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THE GRAIN QUALITY CLASSIFICATION OF WINTER WHEAT GENETIC RESOURCE BY SULFUR AND NITROGEN

Abstract. The aim of this paper is to determine the status of S (S content and the ratio of N: S) in the grain production and breedingof winter wheat in Kazakhstan. Material: 750 samples of winter wheat cuiltivars 2009-2014 harvest, wild relatives and introgressive forms.Regions of winter wheat cultivation in sulfur content ranged from 1130 mg/kg (at the level of the deficit) for Zhambyl andTaldy-Korgan to a maximum 1640 mg/kg for the Ily region and the ratio ofN:S from14.9 (Sairam) to 19.6 (Sarkand). The level of S accumulation in the wild relatives grain was for: Ae. Triaristata 2404-2565 mg/kg; Aegilopscylindricae 2164-2404 mg/kg; T.militinae 2190-2330 mg/kg; T.timopheevi 1841-2443 mg/kg; T.kiharae 2124-2205 mg/kg in comprasion with the cultivars in the range of 1452-1836 mg/kg.Introgressiveform was characterized by S containing, intermediate between wild and cultivated form-sand N:S ratio in these forms ofits optimal for wheat bread (no more than 17:1). Thus, the constant line can be adaptive resource of high protein and sulfur. Commercial and perspective cultivars of winter common wheat and regions of their cultivation are classified under the maintenance of sulfur (1005 up to 1818 mg/kg) and to balance N:S (from 13.6 up to 20.9).

Keywords: wheat, wild relatives, quality, sulfur, nitrogen/sulfur.

Introduction. It is known that the nutrient status sulfur (S) of wheat has an important influence on the baking properties of flour (Randall, Wrigley, 1986), which is expressed through the essential role of disulfide bonds to ensure the gluten functionality. The value of S-S bondscorrelate with the properties of elasticity and balance S-poor form proteins (ω-gliadins, HMS-glutenin) and S-rich (α, γ-gliadin and glutenin-LMS), including at the level of gliadin biotypes [1].

The results [2]showed that the contents of GMP (Gluteninmacropolymer), high molecular weight glutenin subunit (HMW-GS) and low molecular weight glutenin subunit (LMW-GS) were improved by sulphur fertilizer under lower nitrogen (N) condition in both cultivars. Under normal N (240 kg N/ha) conditions, sulphur application improved the contents of HMW-GS, LMW-GS and GMP within sulphur rates from 30-60 kg/ha, while decreased when sulphur rate of 90 kg/ha. It is suggested that appropriate sulphur fertilizer was favourable for the formation of large GMP particles, but too much of it was unfavourable under normal nitrogen condition. Sulphur fertilizer did not significantly affect the number distribution of GMP particles in both cultivars [2].

During the last decades, sulphur (S) deficiency in agricultural soilshas become widespreadin many European countries [3-9].

Need wheat in sulfur is not so great: about 20 kg s for the average yield of 8 t/ha [10]. Several studies have shown the status of S (S content and the ratio of N: S) as an important factor affecting the baking quality of flour [11]. At the same time A.R.Woodinget. al. [12] believe that the baking properties of N: S = 12,5:1 is the optimum, and in > 13:1 additional need for mixing dough. Structural part of the s 1 requires 15 pieces N. If s is in short supply as a result of N fertilizer, the accumulation of non-protein

components, such as amides increases the N: S to more than 15:1 [13]. Comparison of the total N and S, and protein N: S provides useful information on the nutrient balance between N and S in plants and used in the diagnosis of the status of S. There was a trend that decreases with time and content S (1992-1993 - 1,35 mg/g, 1981-1982 - 1.72 mg/g) and N:S increases from 12:1 up to 16:1. S content is limit in second place after N (for example, in the north of germany) contentis critical and scarce S 1,2 mg/g and 17:1 (N: S) [11].

Furthermore, the technological properties of bread wheat are greatly affected by S deficiency [11, 14]. Forexample, S deficiency has been reported toproducedoughsthat are less extensible and loavesof smaller volume and poorer texture [14, 15]. These deterioration sinrheological properties of doughsandin bread-making quality of grain were associated with changes in thequantitative composition of gluten proteins [17, 18].

Aim: To determine the status of S (S content and the ratio of N:S) in the grain business and promising varieties of winter wheat in Kazakhstan.

