LEAF RUST AND POWDERY MILDEW IN POLISH WINTER WHEAT

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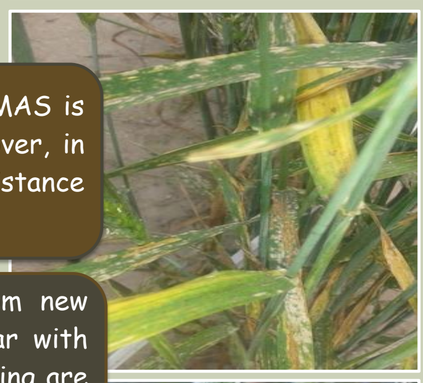
INTRODUCTION AND GOAL

Leaf rust, caused by *Puccinia recondita* f. sp. *triticina*, and powdery mildew, caused by *Blumeria graminis* f. sp. *tritici*, are the two most important diseases of wheat worldwide. Every year, these two diseases cause significant agricultural production losses, the extent depending on the weather conditions. Unfortunately, the varieties of wheat that are grown in Poland are still sensitive to the natural populations of *P. recondita* and *B. graminis*.

Pyramiding resistance genes for leaf rust and powdery mildew combined with the MAS is very effective process to obtain a new cultivars resistant to this diseases. Moreover, in breeding programs there are several examples of the successfully introduction resistance genes into a single cultivar and molecular markers are commonly used in this process.



The strategy of accumulation a new effective resistance genes originating from new sources of resistance into one genotype is the best way to obtain a new cultivar with durable and effective resistance resulting in more stable yields. In the plant breeding are many examples for such process but an introduction Lr41, Lr47, Lr55, Pm21, Pm36, Pm37 resistance genes in wheat is reported first time in presented

The second objective is of our study is to clarify the location Lr55 gene in wheat genome and mapping closely linked molecular markers suitable for markers assisted selection (MAS).

The third goal of this research is to determine the effectiveness of resistance genes for powdery mildew and leaf rust in relation of the populations *B. graminis* and *P. triticina* currently occurring in Poland.

EXPERIENCE SCHEME

Source of resistance to leaf rust / powdery mildew

↓

Screening for resistance to leaf rust / powdery mildew using natural populations of this pathogens occurring in Poland

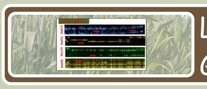
↓

Selection of effective sources of resistance to leaf rust / powdery mildew

↓

An introdution of resistance genes to leaf rust / powdery mildew to Polish elite winter wheat cultivars

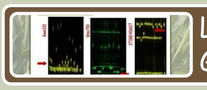
PARENTAL PLANT AND FOREGROUND SELECTION



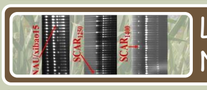
Line KS90WGRC10 = Lr39 (=Lr41) gene
Gdm35, Barc124, Gwm210, Gwm261, Gwm296

Line KS04WGRC45 = Lr55 gene
DArT, SSR

Line UC996610010 = Lr47 gene
(PCAPSR + PS10L + PS10L2), Gwm60



Line NC99BGTA11 = Pm37 gene
Gwm332, Wmc790, STSBE406627



Line Yangmai 5 = Pm21 gene
NAU/xibao, SCAR1400, SCAR1250

Line MG29896 = Pm36 gene

Recurrent parents (PR) – 4 varietes of winter wheat:
Bogatka, Nadobna, Muszelka, RAH979

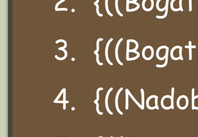
RESULTS

Up to now, the following populations were obtained:

