

Assessing stem rust tolerance in commercial wheat varieties: insights from field trials in Kazakhstan

AKERKE MAULENBAY*, ARALBEK RSALIYEV*

Research institute for biological safety problems, Gvardeisky, Kazakhstan

*Corresponding authors: a.maulenbay@biosafety.kz; aralbek@mail.ru

Citation: Maulenbay A., Rsaliyev A. (2025): Assessing stem rust tolerance in commercial wheat varieties: insights from field trials in Kazakhstan. *Plant Protect. Sci.*, 61: 333–349.

Abstract: This study provides the first comprehensive assessment of stem rust tolerance in commercial wheat varieties from Kazakhstan and Russia, including spring and winter varieties. Field trials were conducted to compare yield and agronomic traits between stem rust-inoculated and fungicide-treated plots, providing a practical framework for assessing tolerance. Key indicators such as disease severity, area under the disease progress curve, thousand kernel weight, and the stress tolerance index were evaluated to gauge variety resilience under stress. Significant variations in tolerance were observed, with varieties such as *Pamyat' 47*, *Nadezhda*, *Lyubava 5*, *Tselinnaya 3s*, *Severyanka*, *Egemen-20*, *Zhemchuzhina Povolzh'ya*, *Dimash*, *Serke* and *Korona* maintaining yield potential despite high disease pressure. Correlations revealed that traits such as flag leaf area, vegetative period, and plant height were associated with greater tolerance, highlighting their potential in breeding. With the expected increase in stem rust outbreaks due to climate change and the evolving virulence of stem rust pathogens, these findings emphasise the need for breeding programs incorporating resistance and tolerance, offering a sustainable alternative to fungicide use. This study provides critical insights for breeders and plant pathologists seeking to enhance wheat resilience in regions prone to rust epidemics.

Keywords: stem rust; wheat; resistance; tolerance; yield

ELECTRONIC SUPPLEMENTARY MATERIAL (ESM)

The authors are fully responsible for both the content and the formal aspects of the electronic supplementary material. No editorial adjustments were made.

<https://doi.org/10.17221/219/2024-PPS>

Supplementary Table 1. Variety Name, Year of Registration, State Register of Breeding Achievements Recommended for Use in the Republic of Kazakhstan, Breeder Code, Geographic Origin, and Approved Cultivation Zones in the Republic of Kazakhstan

Variety name	Year of registration	Breeder code**	Geographic origin	Approved cultivation zones in the Republic of Kazakhstan
Spring bread wheat (<i>Triticum aestivum</i> L.)				
Saratovskaya 29	1957*	24	RU***	Akmola, East Kazakhstan, Karaganda, Pavlodar
Saratovskaya 42	1974	24	RU	Aktobe, West Kazakhstan, Karaganda
Tselinnaya yubileynaya	1988	7	KZ****	Akmola, Kostanay
Omskaya 19	1989	26	RU	Akmola, North Kazakhstan
Ul'binka 25	1989	3	KZ	East Kazakhstan
Saratovskaya 55	1990	24	RU	Aktobe
Kazakhstanskaya rannespelaya	1991	6	KZ	Akmola, Kostanay, North Kazakhstan
Omskaya 18	1991	26	RU	Akmola, East Kazakhstan, Kostanay, Pavlodar, North Kazakhstan
Karagandinskaya 70	1992	13	KZ	Karaganda, Pavlodar
Kazakhstanskaya 15	1993	6, 10	KZ	Akmola, Pavlodar
Lyutescens 521	1993	21	RU	East Kazakhstan
Tselinnaya 24	1993	7	KZ	Akmola
Pamyat' 47	1995	9	KZ	Turkestan
Lyutescens 32	1996	6	KZ	Kostanay, Pavlodar
Tselinnaya 3s	1996	7	KZ	Akmola, Kostanay, North Kazakhstan
Omskaya 20	1996	26	RU	Kostanay
Kazakhstanskaya 25	1997	6	KZ	Kostanay
Akmola 2	1998	6	KZ	Akmola and North Kazakhstan
Aray	1999	6	KZ	Almaty
Pavlodarskaya 93	1999	10	KZ	Aktobe, Pavlodar
Miras	2002	5, 6, 15	KZ	Zhambyl
Omskaya 29	2002	26	RU	Kostanay
Omskaya 30	2002	26	RU	Kostanay
Volgouralskaya	2003	25, 24	RU	West Kazakhstan
Lyubava	2003	14	KZ	Kostanay, North Kazakhstan
Astana	2004	7	KZ	Akmola and North Kazakhstan
Nadezhda	2004	5, 6, 15	KZ	Kyzylorda, Turkestan
Omskaya 28	2004	26	RU	Akmola, North Kazakhstan
Pamyat' Azieva	2004	26	KZ	Kostanay, Pavlodar, North Kazakhstan
Altay	2006	3	KZ	East Kazakhstan
Altayskaya 325	2006	20	RU	East Kazakhstan
Alem	2006	5, 6	KZ	Almaty, East Kazakhstan
Zhenis	2006	5, 6	KZ	Almaty, Zhambyl, Turkestan
Shortandinskaya 95 uluchshennaya	2006	7	KZ	Akmola, North Kazakhstan
Yugo-Vostochnaya 2	2007	22, 24	RU	Aktobe
Aktobe 39	2008	19	RU	Aktobe
Astana 2	2008	7	KZ	Almaty, East Kazakhstan
Bayterek	2008	1, 7, 17	KZ	East Kazakhstan

<https://doi.org/10.17221/219/2024-PPS>

Supplementary Table 1. to be continued...