Material and methods. 750 samples of grain of winter wheat of different cultivars from 14 region of Kazakhstan 2009-2014 harvest.Field methods and sampling techniques, according to National standard 13586.3-83, protein content – by *Kjeldal* method. S content in grain and flour are determined by inductive plasma-atomic emission spectrometry (ICPAES) based Sabanci University Istanbul, Turkey [7].

Results. The S content in the grain of winter wheat ranged from 1005 mg/kg (Krasnovodopadskaya 90 cultivars, Zhambyl) to 1793 mg/kg - Sultan 2, Ili rainfed and 1818 mg/kg for Pamyat 47 variety, in Lenger region (Table 1). Critically low maintenance deficit S (less than 1.2 mg/g – byZhao [11], it was noted for cultivars Karligash– 1060mg/kg (Zhana-Korgan), 1118 mg/kg for cultivars Zhetysu, Almaly (Krasnogorsk and Taldy-Korgan); Yuzhnaya 12 (Sairam), Nureke 1151 mg/kg (Sarkand).Basically profiled gene pool on the sulfur content in the range characterized 1100-1500 mg/kg (Figure 1).

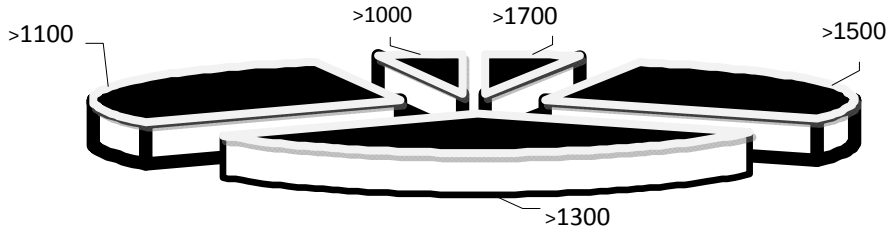

Figure 1 – Distributionof the genofund of the Kazakhstan varietal winter wheat the sulfur (S) mg/kg

Regions of winter wheat cultivation in sulfur content ranged from 1130 mg/kg (at the level of the deficit) for Zhambyl, Taldy-Korgan and Zhana-Korgan to a maximum 1640 mg/kg for the Ily region (Table 1) and the ratio of N: S from 14.9 (Sairam) to 19.6 (Sarkand).

According to the S contentin wheat graindeficientregions Zhambyl,Taldy-Korgan, Zhana-Korgan (average regional values), on the minimum values forindividual varietiesalso identifiedregionsSarkand andZelenovsky. Ratio of nitrogen/sulfur(N:S) in the grainequals16, 9-18, 6for minimumfor regions it Sarkand, Zhambyland furtherregional Kerbulak(by sulfur (S) content it is not identifiedas the critical 1237-1393mg/kg). The mean values of N:Sare to deficit region sadded Zelenovsky (Western Kazakhstan), Taldy-Korganand Saryagash. Similarity of the regionson the S contentandthe ratio of N:S synchronously classification of regionsin the wholegrainmineral composition according to the resultsof the cluster analysis (Figure 2). Thus, winter wheatgrowing regionsaredifferentiated bythe ability to accumulateina different level ofgrainelementsincluding.

Grain sulfur deficiencyin differentiatedfor cultivarsin the region. S contentless than 1200 mg/kg noted for third severale winter wheatin Kazakhstan. Cultivars Zhadyra, Karlygash, Krasnovodopadskaya 90, Bezostaya1, Zhetisu, Aliya, Sultan 2characterized by low levels (less than 1200 mg/kg) in 30-50%of allthe researched samples (Table 2). According toa ratio of N:S in winter wheatis characterized by lackof sulfuras a whole, since half ofthe samplesthe ratioN:Sis inthe range of17:1to 19:1, andfor cultivars Zhadyra, Reke, Aliyaisa more than19:1 ratio (Table 2).