1. {((Bogatka x Lr41) x (Bogatka x Pm21) x Bogatka x RAH979 x Lr47 x Bogatka x Bogatka x Lr47 x Bogatka
2. {((Bogatka x Lr41) x (Bogatka x Pm21) x Bogatka x RAH979 x Lr47 x Bogatka x Nadobna x Lr47 x Nadobna
3. {((Bogatka x Lr41) x (Bogatka x Pm21) x Lr47 x Lr47 x Nadobna x Pm37
4. {((Nadobna x Lr41) x (Nadobna x Pm21) x Nadobna x Nadobna x Lr47 x Nadobna x Bogatka x Lr47 x Bogatka
5. {((Bogatka x Lr41) x (Bogatka x Pm21) x Lexus x Meteor x Pm37 x Pm37 x Bogatka x Pm37 x Bogatka
6. {((Bogatka x Lr41) x (Bogatka x Pm21) x Lexus x Meteor x Pm37 x Pm37 x Nadobna x Pm37 x Nadobna
7. {((Bogatka x Lr41) x (Bogatka x Pm21) x Lexus x Meteor x Pm37 x Pm37 x Pm37 x Lexus x Lr47
8. {((Bogatka x Lr41) x (Bogatka x Pm21) x Lexus x Meteor x Pm37 x Pm37 x Pm37 x Bogatka x Lr47
9. {((Bogatka x Lr41) x (Bogatka x Pm21) x Lexus x Meteor x Pm37 x Pm37 x Lr47 x Nadobna x ???
10. {((Bogatka x Lr41) x (Bogatka x Pm21) x Lexus x Meteor x Pm37 x Pm37 x Lr47 x Lexus x Pm37
11. {((Bogatka x Lr41) x (Bogatka x Pm21) x Lexus x Meteor x Pm37 x Pm37 x Lr47 x Bogatka x Pm36

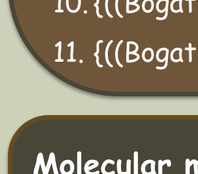
Molecular mapping:

- Four mapping populations: (Lr55 x Bogatka), (Lr55 x Nadobna), (Lr55 x Kompana), (Lr55 x Muszelka)
- SSRs: 29 markers and other additional
- DArT: 60 markers and restriction enzymes



The part of results concerning virulence of 50 *B. graminis* f.sp. *tritici* isolates to the resistance genes present in the differential set of lines and cultivars

