluation and subsequent transfer of unique wheat gene alleles from its wild relatives. Maintain and keep normally identified gene (allele) of wheat-alien hybrids (WAH) much easier than tracking it in populations of wild relatives.

Goals. To study the features of mineral composition of the spring wheat introgressive form grains in comparison with wild relatives and varieties and to identify sources and donors of high content of macro- and microelements for the development of breeding for nutritional and technological properties.

Materials and methods.

Plant material. Species of wheat and Aegilops (table 1) were used: tetraploid (T.dicoccum, T.militinae, T.timopheevii, T.dicoccoides), hexaploid (T. kharae, T.aestivum); b) constant transitional forms from intergeneric and interspecific crossings F6-F8 [6]; c) topcrosses between transitional forms and registered varieties [17].

The material was grown in 2006-2009 in south-east agroecological conditions the Kazakh Research Institute of Agriculture and Plant Growing (KazRIA&PG), 42^0 N, 77^0 E, 740m above sea level, and in 2014-2016 in north conditions the Karabalyk Agricultural experimentation station, 43^0 N, 75^0, at $5m^2$ plots in 2 replications in accordance with the accepted agrotechnics.

Methods. The content of macro- and microelements in the grain was determined by inductively-plasma-atomic emission spectrometry (ICP-AES) [3]; The N content is determined by the Kjeldahl method. The cluster analysis was carried out by SP Martynov's algorithm using the minimum product between the Euclidean distances and the correlation coefficient D $(1\text{-}R)^2$ [18].

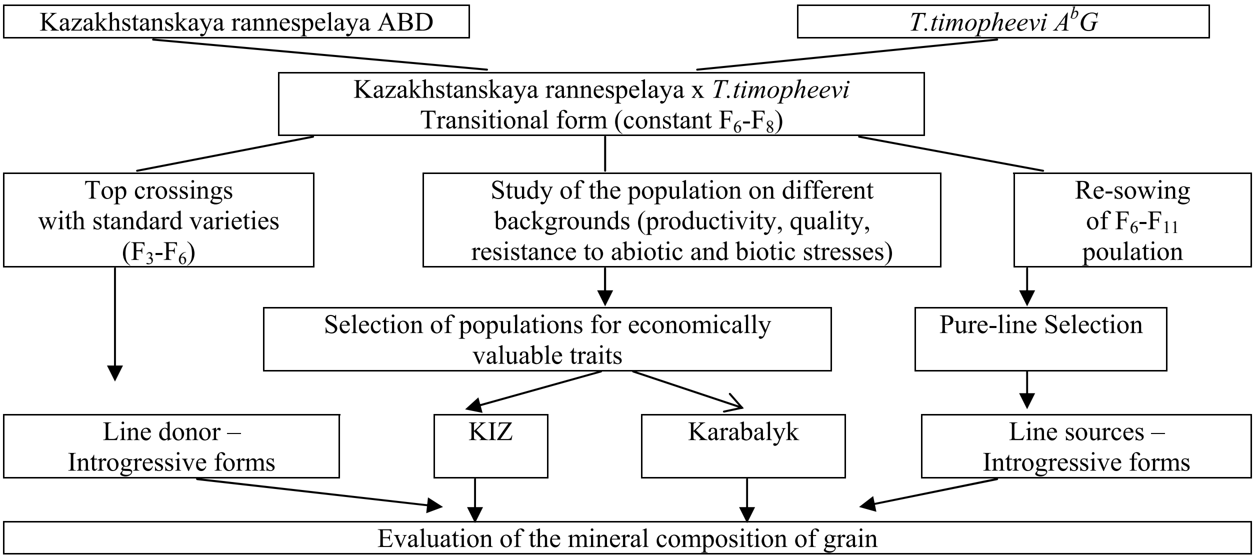

Figure 1 – General scheme for the creation and study of transitional (introgressive) forms

Results. Characterization of introgressive spring wheat forms according to the mineral composition of the grain and distinguishing the source of the high content of macro- and microelements.

The nitrogen content in the grains of introgressive wheat forms varied from 13.0% (Kazakhstanskaya rannespelaya x *T.timopheevii*) to 21.8% (Kazakhstanskaya 10 x *T.timopheevii*). The Il'inskaya x *T.timopheevii* (13.5-17.9%) and the Kazakhstanskaya 17 x *T.kiharae* (16.4-16.8%) forms differ by relatively low nitrogen content. Transitional forms occupied an intermediate position between varieties of Kazakhstanskaya 10 (13.8-15.3%), Kazakhstanskaya rannespelaya (13.0-15.1%), Kazakhstanskaya 25 (16.9-17.1%), Ilinskaya (14, 1-14.3%) and wild forms: T.timopheevii (16.0-17.3%), *T.kiharae* (21.9-22.2%), *T.dicoccoides* (19.3%); *T.militinae* (22.2-23.6%), *T.dicoccum* (18.9%).

