



# Genome wide association study of seedling leaf rust resistance in European winter wheat cultivars

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## Objective

Leaf rust caused by the biotrophic fungus *Puccinia triticina* Eriks. (*Pt*) is one of the most important fungal disease affecting wheat worldwide. Genetic resistance is the most economical, effective and ecologically sustainable method of controlling the disease. Almost 80 leaf rust resistance genes have been characterized. Efficient utilization of genetic resistance relies on an appropriate knowledge of the leaf rust resistance genes and their effectiveness in different environments.

## Methods

We applied a genome wide association study (GWAS) approach to identify resistance genes in 143 winter wheat cultivars recently registered in Poland, Germany, France, Switzerland, Denmark and United Kingdom. Identified significant marker-trait associations (MTAs) were verified on a panel of 36 Thatcher near-isogenic lines containing different *Lr* genes (Tc-LrNILs). Wheat cultivars and Tc-LrNILs were genotyped on DArTseq platform and phenotyped with 18 single *Pt* isolates at seedling stage.

## Results

After filtering, out of 40 035 SNP only 2 983 were used in GWAS using restricted maximum likelihood (REML) approach and information on structure of the analyzed wheat set was included. (Fig., Tab. 1) We identified four resistance genes *Lr3bg* (6B), *Lr9* (6B), *Lr24* (3D) and *Lr26* (translocation T1BL1RS) and several leaf rust resistance loci not present in Tc-LrNILs set on chromosomes 1B, 2A, 3B, 6B, 7A and 7D. Only one-third of the cultivars contained at least one of the identified resistance genes. For some resistant cultivars we were not able to identify *Lr* genes that might be attributed to the low resolution of *Pt* isolates used in the study. (Tab. 2)

## Acknowledgments

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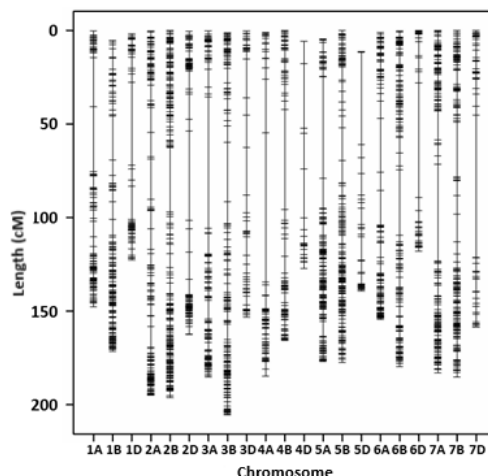


Figure (left) - Genetic map of wheat (molecular markers are indicated with horizontal bands)

Table 1. (right) Chromosome allocation of the 2983 markers used in GWAS.

Chromosome	Number of markers	Length (cM)
1A	124	147,5
1B	166	166,3
1D	80	121
2A	188	194,8
2B	283	196,3
2D	150	162
3A	158	185
3B	199	204,3
3D	60	153
4A	100	183,8
4B	99	165,8
4D	20	121,5
5A	200	172,5
5B	247	177,5
5D	43	128
6A	154	153,5
6B	192	179,5
6D	56	118
7A	204	183
7B	190	185,3
7D	70	158,5

Table 2. Wheat cultivars with postulated *Lr* genes

ID	Cultivar	Postulated <i>Lr</i> gene	ID	Cultivar	Postulated <i>Lr</i> gene	ID	Cultivar	Postulated <i>Lr</i> gene
1	Akteur		51	Agape192	3bg, 9	101	Zappa	
2	Smuga		52	Celebration	26	102	Diderot	
3	Wydma		53	Belenus	26	103	Event	3bg, 9
4	Belepi	26	54	Fakir		104	Ionesco	
5	Baletka		55	Jantarka		105	Lahertis	26
6	Bystra		56	Kris		106	Pamier	26
7	Forum	26	57	Look		107	Tabasco	
8	Kobiera		58	Muszelka		108	Edelrun	
9	KWSOzon	3bg, 9	59	Ostroga	3bg	109	Fermi	
10	Meteor	26	60	Sailor	3bg, 9	110	Joker	26
11	Nutka		61	Askalon		111	Lear	
12	Platin		62	Tulecka		112	Pionier	
13	Alcazar		63	Armada	3bg	113	Tentation	24
14	Speedway		64	Cocoon		114	Elixir	24
15	Zawisza		65	Bockris		115	Genius	
16	Calumet		66	Fidelius	3bg, 9	116	Julius	3bg
17	Bamberka	9	67	Jenga		117	Lithium	24
18	Dorota		68	KWSDacanto		118	Rebel	26
19	Fregata		69	Ludwig		119	Terroir	
20	Kohelia		70	Muza	3bg	120	Ennsio	
21	Lavantus	3bg, 9	71	Oxal	26	121	Gordian	
22	Mewa	3bg	72	Satyna	26	122	Kantao	
23	Olivin		73	Astoria		123	MVLucilla	3bg, 9
24	Praktik	3bg, 9	74	Türkis	3bg, 9	124	RGTDjoko	
25	Arkadia		75	Artagnan		125	Thalys	
26	Sukces		76	Bogatka	3bg	126	Eperon	
27	Zyta		77	Figura		127	Granamax	
28	Capone		78	Kampana		128	KWSCashel	
29	Banderola	26	79	KWSLivius		129	Matheo	
30	Elipsa	24	80	Markiza	26	130	Scout	
31	Garantus	3bg, 9	81	Naridana		131	Tobak	
32	Kranich		82	Patras		132	Eriwan	
33	Legenda		83	Skagen		133	Grapeli	
34	Mikula	26	84	Bagou		134	KWSErasmus	
35	Operetka		85	Turnia		135	Memory	26
36	Rapsodia	26	86	Astardo	3bg, 9	136	Solky	
37	Arktis	3bg, 9	87	Boomer		137	Waxy	24
38	Tonacja		88	Forkida		138	Eron	
39	Addict		89	Kepler		139	Hermann	
40	Caroll	24	90	KWSMagic	24	140	KWSKielder	26
41	Batuta		91	Meister		141	Modern	
42	Estivus	3bg, 9, 26	92	Natula		142	Sorokk	3bg, 9
43	Henrik		93	Pengar		143	Xantippe	24
44	Kredo	26	94	Smaragd				
45	Linus		95	Desamo	24			
46	Mulan		96	Estevan	9			
	Ostka							
47	Strzelecka		97	Heros				
48	Rywalka		98	KWSPius				
49	Artist		99	Nocibe				
50	Torrild		100	Stadium				