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Immune-phytopathological assessment of resistance of wheats to stem rust in conditions of the Southeast of Kazakhstan

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ABSTRACT

The paper presents the results of the immunological evaluation of the varieties of spring wheat of the 17F1SYNT-OMSK-LIST farm: 90 samples and 7 susceptible local varieties jointly created by scientific institutions of Kazakhstan, Western Siberia and the CIMMYT International Wheat and Maize Improvement Center in conditions of the southeast of Kazakhstan. The study was conducted in 2016-2017 on natural and artificial infection background using field and laboratory methods. The varieties of spring and winter wheats sustainable and susceptible to stem rust for selection on immunity have been isolated 6 varieties are sustainable to stem rust, namely: LINE-Ñ-19SB, LUTESTSENS7-04-4, CARBERRY, URALOSYBIRSKAYA, ERITROSPERMUM 85-08 and LYUTESTSENS 6-04-4.From winter wheats have been isolated of resistance 19 lines and the genes Sr2, Sr22, Sr24, Sr26, Sr36. These valuable genotypes will be recommended for use in selection as a valuable source material in releasing stem rust resistant varieties in the future.

Key words : *Wheat, Stem rust, Phytopathogen, Resistant genes, Inoculum, Infection background.*

Introduction

Scientific works on the study of rust in Kazakhstan have been actively conducted throughout 1960-1990 due to deterioration of the phytosanitary situation in the region during the development of virgin lands. At the same time Dzhembayev (1972) determined the spread of rust agents on the territory of the republic, Turapin and Mostovoy (1994) *et al.* established the role of an intermediate host in the development of diseases, estimated the resistance of spring wheat to the disease in the north of Kazakhstan, Kulikova and Zhdanov (1984) differentiated the racial composition of pathogens, Turov *et al*. (1994) selected resistant forms on an infection background, and Koyshibayev *et al.* (2006) worked

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out ways to protect wheat from the disease. The data obtained were used for the integrated crop protection of grains in the republic. However, recently in Kazakhstan purposeful scientific works on studying the composition of the population of rust species determining their virulence and the use in selection have not been carried out.

In 2006, the Ug 99 race was discovered on wheat in Yemen, and in 2007 - in Iran, in 2009 - in Pakistan; Pakistan borders with Tajikistan and, accordingly, the infections can occur in Uzbekistan, Kyrgyzstan and Kazakhstan (Kochorov *et al.*, 2016).

The spring wheat belt of Northern Kazakhstan and Western Siberia produces low yields and the crop is affected by rust and other diseases. Until recently, stem rust was not considered a major disease for spring wheat in Russia and Kazakhastan, but the global threat of Ug99 necennitated systematic efforts to evaluate and screen spring wheat germplasm. The unconfirmed presence of Ug99 in the Saratov region of Russia (Sibikeev *et al.*, 2016), as well at the relatively high stem rust severity and prevalence of Sr31 germplasmin Omsk region Russianin 2015, indicates the increased probability of sudstantial stem rust damage and yield losses in spring wheat areas. However, it rapidly evolved into several pathotypes with additional virulence to Sr24 (Jin *et al.*, 2008), Sr36 (Jin *et al.*, 2009). These isolates appeared to be virulent on Sr22 and Sr26, which are highly effective against races in the Ug99 race group (Shamanin *et al.*, 2016).

Materials and Methods

The studies were conducted in 2014-2017 based on stationary experiments of the Kazakh Research Institute of Agriculture and Plant Growing, in the Kazakh Research Institute for Plant Protection and Quarantine named after Jh.Zhiembaev and in the CIMMYT-Turkey greenhouse.

The resistance of wheat varieties and samples was evaluated by the dominant types of rust. The resistance of wheat lines to stem rust was evaluated in points at the stages of earing and milky ripeness of grain.

When screening wheat for resistance to rust types, two indicators were determined: the type of reaction (qualitative) and the degree of leaf damage (quantitative).

The type of reaction was established by visually viewing at least 25-50 plants of each sample based on the following scale:

0 - no signs of disease on leaves; R- resistance and the presence of chlorosis and necrosis, the urediniawere absent (according to the Stackman scale, 1 point); MR- moderate resistance (2 points), small urediniawere observed, surrounded by a chlorotic zone or necrosis; MS- average susceptibility (3 points), medium-sized uredinia, surrounded by a chlorotic zone; and S – high susceptibility (4 points), there were numerous uredinia without chlorosis or necrosis around.

