SUPPLEMENTARY MATERIALS

to the article Y. Genievskaya, Y. Fedorenko, A. Sarbayev, A. Amalova, S. Abugalieva, S. Griffiths, Y. Turuspekov "Identification of QTLs for resistance to leaf and stem rusts in bread wheat (*Triticum aestivum* L.) using a mapping population of 'Pamyati Azieva × Paragon'"

Supplementary 1

QTLs for leaf rust (LR) and stem rust (SR) detected by composite interval mapping in a RIL population of bread wheat

No.	Trait	Region	QTL name	Chr.	QTL interval (cM)	Peak pos. (cM)	Markers interval	LOD score	R^2	Add.
1	LR	SEKaz	*QLR.IPBB-1B*	1B	41.9–56.0	53.0	GENE-0427_442 / Tdurum_contig60052_184	3.7	0.12	–0.47
2	LR	NKaz	*QLR.IPBB-1D*	1D	55.0–70.2	56.1	wsnp_BE586140D_Ta_2_2 / RAC875_rep_c105196_532	3.3	0.12	0.38
3	LR	SEKaz	*QLR.IPBB-2A*	2A	86.0–110.1	91.2	IAAV2718 / RAC875_rep_c107961_348	3.4	0.11	–0.08
4	LR	SEKaz	*QLR.IPBB-2B*	2B	84.0–110.1	103.1	BobWhite_c16735_131 / BobWhite_c33464_133	6.0	0.18	1.22
5	LR	SEKaz	*QLR.IPBB-3A*	3A	100.0–133.1	119.9	BobWhite_c8674_595 / BS00022862_51	6.0	0.20	–0.11
6	LR	SEKaz	*QLR.IPBB-3B.1*	3B	1.1–15.0	11.2	BS00064776_51 / tplb0059m03_1516	7.8	0.27	0.90
7	LR	NKaz	*QLR.IPBB-3B.2*	3B	38.0–54.0	44.1	wsnp_BE497169B_Ta_2_2 / Tdurum_contig100212_141	3.3	0.12	0.40
8	LR	SEKaz	*QLR.IPBB-3B.3*	3B	61.2–78.1	72.0	RFL_Contig29_1062 / tplb0046p09_685	4.2	0.13	0.48
9	LR	SEKaz	*QLR.IPBB-3B.4*	3B	88.2–102.3	95.3	Kukri_c4074_463 / wsnp_Ku_c4078_7436510	6.0	0.18	0.73
10	LR	SEKaz	*QLR.IPBB-4B*	4B	82.9–101.8	83.9	IAAV8848 / BS00062304_51	4.7	0.17	–0.11
1	SR	NKaz	*QSR.IPBB-1A*	1A	0–26.0	9.1	RFL_Contig854_2201 / BS00065419_51	3.3	0.11	0.50
2	SR	NKaz	*QSR.IPBB-2B*	2B	73.8–108.2	101.2	wsnp_JD_c6350_7516597 / RFL_Contig2751_1562	4.4	0.15	0.31
3	SR	NKaz	*QSR.IPBB-2D*	2D	71.1–126.0	78.0	D_contig31797_313 / Excalibur_c16329_493	5.5	0.22	0.40
4	SR	NKaz	*QSR.IPBB-3B.1*	3B	13.0–26.3	16.0	wsnp_Ex_c40595_47620787 / BobWhite_c9711_71	3.0	0.11	–0.29
5	SR	SEKaz	*QSR.IPBB-3B.2*	3B	98.3–128.3	120.8	TA001464-0572 / wsnp_Ex_c1676_3185400	4.6	0.18	–0.55
6	SR	NKaz	*QSR.IPBB-3B.3*	3B	204.1–216.0	216.0	Excalibur_c63009_102 / BS00071041_51	3.2	0.12	–0.53
7	SR	NKaz	*QSR.IPBB-4A*	4A	0–12.1	4.1	JD_c21248_511 / Tdurum_contig21233_82	3.5	0.11	–0.13
8	SR	NKaz	*QSR.IPBB-6B.1*	6B	14.1–29.2	20.2	wsnp_JD_c2297_3138694 / BS00003891_51	5.5	0.20	–0.93
9	SR	NKaz	*QSR.IPBB-6B.2*	6B	86.0–106.1	94.2	BobWhite_c35035_317 / Kukri_c27662_675	3.1	0.10	0.12

Notes: LR – leaf rust; SR – stem rust; NKaz – North Kazakhstan; SEKaz – South-East Kazakhstan; QTL – quantitative trait locus (loci); Chr. – chromosome; Pos. – position on chromosome; LOD – maximum-likelihood LOD score of the QTL; Add. – additive effect; R^2 – phenotypic variation explained by the QTL.