Variety name	Year of registration	Breeder code**	Geographic origin	Approved cultivation zones in the Republic of Kazakhstan
Seke	2008	10	KZ	Karaganda, Pavlodar
Omskaya 36	2009	18, 26	RU	Akmola, Kostanay, North Kazakhstan
Almaken	2010	6	KZ	Almaty
Stepnaya 2	2010	2	KZ	Aktobe
Saratovskaya 70	2010	24	RU	Aktobe
Ertis 7	2011	10	KZ	Aktobe, Pavlodar
Lyubava 5	2011	14	KZ	Kostanay
Lyazzat	2011	3	KZ	East Kazakhstan
Nargiz	2011	3	KZ	East Kazakhstan
Severyanka	2011	5, 16, 10	KZ	Pavlodar, North Kazakhstan
Shortandinskaya 2007	2012	7	KZ	West Kazakhstan
Samgau	2012	6, 11	KZ	Pavlodar
Asyl sapa	2015	7	KZ	Akmola, North Kazakhstan
Karabalykskaya 20	2015	8	KZ	Akmola, Kostanay, North Kazakhstan
Altayskaya zhnitsa	2016	19	RU	Akmola, Kostanay, North Kazakhstan
Omskaya 37	2016	26	RU	East Kazakhstan
Oral	2016	7, 12	KZ	West Kazakhstan
Pavlodarskaya yubileynaya	2016	10	KZ	Pavlodar
Stepnaya volna	2016	19	RU	Kostanay
Avgustina	2017	8	KZ	Kostanay
Karagandinskaya 60	2017	13	KZ	Akmola, East Kazakhstan, Karaganda, Kostanay, North Kazakhstan
Oskemen	2017	4, 6	KZ	East Kazakhstan, Kostanay
Shortandinskaya 2014	2017	7	KZ	Akmola, Kostanay, North Kazakhstan
Tabys 60	2019	5, 6	KZ	Almaty
Spring durum wheat (<i>Triticum durum</i> Desf.)				
Bezenchukskaya 139	1982	25	RU	Akmola, Kostanay
Korona	2010	7	KZ	Akmola, Karaganda
Lan	2010	6	KZ	East Kazakhstan
Serke	2017	6	KZ	East Kazakhstan
Seymur 17	2020	6	KZ	Almaty, Turkestan, Zhambyl
Winter bread wheat (<i>Triticum aestivum</i> L.)				
Bogarnaya 56	1965	27	RU	Akmola, East Kazakhstan, West Kazakhstan, Kostanay, North Kazakhstan
Karlygash	1981	6	KZ	Almaty, Zhambyl, Kyzylorda
Zhetysu	1986	6	KZ	Kyzylorda
Steklovidnaya 24	1993	6	KZ	Almaty, Zhambyl, Turkestan
Sapaly	1995	6	KZ	Almaty, Zhambyl, Turkestan
Almaly	2001	6	KZ	Almaty
Zhemchuzhina povolzh'ya	2003	6	KZ	Almaty, Zhambyl, Kyzylorda, Turkestan
Mironovskaya 808	2011	24	RU	West Kazakhstan
Mereke-70	2011	6	KZ	Almaty, Zhambyl
Farabi	2011	6	KZ	Almaty, Zhambyl

<https://doi.org/10.17221/219/2024-PPS>

Supplementary Table 1. to be continued...

Variety name	Year of registration	Breeder code**	Geographic origin	Approved cultivation zones in the Republic of Kazakhstan
Konditerskaya yarovaya	2015	10	KZ	Akmola, Karaganda, Kostanay, Pavlodar, North Kazakhstan
Egemen-20	2016	6	KZ	Almaty, Turkestan
Grom	2019	23	RU	Almaty, East Kazakhstan, Zhambyl
Dimash	2021	6	KZ	Zhambyl
Vavilov	2021	6	KZ	Zhambyl, Turkestan

