

Detection and evaluation of residual effects by defeated stripe rust resistance genes (*Yr* genes) in common wheat against virulent *Puccinia striiformis* f. sp. *tritici* isolates

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Introduction

- Stripe rust of wheat caused by *Puccinia striiformis* f. sp. *tritici* (*Pst*) has been one of the most destructive wheat diseases at most wheat growing regions in the world. The disease has become more prevalent and destructive in western Canada recent years since 2010.
- The host resistance by *Yr* genes has provided effective, and economically and ecologically sound protection. However, *Yr* genes deployed in many cultivars are single-gene all-stage resistance that often were overcome by the virulent *Pst* populations only a few years after the introduction.
- Durable disease resistance against stripe rust of wheat is urgently needed.
- Some studies indicate that defeated disease resistance genes possess non-race-specific partial resistance against virulent pathogen isolates (residual effects). No study has been done on the residual effect by defeated *Yr* genes in wheat.



Hypothesis

Defeated *Yr* genes, *Yr10*, *Yr26* and *Yr32*, have residual effects as non-race specific partial resistance against virulent *Pst* isolates.

Objective

To detect and evaluate the partial resistance in spring wheat lines with defeated resistance genes.

Materials and Methods

Near isogenic lines (NILs) carrying single *Yr* genes, *Yr10*, *Yr26* or *Yr32*, and combinations of *Yr26/Yr10*, *Yr32/Yr10* or *Yr32/Yr26* were inoculated by one of three *Pst* isolate/mixtures and control inoculum (Table 1) along with cv. Avocet, which is the background genotype for all NILs.

Growth chamber experiment was designed as split plot with *Pst* isolate as the whole plot factor and genotypes as the sub-plot factor.

Table 1 The virulence profile of *Pst* isolates used in growth chamber experiment.

Inoculum	Isolates	<i>Yr10</i>	<i>Yr26</i>	<i>Yr32</i>
A (mix of 2)	T034	+	+	-
	W050	-	-	+
B	W020	+	+	+
C	W049	+	+	+
D (-ve control) (no spore)

* (+) = virulent, (-) = avirulent.

NILs were inoculated at seedling stage and infection area (IA) (%) and infection type (IT) in 0-9 scale were recorded on 14 day post inoculation (dpi). Latent period (LP) was recorded when urediniospores became visible outside of a pustule on leaf surface.

The same NILs were evaluated in stripe rust nurseries in Saskatoon, SK and Lethbridge, AB during the growing season of 2018. Disease incidence and severity were recorded at soft-dough stage.



Results

Table 2 F values and *p* values for the effects and interaction of isolate and wheat genotypes on LP, IA and IT from the growth chamber experiments.

Source	df	ANOVA LP		ANOVA IA		ANOVA-type statistic (ATS) IT			
		F value	<i>p</i> value	F value	<i>p</i> value	<i>df_N</i>	<i>df_D</i>	F value	<i>p</i> value
inoculum (I)	2	100.9	<0.0001	36.9	<0.0001	2.35	42.41	277.42	<0.0001
genotype (G)	6	50.1	<0.0001	50.5	<0.0001	4.87	∞	26.96	<0.0001
I x G	12	15.7	<0.0001	31.2	<0.0001	10.58	∞	10.11	<0.0001

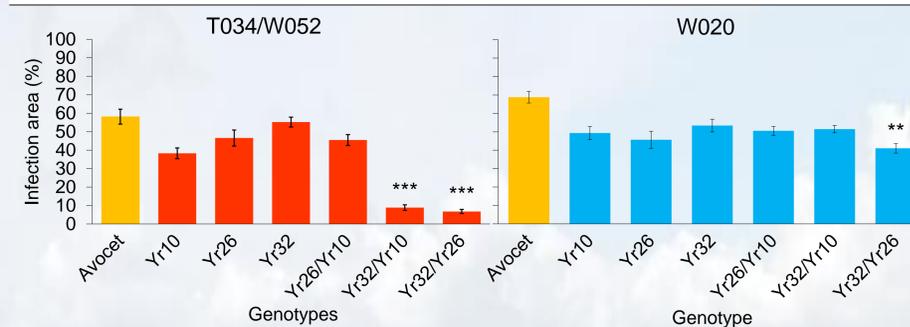


Fig. 1 Mean IA (%) of all genotypes inoculated with T034/W052 and W020 compared to 'Avocet'. Error bars indicate standard errors. ** 0.01 < *p* < 0.05, *** *p* < 0.001, by Dunnett's test.