Table 1 – Sand N:S content in winter wheat grain in the regions of Kazakhstan

Region of Kazakhstan	Latitude	Longitude	S, mg/kg		N:S	
			min	max	min	max
Ily (irrigated)	43°48'	77°32'	1511	1703	16,3	17,9
Ily (rained)	43°25'	76°95'	1421	1793	16,7	18,1
Kerbulak	44°88'	77°95'	1237	1393	16,9	18,1
Sarkand1	43°60'	80°48'	1151	1387	17,7	20,9
Sarkand 2	43°60'	80°48'	1200	1341	18,6	20,9
Zhambyl	42°85'	71°38'	1005	1310	17,9	20,3
Zelenovsky	51°25'	51°28'	1176	1643	14,6	19,0
Taldy-Kurgan	44°92'	78°48'	1118	1304	16,2	17,7
Zhana-Korgan	43°88'	67°23'	1060	1334	13,6	17,3
Sairam 1	42°42'	69°83'	1137	1679	14,2	16,7
Sairam 2	42°42'	69°83'	1256	1671	14,2	17,1
Saryagash	41°45'	69°17'	1320	1568	16,2	18,5
Georgiev	42°28'	69°62'	1219	1489	15,5	18,1
Lenger	42°28'	69°62'	1287	1818	14,8	18,3
Zhualin	42°72'	70°83'	1226	1442	14,7	17,1
Krasnogor	43°37'	75°25'	1118	1631	15,0	18,1

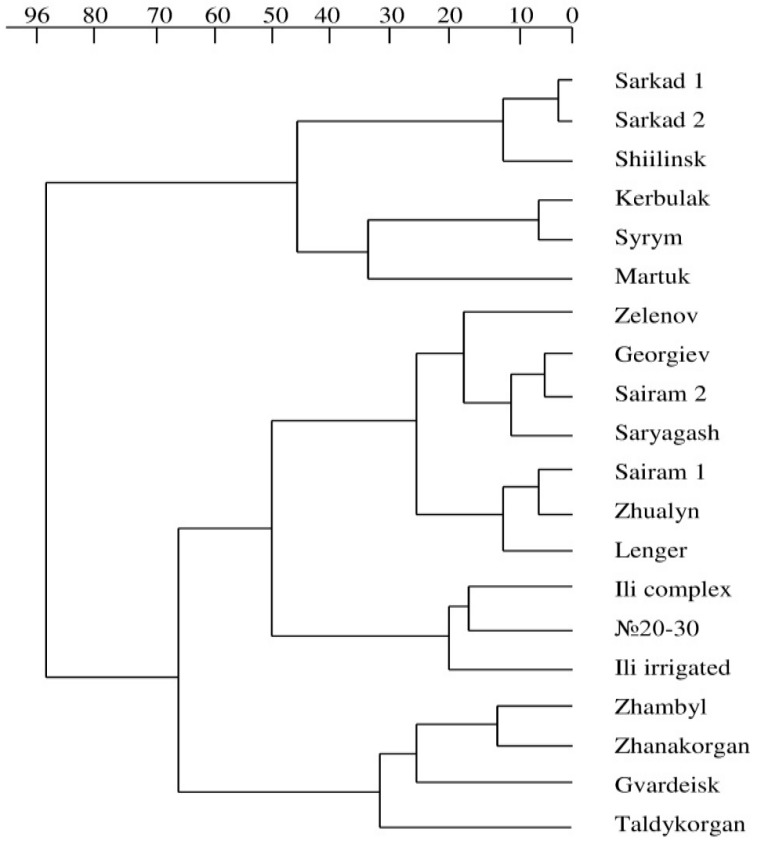

Figure 2 – Classificationof Kazakhstan winter common wheat regions on grain mineral content

Table 2 – Thecharacterization of winter wheat cultivars by S and N:S grain content, 2009-2014