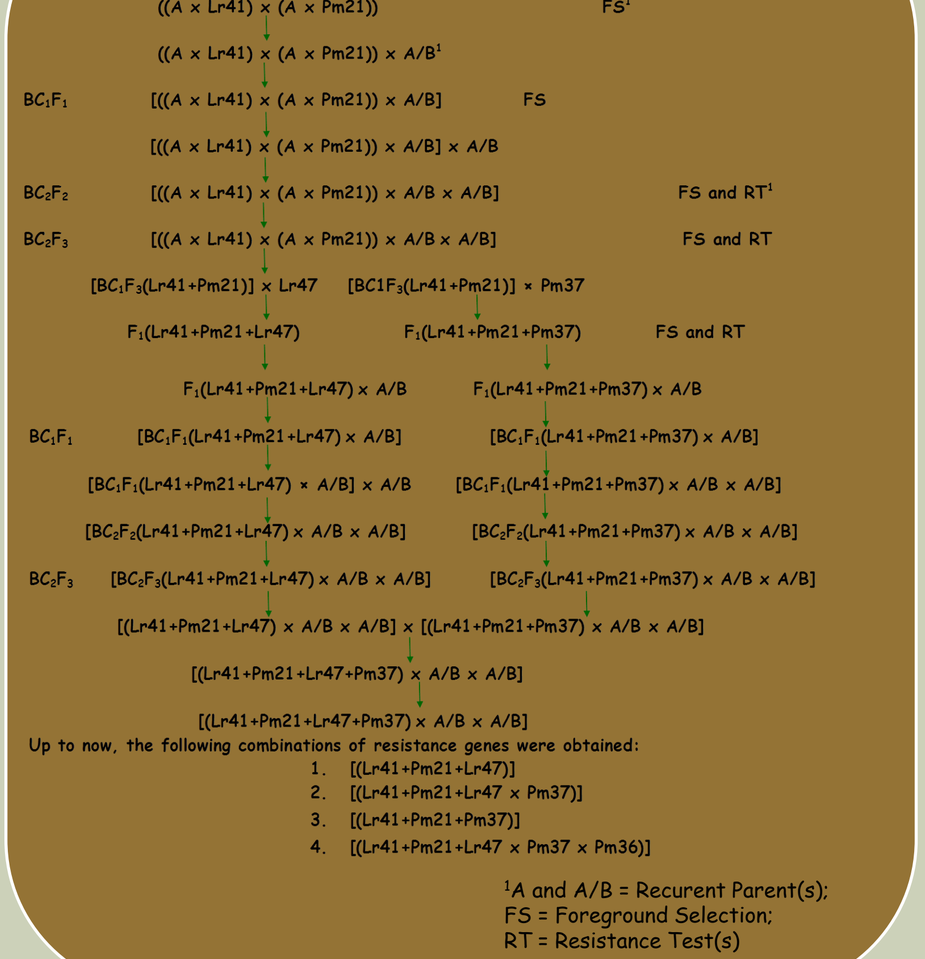
Cultivar/Line \ Isolates	Bgt 1	Bgt 2	Bgt 3	Bgt 4	Bgt 5	Bgt 6	Bgt 7	Bgt 8	Bgt 9	Bgt 10	Bgt 11	Bgt 12	Bgt 13	Bgt 14	Bgt 15	Bgt 16	Bgt 17	Bgt 18	Bgt 19	Bgt 20	Bgt 21	Bgt 22	Bgt 23	Bgt 24	Bgt 25	Bgt 26	Bgt 27	Bgt 28	Bgt 29	Bgt 30	Bgt 31	Bgt 32	Bgt 33	Bgt 34	Bgt 35	Bgt 36	Bgt 37	Bgt 38	Bgt 39	Bgt 40	Bgt 41	Bgt 42	Bgt 43	Bgt 44	Bgt 45	Bgt 46	Bgt 47	Bgt 48	Bgt 49	Bgt 50
Sorbas Pm4b+8	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
Kronjuwel Pm	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
Granada Pm 5+8	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
Apollo Pm2+4b+8	4	4	4	4	4	4	4	0	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	2	4	4	4	4	4	4	4	4	4	4
Sappo Pm1+2+4b+9	2	2	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	2	2	2	4	2	4	0	0	0	0	0	0	0	0	0	0
Amigo Pm17	4	0	0	4	2	0	0	0	0	4	4	4	4	4	2	4	4	2	4	4	0	0	0	0	2	0	0	0	0	4	4	2	2	4	2	2	0	4	2	4	4	4	4	4	4	4	4	4	4
Yangmai5 Pm21	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**2**	**0**	**0**	**0**	**0**	**0**	**0**	**2**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Virest Pm22	0	-	-	-	-	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4	4	4	2	2	2	-	-	-	0	0	0	0	0	0	0	0	0	0
Pova Pm29	0	0	2	2	2	0	0	0	2	0	2	0	0	0	0	0	0	0	0	0	0	0	0	2	0	2	2	2	0	0	2	2	2	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0
NC96BGTD3 Pm35	0	0	2	2	2	1	0	0	2	4	4	4	4	4	4	2	4	2	2	0	0	0	0	2	2	0	0	0	0	0	3	2	4	4	2	4	2	2	2	0	4	0	4	4	4	0	0	0	4	0
Nimbus	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
NC97BGtD7 Pm34	0	0	0	0	0	0	0	0	0	2	4	4	4	4	4	0	4	4	4	0	0	0	0	0	4	4	4	0	0	0	0	4	2	0	0	2	4	4	4	3	4	3	0	0	0	0	0	4	0	0
NC99BGTAG11 Pm37	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**2**	**2**	**0**	**0**	**2**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
MG 29896 Pm36	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0



The part of results concerning virulence of 12 *P. recondita* f.sp. *triticina* isolates to the resistance genes present in the differential set of lines and cultivars