In Turkey, farm were sown in a greenhouse in one row of 1 meter long. Inoculation was conducted to assess stem rust in greenhouse conditions. Samples of rust uredopustulewere collected during the milky-wax stage in the greenhouse by artificial means using a special apparatus. Reproduction of the inoculum was carried out under the greenhouse conditions on the Demir universally susceptible wheat variety. Shoots were inoculated into a 2-3-leaf stage. The incubation period of the disease depends on the room temperature. For rust at a temperature of 26-28 °C the incubation period was 7-8 days. The manifestation of the disease was taken into account after 14 days on the Mackintosh scale (Figure 1, Table 1).

The study of cereals in the greenhouse and climatic chamber conditions is shown in Figures 1.

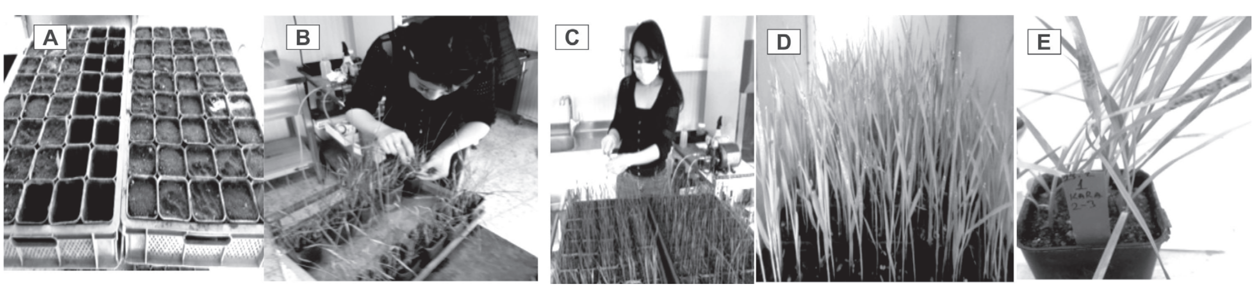

Fig. 1A. Sowing of wheat material, B - Collection of spores, C - Day of inoculation, D - A day after inoculation, E - Assessment of resistance of wheat varieties to stem rust in the greenhouse

Table 1. Immune-phytopathological, phenological control of spring wheat samples in the field and an artificial infectious background