Winter wheat Cultivars	S content in the grain, mg/kg		frequency genotypes of the S content, %		N:Scontent		Genotypes frequency with N:S attitude, %	
	min	max	more 1800 mg/kg	less 1199 mg/kg	min	max	17-19	>19
Akterekskaya	1232	1617	–	–	16,1	17,7	–	–
Akdan	1047	1671	–	10	13,6	18,4	12	–
Aliya	1045	1681		34	16,1	20,3	28	27
Almaly	1055	1740	–	22	14,6	20,1	53	17
Bezostaya 1	1024	1630	–	38	15,8	19,4	64	9
Bogarnaya 56	1137	1596	–	20	16,1	18,3	40	–
Bonpen	1332	2066	11	–	16,8	17,0	–	–
Guadelupe	1071	1637	–	33	16,4	16,9	–	–
Egemen	1091	1680	–	17	14,2	19	11	11
Zhadyra	1199	1227	–	50	16,2	19,6	–	50
Zhetysu	1017	1642	–	40	16,6	19,7	62	13
Intensivnaya	1153	1638	–	3	14,8	18,1	50	–
Karlygash	1060	1308	–	50	14,9	17,6	33	–
Kazakhstanskaya 10					16,3	17,9	67	–
Karasay	1286	1650	–	–	14,6	16,3	–	–
Krasnovodopadskaya 90	1005	1667	–	46	15,8	20,2	11	11
Krasnovodopadskaya 97	1060	1631	–	17	15,7	20,5	11	22
Krasnovodopadskaya 210	654	1861	25	–	14,7	16,7	–	–
Mayra	1079	1703	–	16	14,9	20,3	31	12
Naz	1271	1643	–	–	14	19,9	30	20
Nureke	1044	1579	–	23	15,6	20,9	25	25
Odesskaya 120	1180	1387	–	25	16,8	20,1	25	25
Pamyat 47	1270	1598	–	–	14,4	16,9	–	–
Reke	1162	1688	–	10	15,5	19,8	60	30
Ramin	1176	1715	–	6	15,4	19,8	56	22
Sapaly	1221	1539	–		16,9	20,3	44	12
Steklovidnaya 24	1203	1508	–	–	15,9	20,9	60	7
Sultan 2	981	1793	–	29	16,8	17,7	67	–
Tungish	1311	1687	–	–	16,1	17,5	33	–
Erithrospermum 350	1415	1788		33	16,8	17,6	67	–
Yubileynaya 70	1270	1794	–	25	14,7	17,1	25	–

Two cultivars – Sultan2 and Erythrospermum350 in 33% cases are formed the level more than 1700 mg/kg, in 20-25% cases are Yubileinaya 70 and Pamyat 47cultivars, which are 4.8% of the total researched genofund. Less than 1100 mg/kg S formed in the cultivars grain: Intensivnaya (in 50% of cases), Pamyat 47 and Karasai (28%), Nureke, Yuzhnaya 12, Zhetysu and Akdan (in 13% of cases).S content isimportant for the formationof the protein compositionandgluten quality. Certainlydifferentsoil and climatic conditions, genotypicdifferencesof differentvarietiesof agroecotypescause, a wide range of variability inbothyield andprotein content. Inconnection with it, the role of information about theamountof protein andthe stabilityof its formationas a basis forglutencomplexis great.

To research therelationshipswithmajormacronutrientcontentandquality indicatorsselectedmaterial ofeach varietya few samplesin several (7-11) testregions. As a result ofa comprehensive studyof the

proteincomposition of thegrain of the winterwheatvarieties and hybridswith a maximum valueof proteinandstablebut average; for cultivars Erythrospermum 350, Yubileinaya70,Karasai. Cultivars Almaly, Naz, Pamyat47 and Intensivnayacharacterized by high(but not always stableregions) protein content.

Highly stablegliadin contentin grainvarietiesnoted for Erythrospermum350, Bezostaya1, Karasay. Absolute maximum ofgliadin content markedoptional forcultivarsAlmaly, Zhetysu, Ramin, Odesskaya 120 andSapaly. As a highly stableglutenincontentstoodcultivar isSmuglyanka; andthe absolute maximum (35.5%) was characterized Ramincultivar.

The fact ofsynchronicityconsistently highprotein contentand its fractionsin the graincultivars Erythrospermum350, Egemen, Bezostaya1, Ramin, Zhetysuwithincreased accumulation ofiron and zinc, similar to those described previously. According tomultivariate statistical processing system installed correlation coefficients between the contentof Fe and Z nand individual macronutrients – Zn and Mg (+0.73); Cu and Fe (+0.73); Feand Zn (0.76); Znand P (I 0.74) atwithin specific regionsof cultivation.

Forregions characterized bydeficiency of sulfurin the grain the high correlation wasfound between sulfurand flourstrength (Figure 3).