Isolates \ Cultivar/Line	Lr1	Lr2a	Lr2b	Lr2c	Lr3	Lr9	Lr10	Lr11	Lr12	Lr13	Lr14a	Lr14b	Lr15	Lr16	Lr17	Lr18	Lr19	Lr20	Lr24	Lr25	Lr26	Lr28	Lr29	Lr30	Lr32	Lr33	Lr34	Lr35	Lr37	Lr38	Lr44	LrB	LrW	Tc	Lr46	Lr47	Lr41	Lr50	Lr55	Lr34	Lr46	Lr62	Lr16	Lr52
Pt1	4	2	2	4	4	**0;**	4	4	4	4	4	4	4	4	4	4	**0;**	0;	4	4	2	**0;**	2	4	4	4	4	4	4	4	4	4	2	4	4	**0**	**2**	4	**0**	2	4	**0;**	4	4
Pt2	4	2	4	4	4	**0**	4	4	4	4	4	4	4	4	4	4	**4**	4	4	4	0;	**0;**	0;	4	4	4	4	4	4	4	4	4	4	4	4	**0;**	**0;**	4	**0**	4	4	**0;**	4	4
Pt3	4	0	2	4	4	**0**	4	4	4	4	4	4	4	4	4	4	**2**	4	4	4	2	**0;**	0	4	4	4	4	4	4	4	4	4	4	4	4	**0**	**0**	4	**0**	4	4	**2**	4	4
Pt4	4	0;	2	4	4	**0**	4	4	4	4	4	4	4	4	4	4	**0**	4	4	4	0	**0;**	0;	4	4	4	4	4	4	4	4	4	4	4	4	**0**	**0;**	4	**0**	4	4	**0;**	4	4
Pt5	4	0;	4	4	4	**0**	4	4	4	4	4	4	4	4	4	4	**0**	4	4	4	0	**2**	0;	4	4	4	4	4	4	4	4	4	2	4	4	**0**	**0;**	4	**2**	4	4	**0;**	4	2
Pt6	4	0;	2	4	4	**0**	4	4	4	4	4	4	4	4	4	4	**0**	4	4	4	0	**0;**	0;	4	4	4	4	4	4	4	4	4	**2**	**0;**	4	**0**	4	4	**0;**	4	4				
Pt7	4	0	2	4	4	**0**	4	4	4	4	4	4	4	4	4	4	**0;**	4	4	4	2	**0**	2	4	4	4	4	4	4	4	4	4	2	4	4	**0**	**0;**	4	**0**	4	4	**0;**	4	4
Pt8	4	4	0;	2	4	**0**	4	4	4	4	4	4	4	4	4	4	**0;**	4	2	4	0	**0;**	4	4	4	4	4	4	4	4	4	4	2	4	4	**0**	**0;**	4	**0**	2	2	**2**	4	2
Pt9	4	0	4	4	4	**0**	4	4	4	4	4	4	4	4	4	4	**0**	4	4	4	2	**0;**	0;	4	4	4	4	4	4	4	4	4	4	4	4	**0**	**0;**	4	**0**	4	4	**0;**	4	4
Pt10	4	0	2	4	4	**0;**	4	4	4	4	4	4	4	4	4	4	**0**	4	4	4	0;	**2**	2	4	4	4	4	4	4	4	4	4	0;	4	4	**2**	**2**	4	**0**	2	2	**0;**	4	4
Pt11	4	2	2	4	4	**0**	4	4	4	4	4	4	4	4	4	4	**0;**	4	2	4	2	**2**	4	4	4	4	4	4	4	4	4	4	4	4	4	**2**	**0;**	4	**0**	4	4	**2**	4	4
Pt12	4	2	4	4	4	**0**	4	4	4	4	4	4	4	4	4	4	**0;**	4	4	4	2	**0;**	0;	4	4	4	0;	4	4	4	4	4	4	4	4	**0**	**0;**	4	**0**	4	4	**4**	4	4

BREEDING SCHEME



Up to now, the following combinations of resistance genes were obtained:

1. [(Lr41+Pm21+Lr47)]
2. [(Lr41+Pm21+Lr47 x Pm37)]
3. [(Lr41+Pm21+Pm37)]
4. [(Lr41+Pm21+Lr47 x Pm37 x Pm36)]

[1]A and A/B = Recurent Parent(s);
FS = Foreground Selection;
RT = Resistance Test(s)

SUMMARY

In summary, pyramiding of several resistance genes using marker assisted proved that this strategy is more efficient and speed up recurrent genome recovery. However, this approach can not completely replace the traditional methods, especially for verification of the results in pathology tests. The resistance tests using differential set of host and pathogen are essentaial in MAS, especially when the foreground selection results can be sometimes problematic to interpret. The practical outcome of presented study are the newly produced homozygous wheat lines which can be used as the source of effective resistance for the leaf rust and powdery mildew in breeding programes.

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