The phosphorus content varies from 3531 mg/kg (Kazakhstan 17 x *T.kiharae*) to 5944 mg/kg (Kazakhstanskaya 10 x T.dicoccum). The Kazakhstanskaya 10 x *T.timopheevii* (4902-5729 mg/kg) and Kazakhstanskaya rannespelaya x *T.timopheevii* (4246-5563 mg/kg and 3831-5779 mg/kg on the 2 numbers with the same origin) are characterized by a stable high phosphorus content. Hybrid forms are characterized by superiority over parental forms, such as Kazakhstanskaya 10 from 3830 to 4674 mg/kg, Kazakhstanskaya rannespelaya 3646 to 3888 mg/kg), Kazakhstan 25 (3034-4367 mg/kg) and wild relatives *T.kiharae* (4257 mg/kg), *T.dicoccoides* (2959-4618 mg/kg) and T. timopheevii from 3359 to 5433 mg/kg (Table 30). The transitional forms occupied an intermediate position between the varieties (3888-4122 mg/kg) and the species *T.timopheevii* (5433 mg/kg) by phosphorus content only in the first reproduction (table 1).

Potassium content ranged from 3509 mg/kg - 4349 mg/kg in minimum values to 4411-6684 mg/kg in the maximum values by all reproductions of transitional forms.

The maximum values were stably differed by the Kazakhstanskaya 10 x *T.dicoccum* (3624-6684 mg/kg), with excess over the parent forms: Kazakhstanskaya 10 (3960 mg/kg - 4315 mg/kg) and the hybrid transitional form Kazakhstanskaya 10 x *T.timopheevii* (4242 -4829 mg/kg) with excess over *T.timopheevii* from 3512 mg/kg to 4515 mg/kg, respectively (table 1).

The content of Ca in the grain of transitional spring forms varied from 443 mg/kg (6631 x *T.militinae*-1) to 729 mg / kg (Kazakhstanskaya 10 x *T.dicoccum*). Synthetic forms were characterized by high calcium content relative to varieties (411-542 mg/kg for Kazakhstanskaya 10 variety, 405-499 mg/kg for Kazakhstanskaya rannespelaya variety, 415-504 mg/kg for Kazakhstanskaya 25 variety, Ilinskaya 418-429 mg/kg) and relative to wild relatives *T.militinae* - 284-393 mg/kg, *T.timopheevii* 333-368 mg/kg; *T.dicoccoides* 341-421 mg/kg; *T.dicoccum* and *T. kiharae* 396-421 mg/kg (Table 31).Genotypes: Kazakhstanskaya 30 x T.timopheevii (605-668 mg/kg); 6569 x *T.militinae*-1 (561-644 mg/kg); Kazakhstanskaya 10 x *T.timopheevii* (awned) (464-646 mg/kg) and 6625 x *T.timopheevii* (574-598 mg/kg) were differed by a stable maximum value.

Table 1 – Characteristics of transitional spring forms in terms of nitrogen (N x 5,7), potassium and phosphorus content (N, P, K) in grain

Genotypes of spring wheat synthetics	N content (protein), %		P content (phosphorus)		K content, mg/kg	
	Min	max	min	max	min	max
Parents: wild relatives						
T.kiharae	21,9	21,9	4257	4257	4076	4076
T.dicoccoides	19,3	19,3	2959	4618	3344	3753
T.dicoccum	18,9	18,9	3023	3023	3221	3221
T.timopheevii	16,0	17,3	3350	5433	3512	4515
T.militinae	22,2	23,6	4403	4848	3747	4108
Parents: varieties						
Kazakhstanskaya 10	13,8	15,3	3830	4674	3960	4315
Kazakhstanskaya rannespelaya	13,0	15,1	3646	3888	3343	4003
Kazakhstan 25	16,9	17,1	3034	4367	3401	3671
Iliinskaya	14,3	14,3	3909	3909	4476	4476
Kazakhstanskaya 10 x *T.kiharae*	15,6	18,6	4827	4827	4708	4708
Kazakhstanskaya 17 x *T.kiharae*	16,4	16,8	3531	4029	4286	4531
Kazakhstanskaya 10 x *T.dicoccum*	16,7	17,8	3789	5944	3624	6684
Iliinskaya x T.timopheevii	13,5	17,9	3664	3951	3777	4391
iliinskaya x T.timopheevii	15,4	15,4	3869	3869	4349	4349
Kazakhstanskaya r/sp x T.timopheevii	13,0	20,6	3831	5779	4189	4480
Kazakhstanskaya r/sp x T.timopheevii	19,8	21,8	4226	5563	4411	4672
Kazakhstanskaya r/sp x T.timopheevii	13,0	14,8	3615	3968	4442	4442
6583 x T.timopheevii	15,4	20,5	3717	4696	4017	4653
6625 x T.timopheevii-1	15,4	19,4	3974	4728	3673	4153
6625 x T.timopheevii-2	18,9	19,6	4014	4608	3752	4151
6625 x T.timopheevii-3	18,1	18,1	3721	3721	3509	3509
Kazakhstanskaya 25xT.timopheevii-1	17,7	17,7	3781	3781	3980	3980
Kazakhstanskaya 25xT.timopheevii-1	18,1	18,1	3942	3942	4022	4022
Kazakhstanskaya 10 x T.timopheevii (awn)	21,0	21,6	4902	5750	4242	4829
Kazakhstanskaya 10 x T.timopheevii (awnless)	20,5	21,8	5669	5729	4581	4704
Kazakhstanskaya 30 x T.timopheevii	19,4	19,5	4717	5392	4186	4545
6628 x T.timopheevii	19,4	20,6	3956	4720	3627	4334
6628 x T.timopheevii	18,1	18,1	4544	4544	4244	4244
6631 x T.timopheevii	18,7	21,4	4240	5268	4434	5802
6569 x T.militinae-1	18,9	20,0	4065	4634	4073	4417
6569 x T.militinae-2	19,5	19,5	4205	4205	3858	3858
6628 x T.militinae	19,0	19,0	4149	4149	3829	3829
6631 x T.militinae-1	18,4	19,7	4477	4638	3978	4733
6631 x T.militinae-2	20,0	20,0	4402	4402	4181	4181
Kazakhstanskaya 10 x T.zhukovkyi	17,7	17,7	5251	5251	4213	4642
Dawıl x T.timopheevii	17,7	19,0	4334	4334	4422	4422