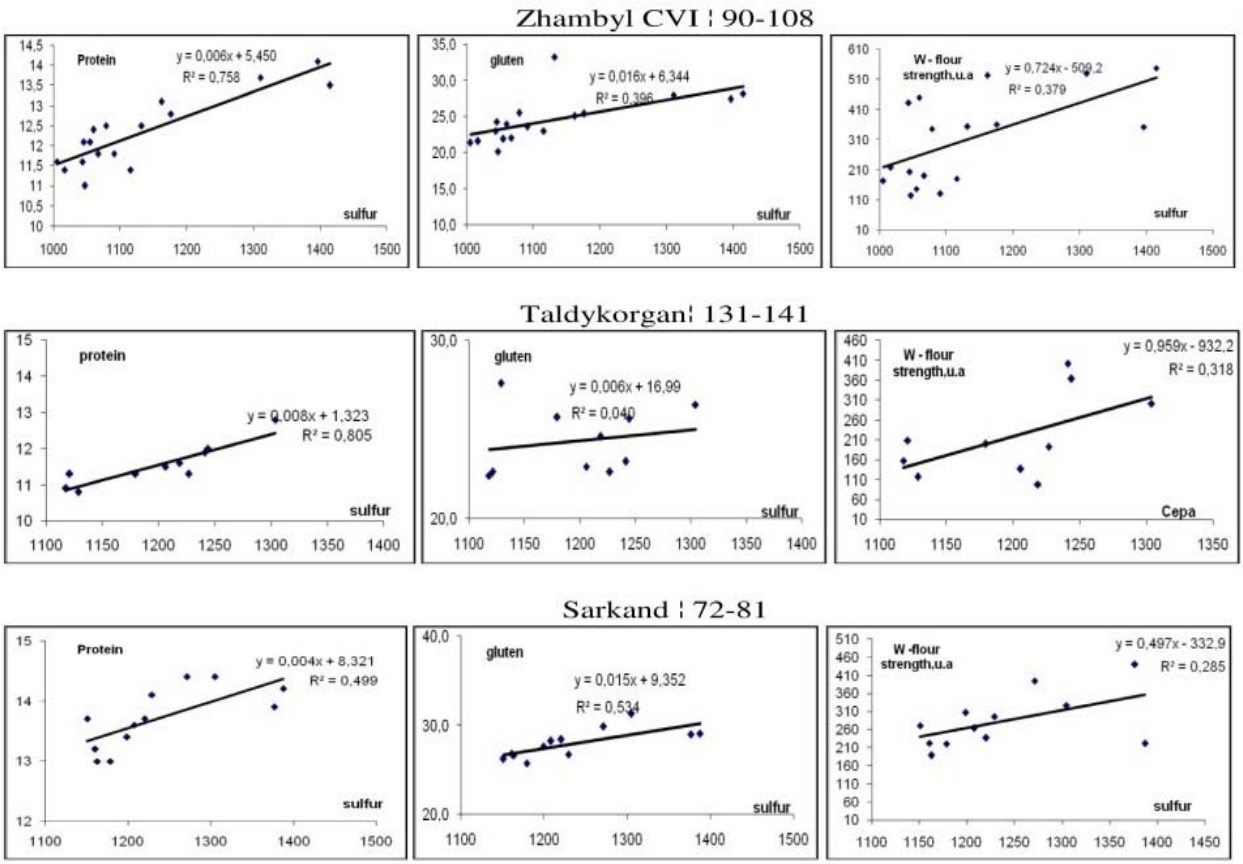

Figure 3 – Correlationbetween the S andprotein, gluten content,flourstrength by alveograph(W), for winter wheat.

Quality characters were significantly correlated to both N and S concentration of grain, but for any given quality character the relationship was strongest with S concentration than with N concentration. SDS and gluten quality parameter were correlated most strongly with both N and S grain concentration. The alveograph W showed a high correlation with S concentration. Correlation between grain N and S concentration, on the contrary,was low, and this is confirmed by the wide variation of the N:S ratio in grain, ranging from 13,6 to 20,5. Lerner et al. [19] suggested that the amino acid composition of storage proteins changes with grain S concentration, so under high S availability the synthesis and accumulation of S-rich storage proteins is favoured at the expense of S-poor proteins. It is reasonable to suggest that these changes in protein composition may be at least in part responsible for the relatively major alterations in quality characters in response to S availability. These results are consistent with those from studies on bread wheat [14, 16].