Supplementary Table 2. Breeder code, breeder name, and country

Breeder code*	Breeder name	Country
1	Kazakh State Agrotechnical University named after S. Seifullin	Kazakhstan
2	Aktobe Agricultural Experimental Station	Kazakhstan
3	East Kazakhstan Scientific Research Institute of Agriculture	Kazakhstan
4	Experimental Production Farm „Oilseed Crops“	Kazakhstan
5	Institute of Biology and Biotechnology of Plants	Kazakhstan
6	Kazakh Scientific Research Institute of Agriculture and Plant Breeding	Kazakhstan
7	A.I. Baraev Grain Farming Research Center	Kazakhstan
8	Karabalyk Agricultural Experimental Station	Kazakhstan
9	Krasnovodopad Selection Experimental Station	Kazakhstan
10	Pavlodar Scientific Research Institute of Agriculture	Kazakhstan
11	Prigorodny Vegetable-Milk Farm	Kazakhstan
12	Uralsk Agricultural Experimental Station	Kazakhstan
13	Karaganda Research Institute of Plant Breeding and Selection	Kazakhstan
14	Scientific and Production Firm „Fiton“	Kazakhstan
15	Kazakh State National University named after Al-Farabi	Kazakhstan
16	Agrosemkonsalt	Kazakhstan
17	National Center for Biotechnology (Stepnogorsk)	Kazakhstan
18	Agrocomplex „Kurgansemena“	Russia
19	Altai Scientific Research Institute of Agriculture	Russia
20	Adyghe Scientific Research Institute of Agriculture	Russia
21	Buryat Scientific Research Institute of Agriculture	Russia
22	Ershov Experimental Station of Irrigated Agriculture	Russia
23	Krasnodar Scientific Research Institute of Agriculture named after P.P. Lukyanenko	Russia
24	Scientific Research Institute of Agriculture of the Southeast	Russia
25	Samara Scientific Research Institute of Agriculture named after N.M. Tulaikov	Russia
26	Siberian Scientific Research Institute of Agriculture	Russia
27	Mironovsky Institute of Wheat named after V.N. Remeslo	Russia

* breeder code as listed in ESM Table 1

Supplementary Table 3. Phenotypic and yield-related traits of spring and winter wheat varieties from Kazakhstan and Russia under control and stem rust-inoculated conditions

Info on varieties		Control group									
Wheat varieties	Latin name of wheat varieties	Type of wheat varieties	FLA (sm ²)	PH (sm)	UIL (sm)	SL (sm)	PY (g)	TKW (g)	DH (days)	DM (days)	VP (days)
Akmola 2	<i>Triticum aestivum</i> L.	spring	23,33	97,67	20,67	10,00	148,60	40,40	44	35	79
Aktube 39	<i>Triticum aestivum</i> L.	spring	23,83	99,67	20,67	10,67	170,60	40,80	44	39	83
Alem	<i>Triticum aestivum</i> L.	spring	24,56	102,33	32,00	9,67	142,60	35,00	45	35	80
Almaken	<i>Triticum aestivum</i> L.	spring	39,00	91,33	21,00	9,67	144,20	41,60	46	37	83
Altay	<i>Triticum aestivum</i> L.	spring	21,53	92,00	22,67	7,67	172,00	34,60	46	37	83
Altayskaya 325	<i>Triticum aestivum</i> L.	spring	31,89	100,33	21,67	7,67	164,00	39,60	40	38	78
Altayskaya zhnitza	<i>Triticum aestivum</i> L.	spring	32,80	100,33	23,00	9,67	132,80	37,20	44	34	78
Aray	<i>Triticum aestivum</i> L.	spring	28,70	102,33	23,00	10,67	113,20	39,90	44	34	78
Astana	<i>Triticum aestivum</i> L.	spring	34,67	102,67	21,67	9,00	181,00	39,80	44	35	79
Astana 2	<i>Triticum aestivum</i> L.	spring	22,00	101,00	26,67	7,67	116,60	38,60	45	33	78
Asyl Sapa	<i>Triticum aestivum</i> L.	spring	33,76	94,67	27,00	10,67	152,60	36,60	45	35	80
Avgustina	<i>Triticum aestivum</i> L.	spring	127,60	105,00	23,67	10,00	187,00	40,20	46	34	80
Baiterek	<i>Triticum aestivum</i> L.	spring	38,33	103,33	24,67	10,00	124,40	34,40	47	32	79
Bezenchukskaya 139	<i>Triticum durum</i> Desf.	spring	23,83	87,67	18,67	5,67	170,50	40,20	45	39	84
Ertis 7	<i>Triticum aestivum</i> L.	spring	26,18	105,67	23,00	8,33	152,80	41,00	45	33	78
Karabalykskaya 20	<i>Triticum aestivum</i> L.	spring	29,44	99,67	23,00	9,00	161,80	32,10	48	34	82
Karagandinskaya 60	<i>Triticum aestivum</i> L.	spring	40,13	92,00	21,00	10,00	165,00	39,80	40	41	81
Karagandinskaya 70	<i>Triticum aestivum</i> L.	spring	32,00	100,67	21,33	8,67	149,40	38,60	44	37	81
Kazakhstanskaya 15	<i>Triticum aestivum</i> L.	spring	32,71	91,33	28,33	9,00	161,60	39,00	47	35	82
Kazakhstanskaya 25	<i>Triticum aestivum</i> L.	spring	36,18	94,00	23,33	8,67	149,20	41,00	47	33	80
Kazakhstanskaya rannespelaya	<i>Triticum aestivum</i> L.	spring	24,80	105,67	18,00	9,00	138,60	36,60	40	39	79
Korona	<i>Triticum durum</i> Desf.	spring	31,53	99,00	19,00	6,00	146,60	41,80	40	38	78
Lan	<i>Triticum durum</i> Desf.	spring	49,47	90,33	21,67	7,33	131,80	39,80	44	37	81

FLA - flag leaf area; PH - plant height; UIL - upper internode length; SL - spike length; PY - plot yield; TKW - thousand kernel weight; DH - days to heading; DM - days to maturity; VP - vegetative period; DS - disease severity; RT - reaction type; AUDPC - area under disease progress curve; STI - stress tolerance index

2 - Group A: Varieties with consistently high yields in both the control and experimental plots;

Group B: Varieties that performed well only in the control plots;

Group C: Varieties that yielded relatively higher only in the experimental plots;

Group D: Varieties with low yields in both plot types

Supplementary Table 3. To be continued...