The Mg content in the grain of transitional forms is noted at the level of variability from 1230 mg/kg Kazakhstanskaya 17 x *T.kiharae* and 1228-1243 mg/kg for Ilinskaya x *T.timopheevii* to the maximum 1869 mg/kg (Kazakhstanskaya 10 x *T.timopheevii*) and Kazakhstanskaya 10 x *T.dicoccum*, which in general exceeds the range of variability in both varieties (1118-1459 mg/kg) and wild relatives (1182-1676 mg/kg). An intermediate level of Mg content (1187-1659 mg/kg) in transitional forms between varieties (1171-1288 mg/kg) and wild forms (1676 mg/kg) was noted in the first reproduction. Kazakhstanskaya 10 x *T.timopheevii* was characterized by stably maximum values of Mg content (table 2).

Table 2 – Characteristics of transitional spring forms in terms of Mg, Mn, Ca mg/kg

Genotypes of spring wheat	Ca content		Mg content		Mn content	
Transitional forms	Min	max	min	max	min	max
Kazakhstanskaya 10 x *T.kiharae*	456	564	1187	1508	62	62
Kazakhstanskaya 17 x *T.kiharae*	557	566	1230	1276	37	43
Kazakhstanskaya 10 x *T.dicoccum*	468	729	1337	1912	39	58
Iliinskaya x *T.timopheevii*	504	596	1228	1243	38	51
Iliinskaya x *T.timopheevii*	617	617	1199	1199	49	49
Kazakhstanskaya r/sp x *T.timopheevii*	472	565	1171	1294	40	47
Kazakhstanskaya r/sp x *T.timopheevii*	493	528	1629	1840	44	66
Kazakhstanskaya r/sp x *T.timopheevii*	579	579	1653	1653	61	61
6583 x *T.timopheevii*	553	622	1390	1678	42	51
6625 x *T.timopheevii-1*	574	598	1238	1659	47	56
6625 x *T.timopheevii-2*	518	626	1491	1547	41	59
6625 x *T.timopheevii-3*	515	515	1416	1416	37	37
Kazakhstanskaya 25 x *T.timopheevii-1*	474	474	1249	1249	33	33
Kazakhstanskaya 25 x *T.timopheevii-1*	462	462	1308	1308	34	34
Kazakhstanskaya 10 x *T.timopheevii (ost)*	464	646	1658	1811	53	68
Kazakhstanskaya 10 x *T.timopheevii(bezost)*	512	571	1715	1869	60	65
Kazakhstanskaya 10 x *T.timopheevii*	566	566	1558	1558	60	60
Kazakhstanskaya 30 x *T.timopheevii*	605	668	1547	1583	53	65
6628 x *T.timopheevii*	519	632	1418	1510	45	59
6628 x *T.timopheevii*	528	528	1611	1611	47	47
6631 x *T.timopheevii*	522	609	1530	1715	45	80
6569 x *T.militinae-1*	561	644	1386	1453	40	52
6569 x *T.militinae-2*	530	530	1479	1883	41	41
6628 x *T.militinae*	571	571	1401	1401	44	44
6631 x *T.militinae-1*	473	604	1549	1641	48	59
6631 x *T.militinae-2*	443	443	1596	1596	45	45
Kazakhstanskaya 10 x *T.zhukovkyi*	526	554	1443	1581	44	46
Dawıl x *T.timopheevii*	539	539	1331	1331	48	48
Parents: varieties						
Kazakhstanskaya 10	411	542	1252	1459	44	46
Kazakhstanskaya rannespelaya	405	499	1118	1274	39	45
Kazakhstan 25	415	504	1141	1404	40	42
Iliinskaya	418	418	1288	1288	42	42
Arai	419	419	1439	1439	37	37
Parents: wild relatives						
T.kiharae	421	421	1490	1490	64	64
T.dicoccoides	341	421	1182	1448	35	37
T.dicoccum	396	396	1183	1183	35	35
T.timopheevii	333	368	1169	1676	36	50
T.militinae	284	393	1419	1438	45	53

Table 3 – Characteristics of transitional spring forms in terms of Fe, Zn and S mg/kg