Entry no.	Variety or breeding line	Origin	Onset of the phase of plants' earing	Yield, c/hectare	Vitreousity	Density of sprouting, pcs., of 100 plants	Damage to plants with stem rust, points	
							In the field (milky stage)	under green-house conditions (earing)
1	SERI	KAZ	19.06.17	41,5	65	93	1 MR	3
2	STEPNAYA75	AKTOBE ARS (KAZ)	19.06.17	29,2	75	80	10 MR	2
3	STEPNAYA1414	AKTOBE ARS (KAZ)	26.06.17	37,8	68	54	10 MR	3
4	GVK 2055-1	EAST-KAZAKHSTAN ARI (KAZ)	02.07.17	8,93	80	47	30 MS	3
5	LUTESTSENS2	KARABALYK ARS (KAZ)	02.07.17	36,1	67	60	30 MS	3+
6	LINE-Ñ-19SB	KARABALYK ARS-CIMMYT (KAZ)	29.06.17	13,7	86	67	1 R	1+
7	KARABALYKS KAYA 20	KARABALYK ARS (KAZ)	29.06.17	33,4	71	60	30 MS	3+
8	FANTAZIYA	KARABALYK ARS (KAZ)	29.06.17	21,4	79	67	30 MR	3+
9	BOSTANDYK	KARABALYK & KAZ RI PLANT PROTACTÝON (KAZ)	02.07.17	33,7	76	53.3	10 MR	3
10	LUTESCENS 30 69/97	KARABALYK ARS (KAZ)	29.06.17	21,6	70	93.3	30 MS	3
11	KARAGANDINS KAYA 30	KARAGANDA ARI (KAZ)	01.07.17	35,6	82	47	10 MR	3
12	KARAGANDINS KAYA 31	KARAGANDA ARI (KAZ)	03.07.17	32,7		60	30 MS	3
13	PAVLODARSKAYA YUBILEYNAYA	PAVLODAR ARI (KAZ)	01.07.17	33,9	80	67	30 MS	3
14	KONDITERSKAYA YAROVAYA	PAVLODAR ARI (KAZ)	29.06.17	10,5	86	54	5 MR	3
15	FITONÑ-50SB	FITON-CIMMYT (KAZ)	05.07.17	31,2	84	80	10 MR	3
16	FITON82	FITON (KAZ)	27.06.17	27,6	79	73.3	30 MR	3-
17	FITON-Ñ-54SB	FITON-CIMMYT (KAZ)	02.07.17	42,4	81	53.3	30 MS	2++
18	EKADA148	FITON-EKADA (KAZ)	27.06.17	34,2	78	53.3	30 MS	3
19	EKADA 113	FITON (KAZ)	29.06.17	48,4	83	94	5 MR	2
20	LYUBAVA	FITON (KAZ)	29.06.17	57,7	79	60	5 MS	3
21	FITON 41	FITON (KAZ)	03.07.17	45,5	77	73.3	30 MS	3
22	FITON 204	FITON (KAZ)	30.06.17	47,4	75	73.3	40 S	3+
23	VLADIMIR	SHORTANDY ARI (KAZ)	09.07.17	32	85	53.3	30 MS	3
24	TSELINA50	SHORTANDY ARI (KAZ)	01.07.17	37,6	87	47	40 S	3
25	TSELINNAYA NIVA	SHORTANDY ARI (KAZ)	29.06.17	32,2	88	67	10 MS	3
26	ASYLSAPA	SHORTANDY ARI (KAZ)	30.06.17	25,5	84	67	30 MS	3
27	AKMOLA 2	SHORTANDY ARI (KAZ)	02.07.17	32,3	86	80	40 S	3
28	AK ORDA	SHORTANDY ARI (KAZ)	28.06.17	36,6	75	80	30 MS	3
29	SHORTANDINSKA YA 2012	SHORTANDY ARI (KAZ)	02.07.17	39,1	71	80	40 S	3
30	TSELINNAYA 3S	SHORTANDY ARI (KAZ)	28.06.17	51,7	74	60	30 MS	3
31	ASTANA	SHORTANDY ARI (KAZ)	27.06.17	33,1	78	73.3	40 S	3+
32	ALTAISKAYA70	ALTAY ARI (RUS)	29.06.17	42,7	76	47	30 MS	3
33	ALTAISKAYA110	ALTAY ARI (RUS)	26.06.17	21,7	81	40	30 MS	3
34	TOBOLSKAYA	ALTAY ARI (RUS)	03.07.17	31,8	74	47	30 MS	3+
35	ALTAYSKAYA ZHNITSA	ALTAY ARI (RUS)	30.06.17	35,7	71	80	10 MS	3+
36	STEPNAYA VOLNA	ALTAY ARI (RUS)	27.06.17	41,7	76	67	40 S	3+
37	APASOVKA	ALTAY ARI (RUS)	29.06.17	50,4	72	60	30 MS	3+

