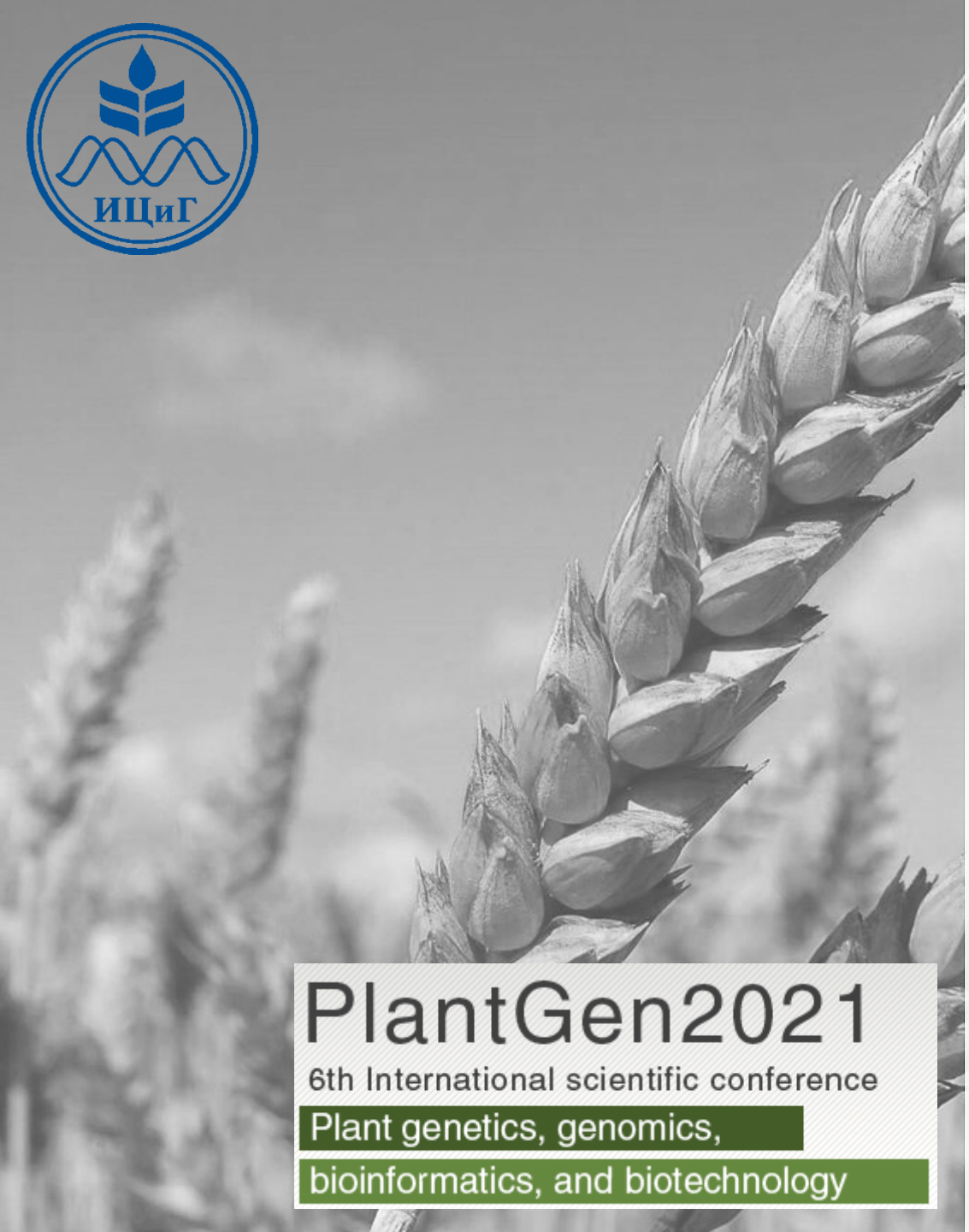

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Laboratory of Plant Molecular Genetics and Cytogenetics
Institute of Cytology and Genetics SB RAS (Novosibirsk)