Table 3 – Sgrain content ofintrogressiveforms winter wheat (example for 2006-2008)

Winter wheat introgressive forms	S content (mg/kg)			N:S	
	2006	2007	2008	2006	2007
231 (Bezostaya1 x *Ae. cylindrica*) x Karlygash	1674	1590	1674	16,9	
1712 (*Erithrospermum350* x *Tr.militinae*)	1889	1696	1920	16,9	14,8
1718 (F_8(*Erithrospermum 350* x *Ae. cylindrica*) x Erithrospermum 350)	1942	1643	1781	16,8	15,6
1721 ((F_7Bezostaya 1 x *Ae.triaristata*)x Progress x (*T.militinae*)) 6	1798	1628-1641	1758	18,1	15,6
1721 ((F_7Bezostaya 1 x *Ae.triaristata*)x Progress x (*T.militinae*)) 9	1738	1647	1630	19,4	15,2
1721 ((F_7Bezostaya 1 x *Ae.triaristata*)x Progress x (*T.militinae*)) 4	1769	1604		18,4	16,2
1723 ((F_7Bezostaya 1 x *Ae.cylindrica*)x *T.kiharae*) x *Tr.kiharae*)	1992	1999-1757	1717-1922	17,9	16,2
1676 (Steklovidnaya 24 x *T.timophevi*)	1761	1605		15,2	15,2
1674 (Zhetysu x (F_7Zhetysu x *T.kiharae*) xAlmaly)	1615	1801	1925	14,8	14,8
1680 (Steklovidnaya 24 x *T.militinae*)	1730	1737	–	18,3	16,3
1675 (Zhetysu x *Tr.kiharae*)	1795	1838	–	17,3	16,5
1825 (Steklovidnaya 24 x *Ae.cylindrica*)	1866	1607	–	17,3	16,5
1727 (Erithrospermum 350 x *T.kiharae*)	1825	1646	–	17,1	16,8
1671 (Zhetysu x *T.militinae*)	2285	2017-1773	1899-1866	13,7	17,8

Inthis context, provideinterest in other types of wheat. Firstly *T.durum* [3] andwild relatives, checklists are widely usedin the breeding process for adaptability and increase protein content (nutritional). There was 5 species of researched material: *Aegilopscylindrica, Ae. triaristata, T.timopheevi, T.militinae, T.kiharae* and constantline F_7-F_8 their crosses with commercial varieties of winter wheat in Kazakhstan (Figure 4).

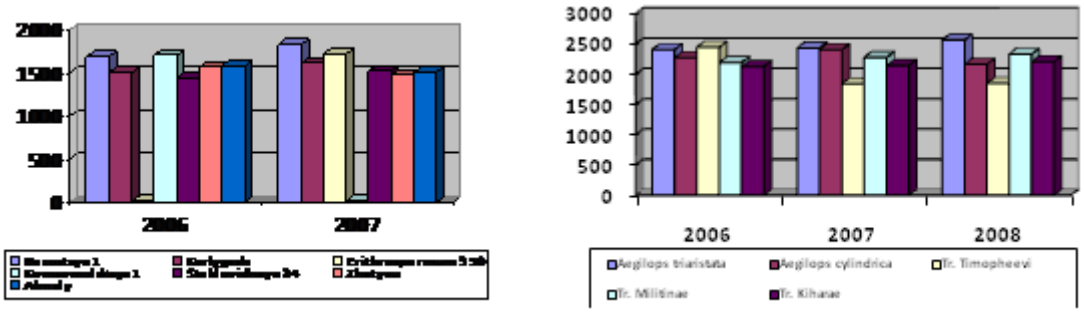

Figure 4 – S content in the grain of winter wheat (left), and in a wild relatives (right)

The level ofSaccumulationin the wild relatives grainofcultivated formssignificantlylimit: *Ae. Triaristata* 2404-2565 mg/kg; *Aegilopscylindrica* 2164-2404 mg/kg; *T.militinae* 2190-2330 mg/kg; *T.timopheevi* 1841-2443 mg/kg; *T.kiharae* 2124-2205 mg/kg in comparisonwith the cultivarsin the range of 1452-1836 mg/kg. Constantlineby crossingwild relativeswas characterized byS containing,intermediate betweenwild and cultivatedforms (Table 3). N: S ratioin these formsis optimal forwheatbread (no more than 17:1). Thus, the constant line can not only beadaptiveresourceformsa highprotein. N:S for wild wheat relatives from 12,4 to 15.4:1; for the cultivars from 14,8 to 16,7 in 2007 and from 16,0 to 18,6 in 2006 [20].

Conclusions. Commercial and perspective cultivars of winter common wheat and regions of their cultivation are analyzed and classified under the maintenance of sulfur (1005 up to 1818 mg/kg) and to balance N:S (from 13,6 up to 20,9).