Genotypes of spring wheat	Fe content		Zn content		S content	
Transitional forms	min	max	min	max	min	max
Kazakhstanskaya 10 x *T.kiharae*	45	54	45	45	1901	1901
Kazakhstanskaya 17 x *T.kiharae*	33	43	32	39	1723	1832
Kazakhstanskaya 10 x *T.dicoccum*	44	58	39	51	1811	2184
Iliinskaya x *T.timopheevii*	35	45	34	43	1792	2001
Iliinskaya x *T.timopheevii*	43	43	34	34	1756	1756
Kazakhstanskaya r/sp x *T.timopheevii*	43	54	31	49	1660	1997
Kazakhstanskaya r/sp x *T.timopheevii*	53	70	67	68	2397	2506
Kazakhstanskaya r/sp x *T.timopheevii*	74	74	66	66	2333	2333
6583 x *T.timopheevii*	41	49	34	56	1800	2191
6625 x *T.timopheevii-1*	43	50	37	52	1893	2122
6625 x *T.timopheevii-2*	41	50	42	50	1966	1979
6625 x *T.timopheevii-3*	39	39	48	48	1971	1971
Kazakhstanskaya 25 x *T.timopheevii-1*	33	33	45	45	1936	1936
Kazakhstanskaya 25 x *T.timopheevii-1*	35	35	47	47	1975	1975
Kazakhstanskaya 10 x *T.timopheevii (ost)*	56	66	62	66	2346	2357
Kazakhstanskaya 10 x *T.timopheevii (bezost)*	63	70	69	76	2305	2411
Kazakhstanskaya 10 x *T.timopheevii*	58	58	59	59	2289	2289
Kazakhstanskaya 30 x *T.timopheevii*	53	56	48	65	2161	2205
6628 x *T.timopheevii*	44	51	43	51	2054	2103
6628 x *T.timopheevii*	47	47	55	55	1998	1998
6631 x *T.timopheevii*	52	66	57	60	1977	2049
6569 x *T.militinae-1*	44	48	43	51	644	2030
6569 x *T.militinae-2*	44	44	52	52	1883	2065
6628 x *T.militinae*	46	58	49	49	2048	2048
6631 x *T.militinae-1*	46	57	46	62	2017	2277
6631 x *T.militinae-2*	53	53	57	57	2243	2243
Kazakhstanskaya 10 x *T.zhukovkyi*	49	49	41	57	1889	1955
Dawıl x *T.timopheevii*	46	46	35	35	1807	1807
Parents: varieties						
Kazakhstanskaya 10	39	43	33	44	1601	1740
Kazakhstanskaya rannespelaya	37	42	30	37	1514	1732
Kazakhstanskaya 25	40	40	34	46	1813	1888
Iliinskaya	37	37	40	40	1630	1630
Arai	38	38	38	38	1774	1774
Parents: wild relatives						
T.kiharae	55	55	51	51	1767	2142
T.dicoccoides	30	36	35	39	1817	1817
T.dicoccum	37	37	35	35	1802	1802
T.timopheevii	35	47	36	53	1841	1849
T.militinae	33	54	40	48	2275	2330

The Mn content in the grain of synthetic spring forms ranges from 33 mg/kg (Kazakhstanskaya 25 x *T.timopheevii*) to 68-80 mg/kg (Kazakhstanskaya 10 x *T.timopheevii*) in the awned and awnless variants – (6631 x *T.timopheevii*). Stable high Mn content by reproductions was formed in the same genotypes of Kazakhstanskaya 10 x T. timopheevii from 53 to 68 mg/kg for awning variants; from 60 to 65 mg/kg for awnless and for Kazakhstanskaya 30 x *T.timopheevii* - from 53 to 65 mg/kg. Moreover, among the parental forms only for *T.kiharae* noted similar levels of Mn ~ 64 mg/kg and in some reproductions for *T.militinae* and *T.timopheevii* (50-53 mg/kg).

Varieties characterized by Mn content at the level of 39-45 mg/kg (for the Kazakhstanskaya rannespelaya), 44-46 mg/kg (Kazakhstanskaya 10); 40-42 mg/kg (Kazakhstanskaya 25) and 38-42 mg/kg (Ilinskaya).

The sulphur content in the grain of spring transitional forms varied from 1660 mg/kg (Kazakhstanskaya rannespelaya x *T.timopheevii*-1) to 2506 mg/kg (Kazakhstanskaya rannespelaya x *T.timopheevii*-2) and Kazakhstanskaya 10 x *T.timopheevii* (awned), surpassing of S level in the grain of varieties Kazakhstan 10 (1601-1740 mg/kg), Kazakhstanskaya rannespelaya (1514-1732 mg/kg), Kazakhstanskaya 25 (1813-1888 mg/kg), Ilinskaya (1630 mg/kg) and in the grain of wild relatives *T.kiharae* (1767-2142 mg/kg), *T.timopheevii* (1841-1849 mg/kg), *T.dicoccum* (1802-1817 mg/kg), *T.militinae* (2275-2330 mg/kg). The stable maximum content of S (more than 2000 mg/kg) is noted for the genotypes of Kazakhstanskaya rannespelaya x *T.timopheevii*-2 and 3, Kazakhstanskaya 10 x *T.timopheevii* awning and awnless forms and in some reproductions for the Kazakhstanskaya 10 x *T.dicoccum* (table 3).