Info on varieties		Control group									
Wheat varieties	Latin name of wheat varieties	Type of wheat varieties	FLA (sm ²)	PH (sm)	UIL (sm)	SL (sm)	PY (g)	TKW (g)	DH (days)	DM (days)	VP (days)
Lyazzat	<i>Triticum aestivum</i> L.	spring	38,40	100,67	12,00	8,33	141,80	38,60	44	38	82
Lyubava	<i>Triticum aestivum</i> L.	spring	30,16	71,00	15,00	8,33	112,40	36,88	44	34	78
Lyubava 5	<i>Triticum aestivum</i> L.	spring	30,31	92,00	12,33	10,00	185,80	43,20	44	35	79
Lyutescens 32	<i>Triticum aestivum</i> L.	spring	39,17	95,67	18,67	8,00	130,20	40,00	40	41	81
Lyutescens 521	<i>Triticum aestivum</i> L.	spring	26,00	97,00	10,33	8,67	175,20	40,60	48	31	79
Miras	<i>Triticum aestivum</i> L.	spring	43,33	99,67	14,33	8,67	151,80	38,78	47	32	79
Nadezhda	<i>Triticum aestivum</i> L.	spring	23,20	97,33	14,67	9,00	221,20	43,80	47	35	82
Nargiz	<i>Triticum aestivum</i> L.	spring	29,00	103,00	14,00	8,33	134,20	40,60	47	33	80
Omskaya 18	<i>Triticum aestivum</i> L.	spring	17,76	107,67	18,00	9,67	128,00	38,60	49	31	80
Omskaya 19	<i>Triticum aestivum</i> L.	spring	16,44	109,00	16,00	9,67	124,40	41,40	49	31	80
Omskaya 20	<i>Triticum aestivum</i> L.	spring	25,32	87,33	16,67	7,67	178,20	35,20	48	35	83
Omskaya 28	<i>Triticum aestivum</i> L.	spring	16,33	105,00	12,00	9,00	133,20	34,60	49	30	79
Omskaya 29	<i>Triticum aestivum</i> L.	spring	19,13	102,67	10,33	10,00	135,20	36,60	47	32	79
Omskaya 30	<i>Triticum aestivum</i> L.	spring	33,94	102,00	22,00	10,33	91,60	35,60	48	33	81
Omskaya 36	<i>Triticum aestivum</i> L.	spring	36,29	100,33	15,33	10,00	118,00	39,20	48	33	81
Omskaya 37	<i>Triticum aestivum</i> L.	spring	33,07	100,33	22,67	8,33	138,20	38,06	48	32	80
Oral	<i>Triticum aestivum</i> L.	spring	27,71	94,00	15,67	8,67	163,40	39,40	44	38	82
Oskemen	<i>Triticum aestivum</i> L.	spring	21,91	102,33	17,33	9,67	157,20	40,40	47	36	83
Pamyat' Azieva	<i>Triticum aestivum</i> L.	spring	12,57	86,67	3,00	8,33	206,60	42,60	46	33	79
Pamyat' Azieva	<i>Triticum aestivum</i> L.	spring	16,80	86,33	16,67	7,33	171,20	41,60	44	36	80
Pavlodarskaya 93	<i>Triticum aestivum</i> L.	spring	23,04	106,00	18,33	7,67	165,60	35,60	44	36	80
Pavlodarskaya yubileynaya	<i>Triticum aestivum</i> L.	spring	18,37	92,00	12,33	7,00	166,60	31,80	44	39	83
Samgau	<i>Triticum aestivum</i> L.	spring	22,61	94,67	15,00	8,33	143,40	40,20	46	37	83
Saratovskaya 29	<i>Triticum aestivum</i> L.	spring	16,19	82,00	9,33	5,67	153,20	37,80	40	39	79
Saratovskaya 42	<i>Triticum aestivum</i> L.	spring	23,22	102,00	25,33	9,33	173,20	39,00	49	32	81
Saratovskaya 55	<i>Triticum aestivum</i> L.	spring	25,08	102,33	20,33	9,00	159,70	41,00	49	30	79
Saratovskaya 70	<i>Triticum aestivum</i> L.	spring	36,67	93,33	26,00	7,33	150,40	38,00	48	31	79
Seke	<i>Triticum aestivum</i> L.	spring	34,76	95,67	15,67	10,00	130,80	38,20	49	34	83
Serke	<i>Triticum durum</i> Desf.	spring	26,43	95,67	16,67	6,33	154,80	42,20	43	40	83

Supplementary Table 3. To be continued...