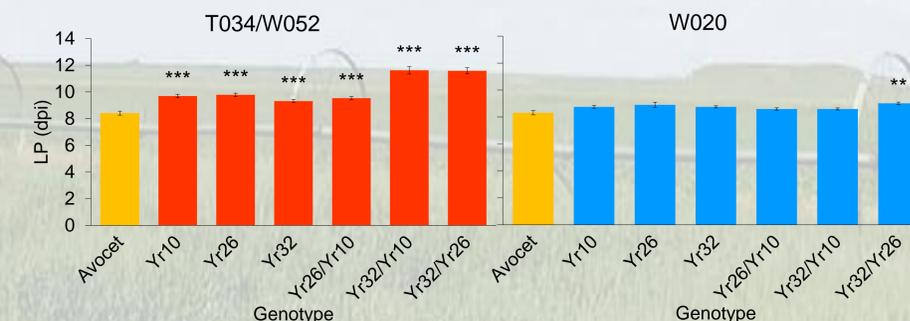


Fig. 2 Mean LP of all genotypes inoculated with T034/W052 and W020 compared to 'Avocet'. Error bars indicate standard errors. ** 0.01 < *p* < 0.05, *** *p* < 0.001, by Dunnett's test.

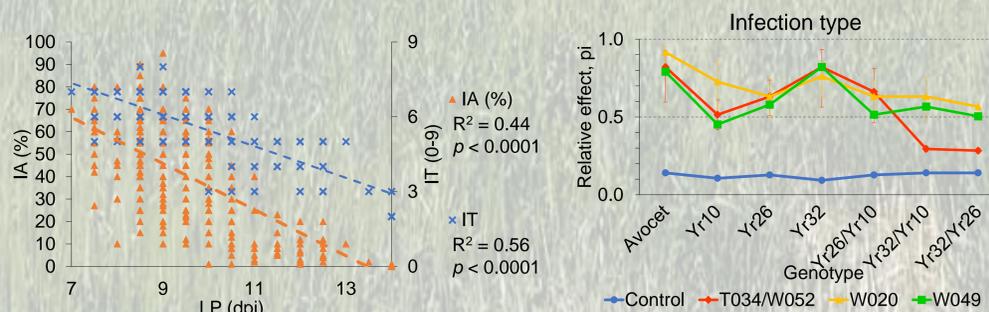


Fig. 3 Negative correlation of IA and IT to extending LP.

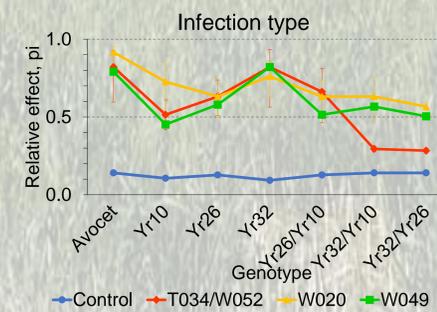


Fig. 4 Relative effect (*pi*) of IT for all treatments. 95% confidence interval is indicated for T034/W052 and W020.

Results

There was the interaction of genotypes and isolates for IA, IT and LP (Table 2). When compared to 'Avocet' and parental lines, IA and IT were reduced in NILs with *Yr32/Yr10* and *Yr32/Yr26* inoculated with T034/W052 and IA was reduced in NILs with *Yr32/Yr26* inoculated with W020 (Fig. 1, Fig. 4). LP had similar results as IA except all NILs with one or two *Yr* genes had extended LP compared to 'Avocet' with T034/W052 (Fig. 2). The results from W049 was similar to that of W020. Both IA and IT had negative correlation with LP with R^2 of 0.44 and 0.56, respectively (Fig. 3). The results from field nurseries were inconclusive due to the avirulence of the natural *Pst* population to NILs with single *Yr10* and *Yr26* gene (data not shown).

Discussion and Conclusion

While individual defeated genes did not lower IA in NILs, the gene combinations of *Yr32/Yr10* and *Yr32/Yr26* exerted partial resistance reaction in NILs to *Pst* isolates with different levels of aggressiveness. On the other hand, even in a combination, *Yr26/Yr10* did not show partial resistance and this indicates not all combinations of *Yr* genes equally exert residual effects. The difference in the degree of reaction of the same NILs inoculated by different *Pst* isolates means the effectiveness of the partial resistance is non-race-specific and depends on the *Pst* aggressiveness. The field nursery experiment needs more control over the *Pst* virulence profile to ensure virulence against all *Yr* genes tested. Possible solution would be inoculation of the nursery with *Pst* spores of virulent isolates or testing adult resistance in growth chambers. This study revealed the presence of residual effects in *Yr* genes in wheat and further research is required to explore the potential benefits of this effects.

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