The content of Fe in the grain of spring transitional forms varied from 33-35 mg/kg (Kazakhstanskaya 17 x *T.kiharae*, Kazakhstanskaya 25 x *T.timopheevii*, Ilinskaya x *T.timopheevii*) to 70-74 mg/kg (Kazakhstanskaya 10 x *T.timopheevii* and Kazakhstanskaya rannespelaya x *T.timopheevii*). The biofortification level of Fe (> 50 mg/kg) is noted for 30-63% of genotypes, depending on the conditions of the year of reproduction. As stable sources of high Fe content marked genotypes: Kazakhstanskaya rannespelaya x *T.timopheevii* - 2,3 (53-74 mg/kg with an average of 62 mg/kg); Kazakhstanskaya 10 x *T.timopheevii* both in the awned variant (56-66 mg/kg) and in the awnless (63-70 mg/kg); Kazakhstanskaya 30 x *T.timopheevii* (53-56 mg/kg); 6631 x *T.timopheevii* (52-66 mg/kg); 6625 x *T.timopheevii*-2 (41-50 mg/kg with an average of 47 mg/kg).

At the same time, a high Fe content was revealed for parental forms only for *T.kiharae* (51-55 mg/kg), and for varieties at the level of 39-43 mg/kg for variety Kazakhstanskaya 10; 37-42 mg/kg for varieties Kazakhstanskaya rannespelaya, Kazakhstanskaya 25 up to 40 mg/kg, for Ilinskaya - 37-38 mg/kg.

The Zn content in the grain of spring transitional forms (table 3) varies from 31-32 mg/kg (Kazakhstanskaya rannespelaya x *T.timopheevii*-1 and Kazakhstanskaya 17 x *T.kiharae*) to 69-76 mg/kg for the genotype Kazakhstanskaya 10 x *T.timopheevii* awnless). The stable maximum value of Zn is typical for the same population in the awned variant (62-66 mg/kg), for the forms of Kazakhstanskaya rannespelaya x *T.timopheevii* 2, 3 (66-68 mg/kg) and 6631x*T.timopheevii* (57-60 mg/kg). Parental forms relatively of synthetic were characterized by a lower content of Zn both in cultural forms (Kazakhstanskaya rannespelaya 30-37 mg/kg, Ilinskaya 38-40 mg/kg, Kazakhstanskaya 10 from 33 to 44 mg/kg and Kazakhstanskaya 25 from 34 to 46 mg/kg), and wild relatives (*T.dicoccum* and *T.dicoccoides* 35-39 mg/kg, *T.militinae* 40-48 mg/kg, *T.timopheevii* 36-53 mg/kg, *T.kiharae* 51-52 mg/kg).

Thus, the synthetic forms of wheat occupied an intermediate position between wild relatives and modern varieties according to the content of macro- and microelements [19-20]. It has been revealed transitional forms with the level of mineral composition typical for wild forms close to modern varieties depending on growing conditions (figures 2, 3).

In general, it has been selected synthetic spring wheat's accessions with the maximum content: Kazakhstanskaya 10 x *T.dicoccum*- K (6684 mg/kg), P (5944 mg/kg), Ca (729 mg/kg), Mg (1869 mg/kg) ; Kazakhstanskaya 10 x *T.timopheevii* - N (21.8%), S, Fe, Zn (176), Mg, Mn (180); Kazakhstanskaya rannespelaya x *T.timopheevii* - Fe (74 mg/kg), S (2506 mg/kg).