Supplementary 2

Comparison of resistant QTLs identified in the current study, possible candidate genes and literature information from earlier works

Region	QTL	Chr.	Interval (cM)	Candidate genes	Catalogued genes on the chromosome (McIntosh et al., 1998, 2007, 2017)	Reference QTLs
SEKaz	*QLR.IPBB-1B*	1B	41.9–56.0	–	*Lr26*, *Lr33*, *Lr44*, *Lr46*[1], *Lr51*, *Lr55*, *Lr71*, *Lr75*	*QLr.ccsu-1B.1* – 39.3–42.6 cM (Kumar et al., 2013); *1B_1* – 43.66–64.89 cM (Gao et al., 2016)
NKaz	*QLR.IPBB-1D*	1D	55.0–70.2	–	*Lr21*, *Lr41*, *Lr42*, *Lr60*	*QLr.ccsu-1D.1* – 52.1–63.5 cM (Kumar et al., 2013); *1D_t1* – 45.55 cM (Gao et al., 2016)
SEKaz	*QLR.IPBB-2A*	2A	86.0–110.1	–	*Lr11*, *Lr17*, *Lr37*[1], *Lr45*, *Lr65*	*QLr.ccsu-2A.3* – 84.81 cM (Kumar et al., 2013); *2A_2* – 101.97 cM (Gao et al., 2016)
SEKaz	*QLR.IPBB-2B*	2B	84.0–110.1	*Lr35*, *Lr50*	*Lr13*, *Lr16*, *Lr23*, *Lr35*[1], *Lr48*[1], *Lr50*	*2B_2* – 88.44–97.26 cM and *2B_3* – 102.28–108.35 cM (Gao et al., 2016); *QLr.hebau-2BS* – 89 cM (Zhang et al., 2017)
SEKaz	*QLR.IPBB-3A*	3A	100.0–133.1	–	*Lr63*, *Lr66*	*QLr.fcu-3AL* – 99.4–129.6 cM (Chu et al., 2009)
SEKaz	*QLR.IPBB-3B.1*	3B	1.1–15.0	*Lr27*, *Lr74*	*Lr27*, *Lr74*[1]	*QLr.ccsu-3B.1* – 9.01–13.81 cM (Kumar et al., 2013); *QLr.uaf.3BS* – 0–6 cM (Muhammad et al., 2018)
NKaz	*QLR.IPBB-3B.2*	3B	38.0–54.0	–		*QLr.hebau-3BS* – 43 cM (Zhang et al., 2017); *3B_t2* – 51.07–51.08 cM (Gao et al., 2016)
SEKaz	*QLR.IPBB-3B.3*	3B	61.2–78.1	–		*QLr.ccsu-3B.2* – 67.3–69.2 cM (Kumar et al., 2013); *QLr.uaf.3BL* – 68–69 cM (Muhammad et al., 2018)
SEKaz	*QLR.IPBB-3B.4*	3B	88.2–102.3	–		*QLr.ccsu-3B.4* – 93.1–95.1 cM (Kumar et al., 2013);
SEKaz	*QLR.IPBB-4B*	4B	82.9–101.8	–	*Lr12*, *Lr25*, *Lr31*, *Lr49*[1]	*4B_3* – 74.62–90.07 cM (Gao et al., 2016)
NKaz	*QSR.IPBB-1A*	1A	0–26.0	*Sr1RS*^{Amigo}	*Sr1RS*^{Amigo} (Yu et al., 2014)	QTL at 33 cM (Bajgain et al., 2016); *wPt730213* – 0.20 cM (Yu et al., 2012)
NKaz	*QSR.IPBB-2B*	2B	73.8–108.2	*Sr36*, *Sr40*, *Sr9a*, *Sr28*	*Sr9a–Sr9g*, *Sr10*, *Sr16*, *Sr19*, *Sr20*, *Sr23-2B*, *Sr28*, *Sr32-2B*, *Sr36*, *Sr39*, *Sr40*	*QSr.umn-2B.2* – 96.9 cM (Bajgain et al., 2015); *IWB1190* – 119.07 cM (Edae et al., 2018); *wPt7750* – 92.8 cM (Yu et al., 2012)
NKaz	*QSR.IPBB-2D*	2D	71.1–126.0	–	*Sr6*, *Sr32-2D*, *Sr34-2D*, *Sr46*	–
NKaz	*QSR.IPBB-3B.1*	3B	13.0–26.3	*Sr2*	*Sr2*[1], *Sr12*	*IWA3691* – 14.5 cM (Elbasyoni et al., 2017)
SEKaz	*QSR.IPBB-3B.2*	3B	98.3–128.3	–		QTLs at 108, 109, 121, 124 cM (Bajgain et al., 2016)
NKaz	*QSR.IPBB-3B.3*	3B	204.1–216.0	–		–

Table (end)

Region	QTL	Chr.	Interval (cM)	Candidate genes	Catalogued genes on the chromosome (McIntosh et al., 1998, 2007, 2017)	Reference QTLs
NKaz	*QSR.IPBB-4A*	4A	0–12.1	–	*Sr7*, *SrND643* (Basnet et al., 2015)	*QSr.umn-4A* – 20.9 cM (Bajgain et al., 2015); *IWA3812* – 20.6 cM (Elbasyoni et al., 2017)
NKaz	*QSR.IPBB-6B.1*	6B	14.1–29.2	–	*Sr11*	*wPt1241* – 24.10 cM (Yu et al., 2012)
NKaz	*QSR.IPBB-6B.2*	6B	86.0–106.1	*Sr11*		*IWA3985* – 80.9 cM (Elbasyoni et al., 2017)

Notes: NKaz – North Kazakhstan; SEKaz – South-East Kazakhstan; QTL – quantitative trait locus (loci); Chr. – chromosome.
[1] Adult plant resistance (APR) genes.