Wild relatives arecharacterized as a high potential on mineral content in grain, also in S content and the other elements.

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КЛАССИФИКАЦИЯ ГЕНЕТИЧЕСКИХ РЕСУРСОВ КАЧЕСТВА ЗЕРНА ОЗИМОЙ ПШЕНИЦЫ ПО СОДЕРЖАНИЮ СЕРЫ И СОСТОЯНИЮ АЗОТА И СЕРЫ

Аннотация. Цель исследований: определениестатусасеры (содержание S и отношение N:S) в зерновом бизнесе для перспективных сортов озимой пшеницы в Казахстане. Материалы: 750 образцов зерна озимой пшеницы различных сортов из 14 регионов Казахстана урожая 2009-2014. Регионы возделывания озимой пшеницы характеризовались содержанием серы вЖамбылскомрегионе в диапазоне от 1130 мг/кг (на уровне

дефицита), иТалдыкоргане до максимального 1640 мг/кг; для региона Илийскийпо отношению N:S от 14.9:1 (Сайрам) до 19,6:1 (Сарканд). Уровень накопления S в диких сородичах находится в пределах: Ae. Triaristata 2404-2565 мг/кг; Ae.cylindrica 2164-2404 мг/кг; T.militinae 2190-2330 мг/кг; T.timopheevi 1841-2443 мг/кг; T.kiharae 2124-2205 мг/кг в сравнении с сортами в пределах диапазона 1452-1836 мг/кг. Линии, скрещенные с дикими сородичами, занимали промежуточное положение между дикими и культурными формами пшеницы по содержанию S, соотношение N:S в этих формах оптимально для пшеничного хлеба (не более 17: 1). Таким образом, константные линии могутне только образовать адаптивный ресурс с высоким содержанием белка, но и серы. Коммерческие и перспективные сорта озимой мягкой пшеницы и регионы их выращивания классифицируются по содержанию серы от 1005 мг/кг до 1818 мг/кг и баланса N:S от 13,6 до 20,9.

Ключевые слова: пшеница, дикие сородичи, качество, сера, азот/сера.

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КҮЗДІК БИДАЙ ДӘНІНІҢ ҚҰРАМЫНДАҒЫ КҮКІРТ ЖӘНЕ АЗОТ ПЕН КҮКІРТТІҢ ЖАҒДАЙЫ БОЙЫНША ГЕНЕТИКАЛЫҚ РЕСУРС САПАСЫН КЛАССИФИКАЦИЯЛАУ

Аннотация. Зерттеу мақсаты: Қазақстанда келешекті күздік бидай сорттары үшін астық өнеркәсібінде күкірт жағдайын (S құрамы және N:S қатынасынанықтау. Зерттеу әдістерімен материалдары: Қазақстанның 14 ауданынан 2009-2014 жж. өнім күздік бидайының түрлі сорттарынан 750 түр. Күздік бидайды өсіріп-өндіру аудандарында құрамындағы күкірт Жамбыл ауданында 1130 мг/кг. (жеткіліксіз деңгейінде), Талдықорғанда максималды 1640 мг/кг дейін; N:S қатынасы бойынша 14.9:1-ден (Сайрам) 19.6:1 (Сарқанд) дейін сипатталды. Жабайы туыстарда S жинақталу деңгейі Ae. Triaristata 2404-2565 мг/кг; Ae.cylindrica 2164-2404 мг/кг; T.militinae 2190-2330 мг/кг; T.timopheevi 1841-2443 мг/кг; T.kiharae 2124-2205 мг/кг, сорттармен салыстырғанда 1452-1836 мг/кг диапазон аралығында болды. Жабайы туыстармен будандастырылған қаталар S құрамы бойынша бидайдың жабайы және мәдени түрлер арасындағы аралық жағдайда, N:S қатынасы бидай наны (17:1 көп емес) үшін қалыпты жағдайда. Сонымен, константты түрлер тек жоғары құрамды белокты бейімделгіш ресурс түзбейді. Күздік жұмсақ бидайдың коммерциялық және келешекті сорттарымен оларды өсіп-өндіру аудандары құрамындағы күкірт (1005-1818 мг/кг) және N:S (13.6-20.9) балансы бойынша жүйеленеді.

Түйін сөздер: бидай, жабайы туыстар, сапа, күкірт, азот/күкірт.

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