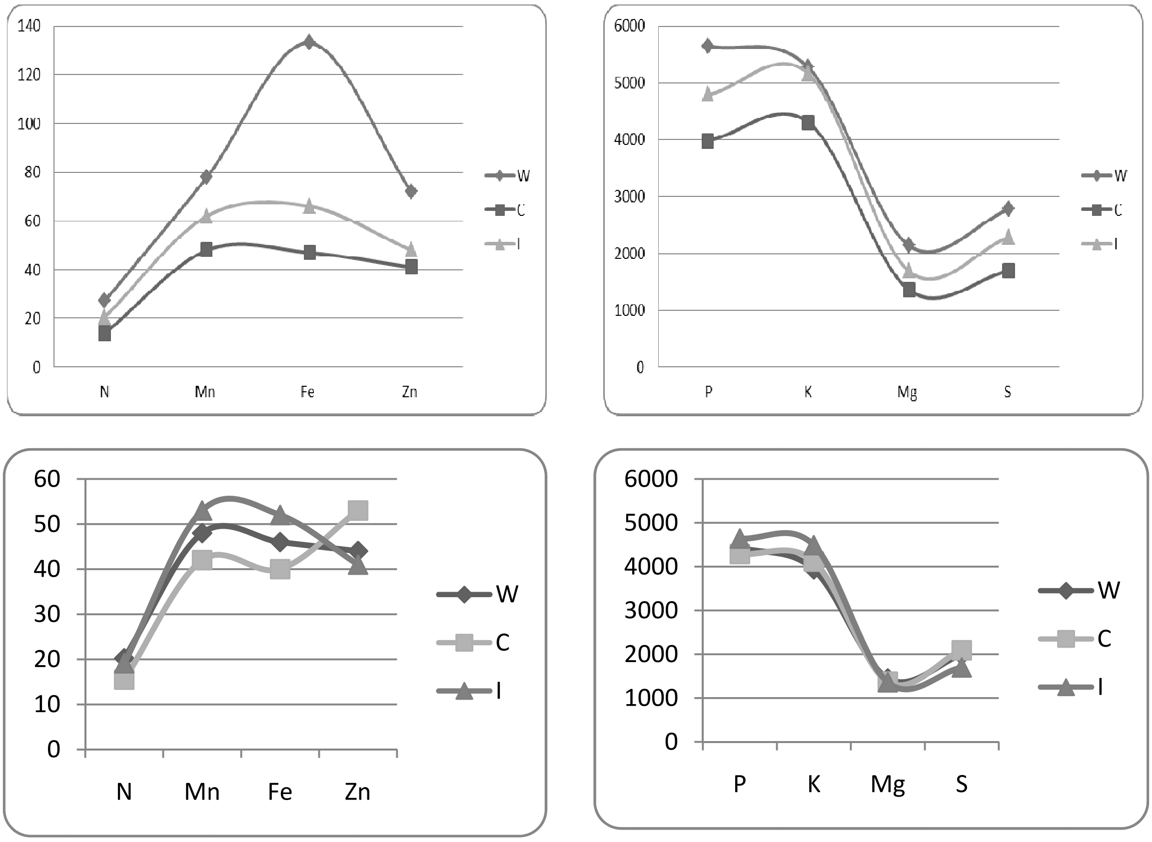

Figure 2 – Comparative characteristics of the range of variability of macro- and microelements content (mg / kg) in the grain of wild relatives (W), modern varieties (C) and synthetic forms of wheat (I) 1 and 2 – winter wheat; 3 and 4- spring wheat

Conclusion. Constant lines between wild forms and spring common wheat varieties have been previously analysed on the content of Zn in the grain. Constant lines with significant content of Zn in grain were identified as sources with high content of Zn in grain.

Wild relatives of wheat are analyzed by the content of N, P, K, S, Mg, Ca, Mn, Fe, Zn, Al, Cd, Cu in the grain.

The content of Cd in a grain of different species of wheat and wild relatives is found from less than 20 mg/kg to 25 mg/kg - *T.kiharae*; 26 mg/kg - *T.militinae*; 35 mg/kg *T.dicoccum*.

Our studies (VOGIS, 2018) reveal that the most favorable ratio of calcium to phosphorus is characteristic for *T.turgidum* species (1: 6,0); *T.persicum* (1: 5,7); at a maximum of 1:19 (*T.compactum*) and 1: 16.0 (*T.spelta*). For introgressive spring forms, the ratio of Ca:P varied from 1: 6.3 (Ilinskaya x *T.timopheevii*) to 1: 11.0 (Kazakhstanskaya 10 x *T.timopheevii*) against the background of wild relatives 1: 7.0 (*T.dicoccoides*) up to 1: 15,5 (*T.militinae*). The most nutritious in addition to the Ilinskii x *T.timopheevii* are Kazakhstanskaya 17 x *T.kiharae* (1: 6,3 - 1: 7,1); Kazakhstanskaya rannespelaya x *T.timopheevii*-1; (1: 7.0 -1: 7.7); and 6583 x *T.timopheevii* (1: 6,6-1: 7,6).

Among the wild relatives as parental forms *T.dicoccoides* (1: 2.5), *T.dicoccum* (1: 2,6) and among the introgressive forms: 6625 x *T.timopheevii*-1, 2, 3 (1: 2.6 - 1: 2.8); 6583 x *T.timopheevii* and 6631 x *T.militinae* (1: 2.7 - 1: 3.0) are balanced by the ratio Ca: Mg.

In general, samples with the maximum content are selected out: Kazakhstanskaya 10 x *T.dicoccum* - K, P, Ca, Mg; Kazakhstanskaya 10 x *T.timopheevii* - N, S, Fe, Zn, Mg, Mn; Kazakhstanskaya rannespelaya x *T.timopheevii* - Fe, S; Ilyinsky x *T.timopheevii* - Zn, P, K.

According to the results of top crossings with the testers (the commercial and most common varieties Arai, Kazakhstanskaya 10, Kazakhstanskaya rannespeelaya) was revealed the transfer of this trait to the offspring in F2-F3 generations for 3 constant lines: Kazakhstanskaya rannespelaya x *T.timopheevii*; 6625 x *T.timopheevii* and 6583 x *T.timopheevii*.