Info on varieties		Control group									
Wheat varieties	Latin name of wheat varieties	Type of wheat varieties	FLA (sm2)	PH (sm)	UIL (sm)	SL (sm)	PY (g)	TKW (g)	DH (days)	DM (days)	VP (days)
Severyanka	<i>Triticum aestivum</i> L.	spring	32,67	106,33	12,67	10,33	150,60	41,80	47	36	83
Seymur 17	<i>Triticum durum</i> Desf.	spring	28,60	91,33	19,67	7,33	179,80	33,20	41	43	84
Shortandinskaya 2007	<i>Triticum aestivum</i> L.	spring	27,44	107,67	24,67	7,67	198,00	40,60	45	34	79
Shortandinskaya 2014	<i>Triticum aestivum</i> L.	spring	24,91	101,67	15,00	9,00	188,90	36,60	45	34	79
Shortandinskaya 95 uluchshennaya	<i>Triticum aestivum</i> L.	spring	36,80	107,00	18,67	11,33	115,20	40,80	44	35	79
Stepnaya 2	<i>Triticum aestivum</i> L.	spring	31,47	101,00	16,67	8,67	125,19	39,44	49	32	81
Stepnaya volna	<i>Triticum aestivum</i> L.	spring	32,07	104,00	16,33	9,33	147,40	43,00	49	31	80
Tabys 60	<i>Triticum aestivum</i> L.	spring	21,67	86,67	17,00	7,33	176,40	39,60	47	37	84
Tselinnaya 24	<i>Triticum aestivum</i> L.	spring	26,60	104,33	19,33	7,67	161,00	35,40	44	38	82
Tselinnaya 3s	<i>Triticum aestivum</i> L.	spring	34,22	100,67	20,00	9,33	140,70	41,40	49	33	82
Tselinnaya yubileynaya	<i>Triticum aestivum</i> L.	spring	25,60	105,00	17,67	8,33	164,60	36,60	47	35	82
Uf'binka 25	<i>Triticum aestivum</i> L.	spring	53,78	102,67	20,33	10,67	149,00	34,60	48	32	80
Volgouralskaya	<i>Triticum aestivum</i> L.	spring	36,48	101,67	24,33	9,00	145,20	38,40	47	32	79
Yugo-Vostochnaya 2	<i>Triticum aestivum</i> L.	spring	28,60	84,00	18,00	8,00	150,60	38,80	45	35	80
Zhenis	<i>Triticum aestivum</i> L.	spring	28,70	90,33	24,33	10,00	134,70	40,80	44	35	79
Almaly	<i>Triticum aestivum</i> L.	winter	21,00	92,00	19,00	9,00	172,20	40,80	198	38	236
Bogarnaya 56	<i>Triticum aestivum</i> L.	winter	36,53	109,00	16,92	10,68	120,80	32,60	202	36	238
Dimash	<i>Triticum aestivum</i> L.	winter	28,13	110,00	13,00	8,70	177,60	40,80	202	33	235
Egenin-20	<i>Triticum aestivum</i> L.	winter	24,15	129,00	18,00	8,00	142,20	42,40	198	40	238
Farabi	<i>Triticum aestivum</i> L.	winter	16,58	111,00	25,00	8,90	152,40	39,60	203	33	236
Grom	<i>Triticum aestivum</i> L.	winter	20,25	78,00	22,00	8,60	120,40	35,00	198	39	237
Karlgash	<i>Triticum aestivum</i> L.	winter	39,72	110,40	18,00	9,48	168,40	38,40	204	32	236
Konditerskaya yarovaya	<i>Triticum aestivum</i> L.	winter	36,89	100,80	16,68	10,90	176,00	35,60	204	33	237
Mereke-70	<i>Triticum aestivum</i> L.	winter	24,38	125,00	31,00	10,00	155,40	33,00	203	33	236
Mironovskaya 808	<i>Triticum aestivum</i> L.	winter	33,05	111,40	19,12	9,79	128,10	34,20	200	38	238
Sapaly	<i>Triticum aestivum</i> L.	winter	13,50	120,00	16,00	9,00	148,80	39,00	202	33	235
Steklovidnaya 24	<i>Triticum aestivum</i> L.	winter	26,33	120,00	24,00	9,00	105,70	34,40	197	38	235
Vavilov	<i>Triticum aestivum</i> L.	winter	24,38	120,00	24,00	8,70	167,40	40,34	197	39	236

Supplementary Table 3. To be continued...

Info on varieties		Control group									
Wheat varieties	Latin name of wheat varieties	Type of wheat varieties	FLA (sm2)	PH (sm)	UIL (sm)	SL (sm)	PY (g)	TKW (g)	DH (days)	DM (days)	VP (days)
Zhemchuzhina Povolzh'ya	<i>Triticum aestivum</i> L.	winter	32,74	81,80	14,48	7,29	122,00	42,60	202	36	238
Zhetysu	<i>Triticum aestivum</i> L.	winter	17,10	110,00	13,00	9,00	113,00	36,40	201	37	238