Advanced panel of molecular markers identifying of stem rust resistance genes *Sr2*, *Sr15*, *Sr22*, *Sr23*, *Sr24*, *Sr25*, *Sr26*, *Sr31*, *Sr35*, *Sr36*, *Sr38*, *Sr39*, *Sr44*, *Sr45*, *Sr57*, *Lr6Ai#2* in Siberian wheat cultivars

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Introduction

- Wheat stem rust is a plant disease caused by pathogenic fungus *Puccinia graminis* f. sp. *tritici* (***Pgt***) which leads to significant damage of the crop wheat.

The aim of this study was to identify genes and gene loci for resistance to wheat stem rust in Russian wheat germplasm **using advanced panel of (Sr) markers**.

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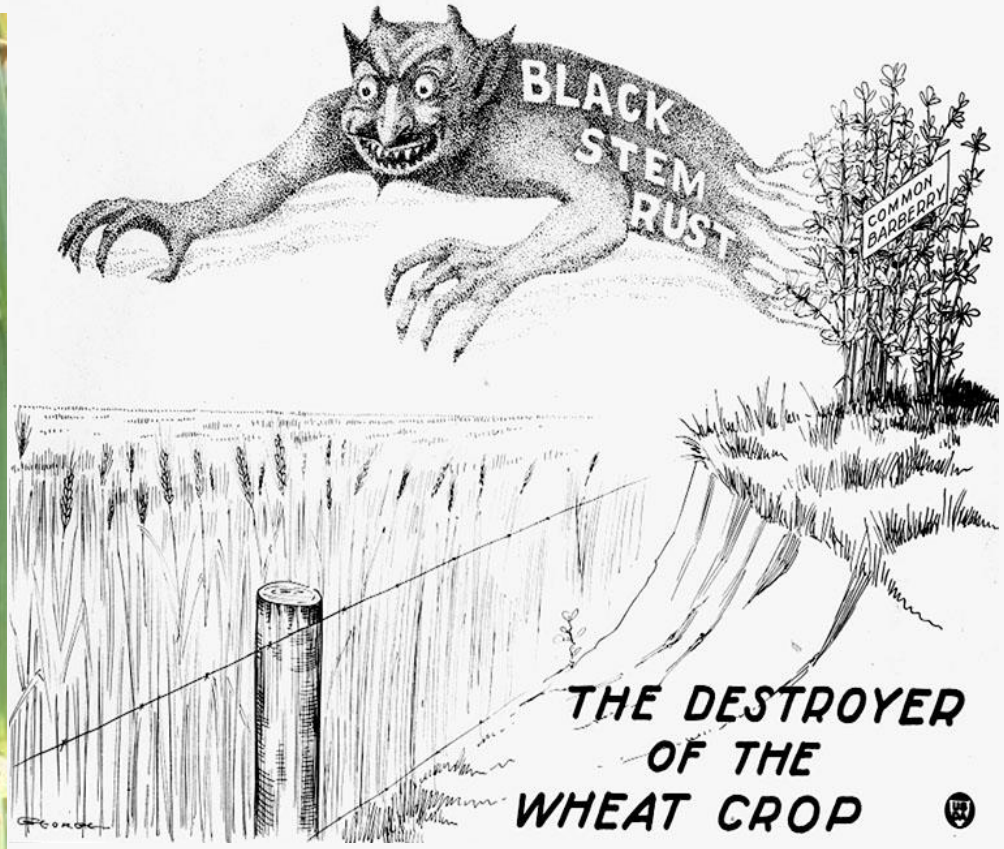
Photo by Robert Park



- ***Pgt*** causes disruption of stem transpiration,
- r e d u c e s the photosynthetic ability of plants,
- r e d u c e s the quality of grain and its baking properties,
- r e d u c e s the strength of stems and sheaths, which leads to lodging of plants.