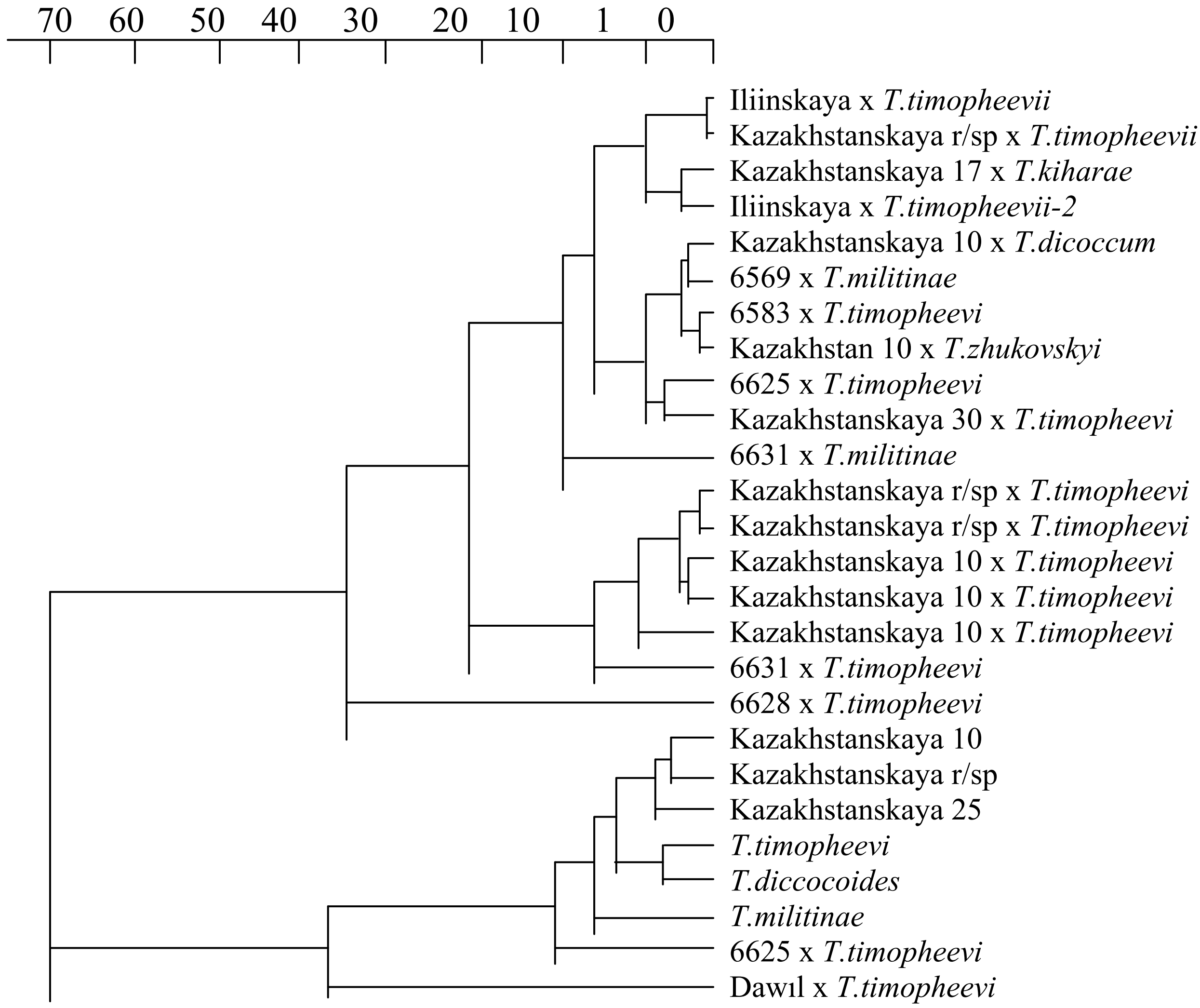

Figure 3 – Dendrogram of similarities-differences of spring synthetic forms and their parents (wild relatives and varieties) according to the mineral composition of the grain in the first reproduction

Genotypes Kazakhstanskaya rannespelaya x *T.timopheevii*-1, 2, 3 and Kazakhstanskaya 10 x *T.timopheevii*-1, 2 were distinguished by an increased level of mineral composition in all reproductions in the south of Kazakhstan (KIZ).

In northern conditions the Ilyinskaya x *T.timopheevii* (N, K, P, Zn) and the Kazakhstanskaya 10 x *T.dicoccum* (Mg, Mn, Fe, Zn) were characterized by a stably increased level of mineral composition.

The genotypes Kazakhstanskaya 10 x *T.dicoccum* as well as the Ilinskaya x *T.timopheevii* in both the south and the north were differed by a stable increase in the content of N, Mg and Fe according to Zn content.

Among the spring wheat introgressive forms prevailed over wild and cultured on the content of P, K, Mg, Fe and Ca; the predominance of varieties according to the content of Zn and S are at the maximum values. Wild relatives remain with the highest values of protein and magnesium. According to the content of macro- and microelements, the introgressive winter forms of wheat occupy an intermediate position between wild relatives and modern varieties (figure 2).

The selection of sources of high content of certain elements, as well as their values depends on the growing conditions. Almost all spring transitional forms of wheat were characterized by high nitrogen content (Table 1). Accessions of the Kazakhstanskaya rannespelaya variety have been identified as a source with minimum nitrogen comtent (mainly in Karabalyk) and hybrids with it.

The genotype Kazakhstanskaya 10x *T.dicoccum* in 6 of 12 reproductions differs by the maximum value of phosphorus, as well as by the content of potassium. Kazakhstanskaya 10 x *T.timopheevii* and Kazakhstanskaya rannespelaya x *T.timopheevi* are distinguished among genotypes with a stably high NP.

Perspective forms for technological directions, for example, the ratio N: S and nutrient (medical), the ratio of Ca : P are of particular interest.

The sources of the high content of elements are wild relatives and synthetic forms: a) for N → Kazakhstanskaya 10 x *T.timopheevii*; Kazakhstanskaya rannespelaya x *T.timopheevii*; Kazakhstanskaya 10 x *T.dicoccum* → *T.spelta* (cvs Faraon); b) N, K → Kazakhstanskaya 10 x *T.dicoccum* → Kazakhstanskaya 10 x *T.timopheevii* → Kazakhstanskaya rannespelaya x *T.timopheevii* → *T.spelta* (cvs Gremme); c) Fe and Zn → Kazakhstanskaya 10 x *T.timopheevii* → *T.timopheevii* = *T.spelta* → Kazakhstanskaya 10 x *T.dicoccum*.