Table 1. *Continued*

Entry no.	Variety or breeding line	Origin	Onset of the phase of plants' earing	Yield, c/hectare	Vitreousity	Density of sprouting, pcs., of 100 plants	Damage to plants with stem rust, points	
							In the field (milky stage)	under green-house conditions (earing)
38	LUTENSCENS89-06	OMGAU (RUS)	29.06.17	37,5	75	87	30 MS	3+
39	DUET	OMGAU (RUS)	29.06.17	31,1	71	80	30 MS	3+
40	PAVLOGRADKA	OMGAU (RUS)	29.06.17	43,6	72	67	10 MS	3-
41	LUTESCENS29-12	OMGAU (RUS)	26.06.17	64,2	86	93.3	1 MR	3+
42	LUTESCENS106-11	OMGAU (RUS)	05.07.17	13,4	82	53.3	5 MR	3+
43	TULAIKOVSKAYA 110	SAMARA (RUS)	01.07.17	27,1	75	73.3	10 MR	3-
44	LUTESCENS916	SAMARA (RUS)	27.06.17	29	77	53.3	10 MR	3-
45	GRECUM1003	SAMARA (RUS)	29.06.17	26,4	85	40	10 MR	3-
46	LUTESCENS1062	SAMARA (RUS)	28.06.17	42,4	71	67	10 MR	3-
47	LUTESCENS89-06	OMGAU (RUS)	20.06.17	24,4	76	60	10 MR	2
48	ERITROSPERMUM 85-08	OMGAU (RUS)	05.07.17	40,4	73	53.3	10 MR	2+
49	SEREBRISTAYA	SIB ARI (RUS)	29.06.17	20	77	80	20 MS	3
50	SERI	RUS	23.06.17	16,7	80	60	1 MR	3-
51	BOEVCHANKA	SIB ARI (RUS)	22.06.17	39,8	83	47	10 MR	3
52	OMSKAYA 37	SIB ARI (RUS)	22.06.17	19,5	70	60	5 MR	2
53	LUTESTSENS 7-04-4	SIB ARI (RUS)	29.06.17	51,6	74	73.3	R	1+
54	LUTESTSENS197-04-7	SIB ARI (RUS)	29.06.17	46,6	71	40	5 MR	2
55	LUTESTSENS220-03-45	SIB ARI (RUS)	05.07.17	31,4	73	67	5 MR	2+
56	TULAIKOVSKAYA 10	SAMARA (RUS)	03.07.17	58,8	75	54	10 MR	3
57	TULAIKOVSKAYA ZOLOTISTAYA	SAMARA (RUS)	24.06.17	35,9	74	47	10 MR	3
58	TULAIKOVSK 100	SAMARA (RUS)	30.06.17	23,5	76	40	5 MS	3-
59	GREKUM 650	SAMARA (RUS)	23.06.17	29,9	74	40	5 MS	2++
60	LUTESCENS 920	SAMARA (RUS)	24.06.17	30,2	82	80	5 MS	3-
61	EKADA 121	SAMARA (RUS)	29.06.17	31,1	80	73.3	40 S	3+
62	CIMMYT	SAMARA (RUS)	30.06.17	49,7	77	60	30 MR	3
63	P-23-17	KURGAN (RUS)	02.07.17	19,6	82	47	30 MS	3
64	PAMYATI RUBA	CHELYABINSK (RUS)	28.06.17	44,5	72	27	10 MS	3
65	CHELYABA 75	CHELYABINSK (RUS)	27.06.17	50,6	73	47	5 MR	2-
66	ERITROSPERMUM 23707	CHELYABINSK (RUS)	05.07.17	32,4	77	47	30 MS	3
67	SY TYRA	US-SYN (US-SYN)	22.06.17	25,4	74	67	10 MR	2++
68	SY GOLIAD	US-SYN (US-SYN)	22.06.17	10,6	70	43.3	5 MR	3
69	SY SOREN	US-SYN (US-SYN)	21.06.17	29,6	82	73.3	5 MR	2+
70	SY ROWYN	US-SYN (US-SYN)	23.06.17	27,9	80	67	5 MR	2
71	SY INGMAR	US-SYN (US-SYN)	23.06.17	19	78	60	R	2+
72	SELECT	US-SDSU (US-SDSU)	20.06.17	31,2	75	60	1 MR	2+
73	FORE FRONT	US-SDSU (US-SDSU)	20.06.17	29,1	77	40	1 MR	2+
74	PREVAIL	US-SDSU (US-SDSU)	23.06.17	27,8	73	47	1 MR	2++
75	ADVANCE	US-SDSU (US-SDSU)	24.06.17	22,8	75	60	1 MR	2++
76	BRICK	US-SDSU (US-SDSU)	20.06.17	36,4	74	40	10 MR	2+
77	CARBERRY	CAN	20.06.17	11,5	78	60	1 R	1+
78	MUCHMORE	CAN	21.06.17	29,4	77	80	1 MR	2
79	URALOSYBIRS KAYA	RUS	21.06.17	30,6	79	53.3	1 R	1+