Materials and methods

- **A total of 224** accessions of wheat germplasm was kindly received from (1) **FSBEI HE Omsk SAU** (Omsk region) - 80 varieties of spring soft wheat and 12 lines of spelt wheat; (2) **FRC IC&G SB RAS** (Novosibirsk region), consisting of 132 varieties of spring soft wheat.
- To identify resistance genes (***Sr***) in the germplasm, **18 markers** were used.

Genes	Chr.	Origin	Marker name	Source
Sr2	3BS	*Triticum turgidum*	Xgwm533 Sr2_ger9_3p	Mago et al., 2011
Sr15/Lr20/Pm1	7A	*T. aestivum*	Xsts638	Hu et al., 1997
Sr22	7A	*T. monococcum*	CFA2019	MAS*
Sr23/Lr16			XTaLr16_RGA266585	Harrison et al., 2016
Sr24/Lr24	3DL	*Agropyron elongatum*	Sr24#12	MAS
Sr25/Lr19	7D	*Thinopyrum ponticum*	Xwmc221	Gupta et al., 2006
Sr26	6AL	*Ag. elongatum*	Sr26#43 BE518379	MAS
Sr31/Lr26/Yr9	1AS, 1BS	Secale cereale	PrCEN-2	Li et al., 2016
Sr35	3AL	*T. monococcum*	NL9	MAS
Sr36	2BL	*T. timophevii*	STM773-2	
Sr38/Lr37/Yr17	2AS	*T. ventricosum*	Ventriup+Ln2	
Sr39/Lr35	2B	*Aegilops speltoides*	BE500705	
Sr44	7DS	*T. intermedium*	Xbe404728	
Sr45	1DS	*Ae. tauschii*	cssu45	
Sr57/Lr34/Yr18/Pm38	7D	hexaploid wheat	csLV34	
Sr6Ai/Sr6Ai#2	6D	*T. intermedium*	TNAC1752_TaqI	Salina et al., 2015

*http://maswheat.ucdavis.edu/protocols/StemRust/index.htm

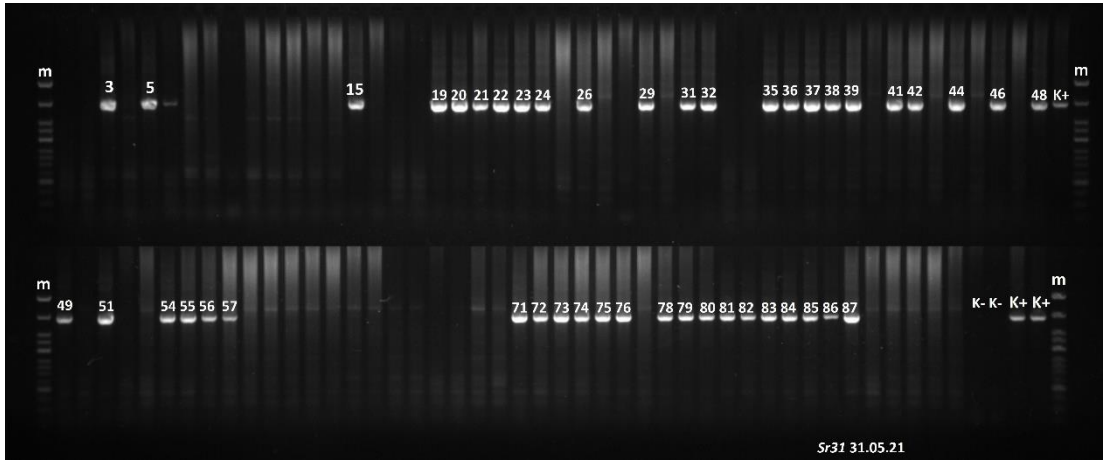
Results and Discussion

Working panel of DNA markers of stem rust resistance genes tested on wheat germ plasma.