Thus, these results indicate that in the breeding for a high level of metabolism, the use of transitional wheat-alien forms of the spring type is promising for the extreme continental conditions in the North of Kazakhstan.

The authors state that there is no conflict of interest.

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КҮЗДІК БИДАЙ СЕЛЕКЦИЯСЫНДА ИНТРОГРЕССИВТІ БИДАЙЛЫ-БӨГДЕ ТҮРЛЕРІНІҢ ҚОРЕКТІК ҚАСИЕТТЕРІНЕ ДӘННІҢ МИНЕРАЛДЫҚ ҚҰРАМЫ

Аннотация. Заманауи маңызды ахуалдардың бірі халықты сапалы толыққанды, құрамында ағзаға қажетті элементтері бар құнарландырылған азықпен қамтамасыз ету. Түраралық және туыс аралық бидайлы-бөгде гибридтер ыңғайлы және болашақты нысан болып табылады, ол коректік, технологиялық қасиеттермен агрономиялық жарамдылықты бірге алып жүре алады. Осы көз қарастан түраралық және туыс аралық гибридтердің интрогрессивті түрлері бидайлы типтен жоспарлы іріктеу $Ғ_6$–$Ғ_8$-дейін, ерте тұқымда үнемі цитологиялық бақылауларда 42-хромасомалық түрлер құндылығын көрсетті. Осы материалды тәжірибелң мақсатта қолдану үшін минералды сипаттамасы метаболикалық потенциалы және дәннің өнімділік негізінде биохимиялық құрамы ретінде қажет.

Дәндегі макро- және микроэлементтер құрамы индуктивті-плазмалы-атомды эмиссионды спектрометрия әдісімен анықталды(*ICP-AES*);

ҚР Солтүстік жағдайында келесі генотиптердің минералды құрамы тұрақты жоғары жеңгейімен сипатталды: Ильинская х *T.timopheevii (N, K, P, Zn)* және Казахстанская 10 х *T.dicoccum (Mg, Mn, Fe, Zn).* Казахстанская 10 х *T.dicoccum* генотипі *N, Mg* және *Fe* құрамы бойынша солтүстікте және оңтүстікте тұрақты жоғарылығымен ерекшеленді, сонымен қатар Ильинская х *T.timopheevii* генотипң құрамындағы *Zn* бойынша ерекшеленді.

P, K, Mg, Fe және Ca құрамы бойынша интрогрессивті түрлерде жабайы және мәдени түрлерге қарағанда басымдылық танытты. Алынған нәтижелер күрт континенталды жағдай үшін күздік өтпелі бидайлы-бөгде түрлері үшін перспективті қолдану метаболизм деңгейінің селекцияда жоғары екенін көрсетеді.

Түйін сөздер: күздік бидай, жабайы туыстармен гибридтер, дәннің макро- и микроэлементтері, селекция.

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МИНЕРАЛЬНЫЙ СОСТАВ ЗЕРНА ИНТРОГРЕССИВНЫХ ПШЕНИЧНО-ЧУЖЕРОДНЫХ ФОРМ В СЕЛЕКЦИИ ЯРОВОЙ ПШЕНИЦЫ НА ПИТАТЕЛЬНЫЕ СВОЙСТВА

Аннотация. Обеспечение людей качественно полноценным питанием, сбалансированным по составу и содержанию необходимых для организма элементов, является одной из важнейших проблем современности. Межвидовые и межродовые пшенично-чужеродные гибриды являются удобным и перспективным объектом, который в идеале может сочетать питательные, технологические свойства и агрономическую пригодность. С этой точки зрения представляют ценность интрогрессивные формы из межвидовых и межродовых гибридов с планомерным отбором пшеничного типа до F_6-F_8 поколения, постоянным цитологическим контролем в ранних поколениях 42-хромосомных форм. Для использования этого материала в практических целях необходима характеристика минерального состава, как метаболического потенциала и биохимического состава зерна на фоне продуктивности.

Содержание макро- и микроэлементов в зерне – определяли методом индуктивно-плазменно-атомной эмиссионной спектрометрии (*ICP-AES*);

В условиях Севера РК стабильно повышенным уровнем минерального состава характеризовались генотипы: Ильинская х *T.timopheevii (N, K, P, Zn)* и Казахстанская 10 х *T.dicoccum (Mg, Mn, Fe, Zn)*. Стабильно повышенным содержанием *N, Mg* и *Fe* отличался генотип Казахстанская 10 х *T.dicoccum* как на юге, так и Севере, а также генотип Ильинская х *T.timopheevii* по содержанию *Zn.*

Для яровых форм отмечено преобладание интрогрессивных над дикими и культурными по содержанию P, K, Mg, Fe и Ca. Полученные результаты указывают на то, что в селекции на высокий уровень метаболизма перспективно использование переходных пшенично-чужеродных форм ярового типа для резкоконтинентальных условий.

Ключевые слова: яровая пшеница, дикие сородичи и гибриды, макро- и микроэлементы зерна, селекция.

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