Table 1. *Continued*

Entry no.	Variety or breeding line	Origin	Onset of the phase of plants' earing	Yield, c/hectare	Vitreousity	Density of sprouting, pcs., of 100 plants	Damage to plants with stem rust, points	
							In the field (milky stage)	under green-house conditions (earing)
80	TORNADO 22	FITON (KAZ)	05.07.17	51,1	70	40	20 MS	3
81	LYUTESTSENS 1012	ALTAY ARI (RUS)	30.06.17	56,8	70	53.3	30 MS	3
82	LYUTESTSENS 7-04-10	KURGAN (RUS)	03.07.17	40,8	71	60	10 MR	2
83	LYUTESTSENS 208-08-4	KURGAN (RUS)	05.07.17	35,1	72	67	5 MS	3-
84	LYUTESTSENS 27-12	OMGAU (RUS)	02.07.17	41,7	70	40	10 MS	3
85	ERITROSPERMUM 85-08	OMGAU (RUS)	30.06.17	33,8	77	67	1 MR	1+
86	LYUTESTSENS 6-04-4	SIB ARI (RUS)	29.06.17	30,1	75	60	5 MR	1+
87	LYUTESTSENS 186-04-61	SIB ARI (RUS)	29.06.17	68,9	73	40	10 MS	1+
88	CHEBARKULS KAYA 3	CHELYABINSK (RUS)	30.06.17	24,1	77	47	20 MS	3
89	LINE D 25	SARATOV (RUS)	28.06.17	28	72	53.3	1 MR	3
90	LINE 654	SARATOV (RUS)	26.06.17	15,7	76	60	10 MS	2+
S1	Arai	KAZ	19.06.17	42,7	73	47	5 MS	3+
S2	Saratovskaya 29	KAZ	27.06.17	26,6	77	50	30 MS	3+
S3	Aktobe 10	KAZ	03.07.17	33,1	71	47	30 MS	3+
S4	Kazakhstanskaya 15	KAZ	29.06.17	28,1	76	50	40 S	3+
S5	Astana	KAZ	27.06.17	30,8	74	49	40 S	3+
S6	Kazakhstanskaya 10	KAZ	26.06.17		72	47	30 MS	3+
S7	Zhenis	KAZ	29.06.17		75	51.3	10 MS	3+

Results

After the manifestation of diseases on susceptible control varieties, the resistance of plants to rust types according to the established scales was assessed 2 to 3 times. The type of affection (in points) with stem rust was determined according to Stakman and Piemeical (1917). Two indicators were also determined: the degree of affection in percent (from 0 to 100%) and the type of plant affection by the nature of the rust pustules.

According to the results of the were identified 6 varieties were resistant; 25 varieties were moderatelyresistant to stem rust, 23 varieties were moderately susceptible, 34 varieties were susceptible and 2 varietiespossessed the R-S reaction type - LYUTESTSENS 186-04-61 and SERI (Table 1).

From the 97 variants of winter wheats were isolated 19 lines. 5 lines of them had 0 reaction in the laboratory and field conditions. They are SUNVALE/PEHLIVAN (Sr36), GA951395-10-7/WX98D011-U38 (Sr36, Sr2), GA951395-10-7/TX98D3447 (Sr36, Sr2), GA961565-27-6/KS99U673 (Sr36, Sr2), VA01W-283/WX03ARS0513 (Sr36, Sr2). In 4 lines were found genes Sr36, Sr2, only 1 linehad gene Sr36.14 lines had a strong and medium resistance to stem rust. They are have genes Sr22, Sr24 (Table 2)

The rest of the isogenic lines demonstrated susceptibility to stem rust or medium resistance to the disease due to infection rate, which was between MS – S.

Discussion

Rsaliev and Koishibaev (2008) noted the foci with the moderate and strong development of stem rust on spring wheat crops in the Kostanay and North Kazakhstan regions. The spread of the disease varied in the range of 20-40%, while in some fields this indicator reached 90-100%. However, the degree of damage to plants did not exceed 10%, and only in