9 Supplementary Table 3. To be continued...

Info on varieties			Experimental group													
Wheat varieties	Latin name of wheat varieties	Type of wheat varieties	DS (%)	RT ¹	AUDPC	STI	Group ²	FLA (sm ²)	PH (sm)	UIL (sm)	SL (sm)	PY (g)	TKW (g)	DH (days)	DM (days)	VP (days)
Akmola 2	<i>Triticum aestivum</i> L.	spring	40	40S	455,00	0,89	B	23,00	91,67	25,33	8,83	120,80	32,90	48	32	80
	<i>Triticum aestivum</i> L.	spring	40	40S	595,00	1,11	A	18,68	99,33	18,33	9,00	166,40	40,50	48	33	81
	<i>Triticum aestivum</i> L.	spring	50	50S	665,00	0,86	D	10,13	91,67	33,00	7,67	144,80	36,70	45	34	79
Alem	<i>Triticum aestivum</i> L.	spring	40	40S	577,50	1,13	A	22,05	104,33	26,33	9,00	140,60	40,60	49	32	81
	<i>Triticum aestivum</i> L.	spring	40	40S	577,50	0,82	D	16,50	99,33	21,33	8,67	173,30	35,20	49	32	81
	<i>Triticum aestivum</i> L.	spring	40	40S	455,00	1,08	A	15,40	88,00	16,33	6,67	169,60	40,50	40	43	83
Altayskaya 325	<i>Triticum aestivum</i> L.	spring	50	50S	805,00	0,94	C	16,04	89,67	26,67	7,67	140,00	37,60	47	32	79
	<i>Triticum aestivum</i> L.	spring	50	50S	630,00	0,96	B	22,05	87,33	24,33	10,00	112,80	35,70	47	36	83
	<i>Triticum aestivum</i> L.	spring	50	50S	805,00	0,99	B	17,00	96,67	29,67	7,67	164,20	37,10	47	32	79
Astana	<i>Triticum aestivum</i> L.	spring	50	50S	665,00	0,92	B	10,60	98,67	29,67	6,33	100,40	35,40	47	32	79
	<i>Triticum aestivum</i> L.	spring	50	50S	805,00	0,87	D	20,63	96,00	27,67	10,00	132,80	35,30	45	38	83
	<i>Triticum aestivum</i> L.	spring	50	50S	490,00	0,89	B	25,20	94,67	19,00	8,83	130,20	33,10	45	38	83
Asyl Sapa	<i>Triticum aestivum</i> L.	spring	50	50S	665,00	0,74	D	18,00	100,33	21,67	10,00	110,20	31,90	48	35	83
	<i>Triticum aestivum</i> L.	spring	40	40S	455,00	1,10	A	24,94	96,33	20,00	8,00	175,80	40,70	42	37	79
	<i>Triticum durum</i> Desf.	spring	50	50S	665,00	0,95	B	21,00	98,33	14,00	7,33	138,90	34,50	49	34	83
Bezenchukskaya 139	<i>Triticum aestivum</i> L.	spring	50	50S	490,00	0,69	D	11,70	87,67	8,33	9,83	136,80	31,86	44	35	79
	<i>Triticum aestivum</i> L.	spring	50	50S	350,00	1,09	A	7,09	89,33	14,00	8,00	169,30	40,98	44	34	78
	<i>Triticum aestivum</i> L.	spring	50	50S	332,50	0,94	B	10,00	95,00	11,00	8,50	129,90	36,40	45	33	78
Ertis 7	<i>Triticum aestivum</i> L.	spring	50	50S	490,00	0,97	B	22,88	93,33	10,67	9,33	145,80	37,20	47	36	83
	<i>Triticum aestivum</i> L.	spring	50	50S	472,50	0,95	B	5,55	94,00	19,33	9,83	120,50	34,48	47	32	79
	<i>Triticum aestivum</i> L.	spring	40	40S	455,00	0,92	C	21,78	91,00	26,67	10,00	139,00	37,38	47	32	79
Karabalykskaya 20	<i>Triticum durum</i> Desf.	spring	30	30S	420,00	1,17	A	16,13	94,33	22,67	7,50	128,80	41,80	40	39	79
	<i>Triticum durum</i> Desf.	spring	30	30S	262,50	0,97	B	23,20	102,00	19,00	8,50	119,40	36,20	46	34	80
	<i>Triticum aestivum</i> L.	spring	30	30S	262,50	1,02	A	19,63	93,00	24,67	7,33	147,00	39,40	44	39	83
Karagandinskaya 60	<i>Triticum aestivum</i> L.	spring	30	30S	262,50	0,81	D	14,00	68,67	21,33	6,33	102,40	32,76	40	39	79
	<i>Triticum aestivum</i> L.	spring	30	30S	280,00	1,15	A	12,98	101,00	16,00	8,33	183,40	39,80	46	34	80
	<i>Triticum aestivum</i> L.	spring	30	30MR	280,00	1,11	A	23,10	83,67	16,00	7,33	132,40	41,20	44	39	83
Karagandinskaya 70	<i>Triticum aestivum</i> L.	spring	30	30MR	262,50	1,18	A	16,50	90,33	16,00	8,17	177,20	43,30	44	39	83
	<i>Triticum aestivum</i> L.	spring	30	30MR	262,50	1,18	A	16,50	90,33	16,00	8,17	177,20	43,30	44	39	83
	<i>Triticum aestivum</i> L.	spring	30	30MR	262,50	1,18	A	16,50	90,33	16,00	8,17	177,20	43,30	44	39	83

Supplementary Table 3. To be continued...