Genes	Marker name	Marker type	Annealing temperature (℃)
Sr2	Xgwm533*	SSR	62
	Sr2_ger9_3p**	KASP	X
Sr15/Lr20/Pm1	Xsts638	STS	61
Sr22	CFA2019	SSR	60
Sr23/Lr16	XTaLr16_RGA266585	RGA	52
Sr24/Lr24	Sr24#12	AFLPs	q.v. MAS***
Sr25/Lr19	Xwmc221	SSR	60
Sr26	Sr26#43	STS	61
	BE518379	STS	61
Sr31/Lr26/Yr9	PrCEN-2		60
Sr35	NL9		61
Sr36	STM773-2	STS	q.v. MAS***
Sr38/Lr37/Yr17	Ventriup+Ln2	STS	65
Sr39/Lr35	BE500705	EST	61
Sr44	Xbe404728	CAPS	q.v. MAS***
Sr45	cssu45	SSR	60
Sr57/Lr34/Yr18/Pm38	csLV34	STS	54
Sr6Ai/Sr6Ai#2	TNAC1752_TaqI	CAPS	56

***http://maswheat.ucdavis.edu/protocols/StemRust/index.htm

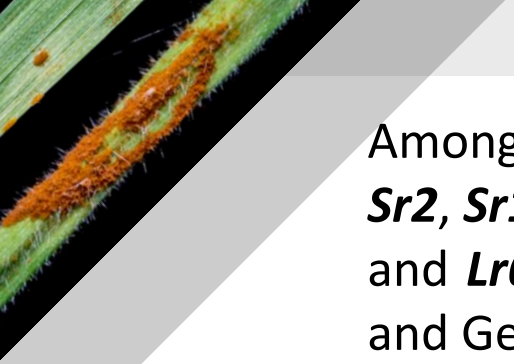
for example: ***Sr31***/*Lr26*/*Yr9* - **PrCEN-2** (5'-aatgatcttccacgacgacg-3', 5'-cctcgttgggaaatggtgca-3'), was designed according to nucleotides 1140–2090 of the pAWRC.1 sequence (GenBank accession No. AF245032).



Note:

*The KASP marker **Sr2_ger9_3p** was developed for **non-*Sr2*** wheat samples showing either the **null allele** or a **G allele** and an **A allele** associated with the presence of the ***Sr2*** gene.

** The microsatellite locus **Xgwm533** is tightly linked to the ***Sr2*** gene. However, there are two different **Xgwm533** loci on chromosome 3BS, one of which does not carry the ***Sr2*** gene but gives an amplification.



Among the Omsk germplasm we observed the varieties carrying the following resistance genes: ***Sr2***, ***Sr15***, ***Sr23***, ***Sr24***, ***Sr25***, ***Sr31***, ***Sr38***, ***Sr57***. The genes ***Sr2***, ***Sr15***, ***Sr22***, ***Sr23***, ***Sr25***, ***Sr31***, ***Sr44***, ***Sr57*** and ***Lr6Ai#2*** in various combinations were identified in the varieties of the Institute of Cytology and Genetics.

Genes	FSBEI HE Omsk SAU	FRC IC&G SB RAS
Sr2 (SSR-marker)	29	63
Sr2 (KASP-marker)	absent	absent
Sr15/Lr20/Pm1	1	3
Sr22	23	59
Sr23/Lr16	4	3
Sr24/Lr24	4	absent
Sr25/Lr19	7	4
Sr26	absent	absent
Sr31/Lr26/Yr9	45	10
Sr35	absent	absent
Sr36	absent	absent
Sr38/Lr37/Yr17	7	absent
Sr39/Lr35	absent	absent
Sr44	50	2
Sr45	absent	absent
Sr57/Lr34/Yr18/Pm38	20	11
Sr6Ai/Sr6Ai#2	absent	6

The genes singly or in combination (FSBEI HE Omsk SAU)

Genes	0	1	2	3	4	5
	5	**27**	**32**	**15**	**11**	**2**
%	5.4	29,4	34.8	16.3	11.9	2.2

The genes singly or in combination (FRC IC&G SB RAS)

Genes	0	1	2	3	4	5
	31	**56**	**33**	**9**	**3**	**0**
%	23.5	42.4	25	6.8	2.7	