Table 2. Superior rust resistant winter wheat varieties and breeding lines

Entry no	Variety or breeding line	Cross ID	Sr genes	Origin	Stemrust		
					Field-1	Field-2	TTKSK
5	TAM200/KAUZ/3/ES14/SITTA//AGRI/NAC	TCI021015	Sr2	TCI	1MR	1MR	3
9	TAM200/KAUZ/4/BEZ/NAD//KZM (ES85.24)/3/F900K	TCI021160	Sr24, Sr2	TCI	0	1RMR	1
12	SERI.1B*2/3/KAUZ*2/BOW//KAUZ/4/BAGCI2002	TCI021198	Sr2	TCI	RMR	5M	3
19	LAGOS-6/DORADE-5	TCI-02-36	Sr2	TCI	1MR	5RMR	3+
23	KS920709-B-5-1-1/BURBOT-4	TCI031171	Sr2	TCI	1MR	5M	4
30	1D13.1/MLT//TUI/3/S?NMEZ/4/ATAY/GALVEZ87	TCI032478	Sr2	TCI	0	1M	3+
33	SELYANKA/MERCAN-1	TCI041084	Sr2	TCI	RMR	10RMR	3+
39	SUNVALE/PEHLIVAN	TCI041374	Sr36	TCI	0	R	0
42	8229/OK81306//BLUEGIL-13/3/PYN/2*BAU	TCI042128	Sr24, Sr2	TCI	1RMR	1RMR	2-/3
47	ALTAY 2000/3/AUS GS50AT34/SUNCO//CUNNINGHAM/4/SÍNMEZ	TCI042638	Sr24	TCI	1MR	20MR	2-
51	PYN/BAU/4/ORPIC/3/PASTOR//MUNIA/ALTAR 84	OCW02S484S	Sr24, Sr2	TCI	RMR	5RMR	2-
68	CV. RODINA/AE.SPELTOIDES (10 KR)	64/98w	Sr22	RUS	1MR	5M	3
72	FL95342/WX02ARS046	ARS07-0318	Sr36	US-NC	0	0	1
73	GA951395-10-7/WX98D011-U38	ARS07-0525	Sr36, Sr2,Sr24	US-NC	0	0	0
74	AR800-1-3-1/NW97S320	ARS09-013	Sr24, Sr2	US-NC	TR	5M	0
75	GA951395-10-7/TX98D3447	ARS09-155	Sr36, Sr2	US-NC	0	0	0
76	GA961565-27-6/KS99U673	ARS09-180	Sr36, Sr2	US-NC	0	0	0
77	AR800-1-3-1/TAM303	ARS09-303	Sr2	US-NC	0	0	1,3-
81	GA961662-1-7/TAM107	ARS09-573	Sr36, Sr2	US-NC	0	0	2-
82	VA01W-283/WX03ARS0513	ARS09-807	Sr36, Sr2	US-NC	0	0	0
95	CF08137	CF99075/CAPHORN//DI01022	Sr2	FRA	5M	5MR	2+3-

rare cases it was 25% (Table 1).

According to Koric (1979), against the background of artificial infection, the strong development of stem rust (99S on the Cobb scale) can reduce the yield of wheat by 69%, the average (66S) - by almost 30%, and the weak (25S)- by 10%. Losses of crops depend to a large extent on the susceptibility of the variety, climatic conditions, the physiological race of the pathogen, the density of the inoculum during artificial infection.Most of the tested varieties have been susceptible to stem rust.

In 2015, a stem rust epidemic in the Omsk region and neighboring areas of Kazakhstan affected spring wheat production on an area probably exceding 1 million ha, with yield losses of up to 20-30%. Under these conditions, only a few genes were

Table 3. Discription of the markers used for Sr genes identification

Genes	Origin	Markername	Markertype	Source	Chromosome
Sr2	Triticumturgidum	wms533	SSRSNP	MAS	3BS
		Sr2_ger9 3p	SSR		
Sr22	Triticumboeoticum	csKP81	STS	https://scholar.google.com	7A
Sr22		Cfa 2123	SSR		
Sr24	Thinopyrumponticum	Sr 24 #12	STS	McIntosh *et al.*, 1976	3D
Sr26	Thinopyrumponticum	Sr 26#43/ BE518579	STS	MAS	6A
Sr36	Triticumtimopheevi	stm773_2	STS	MAS	2BL

MAS – http://maswheat.usdavis.edu

effective (Sr2, Sr11, Sr24, Sr25, Sr26, Sr31, Sr37) based on trap nursery observations. Gene Sr31 in the pathogen in Omsk region Russian and Kostanay region Kazakhstan in 2016 (Shamanin *et al.*, 2016)

The genes Sr2, Sr22, Sr24, Sr26, Sr36were isolated from resistance lines. This variety were present in the table 1 (Table 3).

Conclusion

For 15 years, linear stem rust has been of particular concern to scientists. The rapid spread of new strain of the pathogenic agent may endanger the world's grain reserves. Kazakhstan farmers should also remember about stem rust.

In the field, as a result of phenological observation, 11 varieties of Seri, Pamyatiruba, Sytyra, Sygoliad, Sysoren, Syrowyn, SyIngmar, Select, Carberry, Muchmore proved to be the fastest growing ones.

Of the tested varieties and lines there are no the varieties absolutely resistant to stem rust, but at the same time they differ in stability and susceptibility.

As a result of the research dedicated to the resistance of the wheat germplasm to stem rust, advanced lines of wheat were identified. Valuable genotypes were included in the hybridization program.

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