Info on varieties			Experimental group													
Wheat varieties	Latin name of wheat varieties	Type of wheat varieties	DS (%)	RT ¹	AUDPC	STI	Group ²	FLA (sm ²)	PH (sm)	UIL (sm)	SL (sm)	PY (g)	TKW (g)	DH (days)	DM (days)	VP (days)
Miras	<i>Triticum aestivum</i> L.	spring	30	30S	420,00	1,04	A	23,60	81,00	11,33	8,67	156,20	39,84	45	34	79
	<i>Triticum aestivum</i> L.	spring	40	40S	315,00	1,20	A	18,38	81,00	18,00	8,33	198,20	40,80	46	37	83
	<i>Triticum aestivum</i> L.	spring	40	40S	595,00	1,07	A	27,63	94,33	19,33	10,00	129,20	39,30	46	34	80
Nadezhda	<i>Triticum aestivum</i> L.	spring	40	40S	595,00	0,95	B	14,35	103,00	15,00	6,67	109,00	36,80	47	33	80
	<i>Triticum aestivum</i> L.	spring	40	40S	297,50	1,12	A	12,00	101,00	25,00	7,50	118,20	40,20	47	33	80
	<i>Triticum aestivum</i> L.	spring	40	40S	455,00	0,78	D	19,19	96,67	10,67	10,67	125,60	33,10	42	38	80
Nargiz	<i>Triticum aestivum</i> L.	spring	40	40S	297,50	0,74	D	22,50	95,00	20,67	8,17	106,60	31,80	46	33	79
	<i>Triticum aestivum</i> L.	spring	40	40S	297,50	0,93	C	21,45	85,00	20,33	6,67	133,80	37,90	46	33	79
	<i>Triticum aestivum</i> L.	spring	50	50S	805,00	0,73	D	19,18	97,00	17,00	7,33	64,50	30,42	47	31	78
Omskaya 18	<i>Triticum aestivum</i> L.	spring	40	40S	630,00	0,96	B	19,67	96,67	17,00	6,67	116,60	36,30	47	31	78
	<i>Triticum aestivum</i> L.	spring	30	30MS	420,00	0,99	C	12,14	96,33	20,33	7,67	144,00	38,82	45	33	78
	<i>Triticum aestivum</i> L.	spring	40	40S	595,00	1,02	A	17,42	91,67	23,00	8,67	160,00	38,40	47	37	84
Omskaya 19	<i>Triticum aestivum</i> L.	spring	40	40S	595,00	1,07	A	20,78	100,67	17,67	8,67	135,60	39,40	44	39	83
	<i>Triticum aestivum</i> L.	spring	50	50S	805,00	1,27	A	26,35	83,33	8,33	9,00	210,00	44,40	46	32	78
	<i>Triticum aestivum</i> L.	spring	40	40MS	665,00	1,10	A	25,13	84,00	18,00	8,00	158,00	39,30	46	32	78
Omskaya 20	<i>Triticum aestivum</i> L.	spring	30	30S	630,00	0,80	D	24,53	109,00	26,00	8,00	114,20	33,40	45	30	75
	<i>Triticum aestivum</i> L.	spring	30	30S	455,00	0,65	D	12,75	103,67	23,67	9,00	103,00	30,40	45	30	75
	<i>Triticum aestivum</i> L.	spring	40	40S	455,00	1,03	A	33,15	99,00	10,33	7,67	127,40	38,10	42	36	78
Omskaya 28	<i>Triticum aestivum</i> L.	spring	50	50S	805,00	0,96	C	20,84	78,67	12,67	8,00	156,20	38,00	40	38	78
	<i>Triticum aestivum</i> L.	spring	30	30MS	595,00	1,07	A	23,73	94,67	14,67	9,33	174,80	41,00	46	34	80
	<i>Triticum aestivum</i> L.	spring	30	30S	490,00	0,99	B	23,11	96,00	22,33	10,33	118,40	35,90	47	32	79
Omskaya 29	<i>Triticum aestivum</i> L.	spring	30	30S	595,00	1,01	C	26,54	100,67	23,67	8,33	156,60	39,50	40	39	79
	<i>Triticum aestivum</i> L.	spring	30	30S	227,50	1,00	C	22,37	89,67	11,67	7,33	132,00	39,10	47	32	79
	<i>Triticum aestivum</i> L.	spring	50	50S	472,50	1,32	A	22,74	85,33	22,20	7,67	168,60	46,60	42	37	79
Omskaya 30	<i>Triticum durum</i> Desf.	spring	50	50S	472,50	1,17	A	35,12	93,33	15,67	11,00	156,00	41,60	47	32	79
	<i>Triticum aestivum</i> L.	spring	50	50S	542,50	0,70	D	20,97	88,67	18,50	6,87	135,00	31,60	41	37	78
	<i>Triticum durum</i> Desf.	spring	40	40S	437,50	0,94	B	18,00	104,67	21,67	9,33	162,60	34,50	45	38	83
Omskaya 36	<i>Triticum aestivum</i> L.	spring	40	40S	735,00	0,92	C	11,75	93,67	11,33	9,00	185,60	37,60	45	38	83
	<i>Triticum aestivum</i> L.	spring														
	<i>Triticum aestivum</i> L.	spring														

Supplementary Table 3. To be continued...

Info on varieties			Experimental group													
Wheat varieties	Latin name of wheat varieties	Type of wheat varieties	DS (%)	RT ¹	AUDPC	STI	Group ²	FLA (sm ²)	PH (sm)	UIL (sm)	SL (sm)	PY (g)	TKW (g)	DH (days)	DM (days)	VP (days)
Shortandinskaya 95 ululuchshennaya	<i>Triticum aestivum</i> L.	spring	40	40S	630,00	1,05	A	15,40	104,00	18,33	10,00	109,00	38,32	45	38	83
	<i>Triticum aestivum</i> L.	spring	30	30S	420,00	1,00	A	25,30	91,33	19,33	8,67	120,14	37,81	40	39	79
	<i>Triticum aestivum</i> L.	spring	30	30MS	420,00	1,16	A	18,68	108,33	25,67	8,67	132,40	40,30	46	34	80
Stepnaya volna Tabys 60	<i>Triticum aestivum</i> L.	spring	40	40S	455,00	0,97	B	13,50	100,67	8,00	10,00	161,80	36,40	44	35	79
	<i>Triticum aestivum</i> L.	spring	40	40S	630,00	0,78	D	14,00	93,00	17,33	10,00	142,80	32,80	44	35	79
	<i>Triticum aestivum</i> L.	spring	40	40S	665,00	1,17	A	15,68	95,33	21,00	10,33	141,00	42,20	42	36	78
Tselinnaya 24 Tselinnaya 3s	<i>Triticum aestivum</i> L.	spring	30	30S	420,00	0,84	D	18,53	94,67	19,33	9,67	147,00	34,20	45	34	79
	<i>Triticum aestivum</i> L.	spring	40	40S	595,00	0,79	D	37,16	93,00	26,33	10,33	134,60	33,90	42	37	79
	<i>Triticum aestivum</i> L.	spring	50	50S	472,50	0,94	D	10,80	91,67	11,33	6,67	133,20	36,60	49	34	83
Volgouralskaya Yugo-Vostochnaya 2	<i>Triticum aestivum</i> L.	spring	40	40S	595,00	0,94	B	17,33	95,33	21,00	7,00	95,90	36,20	46	37	83
	<i>Triticum aestivum</i> L.	spring	40	40S	770,00	1,03	A	16,04	81,67	14,67	8,33	125,50	37,60	49	34	83
	<i>Triticum aestivum</i> L.	winter	70	70S	682,50	1,05	A	22,74	96,00	21,84	9,01	163,50	38,40	198	38	236
Bogarnaya 56 Dimash	<i>Triticum aestivum</i> L.	winter	70	70S	840,00	0,69	D	36,53	109,20	18,20	10,68	114,20	31,76	202	36	238
	<i>Triticum aestivum</i> L.	winter	60	60S	805,00	1,09	A	21,31	115,00	16,24	9,14	170,00	39,80	202	33	235
	<i>Triticum aestivum</i> L.	winter	90	90S	892,50	1,26	A	21,85	125,60	21,52	8,92	143,80	44,40	198	40	238
Egemin-20 Farabi	<i>Triticum aestivum</i> L.	winter	90	90S	#####	1,02	A	18,08	104,40	24,52	9,63	146,60	38,20	203	33	236
	<i>Triticum aestivum</i> L.	winter	90	90S	630,00	0,76	D	17,53	74,80	18,00	8,79	105,40	32,20	198	39	237
	<i>Triticum aestivum</i> L.	winter	60	60S	542,50	1,11	C	38,49	110,40	16,20	9,27	176,70	43,00	204	33	237
Karlygash Konditerskaya yarovaya	<i>Triticum aestivum</i> L.	winter	70	70S	647,50	0,72	D	35,72	101,00	16,64	10,11	174,90	30,20	204	33	237
	<i>Triticum aestivum</i> L.	winter	90	90S	700,00	0,73	D	30,59	127,20	31,28	10,17	143,00	32,80	203	33	236
	<i>Triticum aestivum</i> L.	winter	70	70S	770,00	0,72	D	31,05	112,40	19,12	9,72	122,50	31,34	200	38	238
Mereke-70 Mironovskaya 808	<i>Triticum aestivum</i> L.	winter	80	80S	945,00	1,01	A	15,10	119,00	20,52	8,54	150,20	38,60	202	33	235
	<i>Triticum aestivum</i> L.	winter	80	80S	875,00	0,84	D	28,19	117,20	19,40	8,84	103,60	36,20	197	38	235
	<i>Triticum aestivum</i> L.	winter	70	70S	630,00	1,05	A	22,49	120,00	23,36	8,85	163,80	38,72	197	39	236
Zhemchuzhina Povolzh'ya Zhetysu	<i>Triticum aestivum</i> L.	winter	90	90S	770,00	1,14	A	33,54	79,20	14,48	7,31	114,60	39,90	202	36	238
	<i>Triticum aestivum</i> L.	winter	90	90S	980,00	0,87	D	19,15	102,40	11,12	9,02	108,33	35,74	201	37	238