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The Changing Virulence of Stripe Rust in Canada Over the Last 30 Years

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Background

Stripe rust of wheat, caused by the fungal pathogen *Puccinia striiformis* f. sp. *tritici* (*Pst*), is one of the most important cereal diseases worldwide. The rise of stripe rust as threat to wheat production since 2000 is due to the emergence of new virulent races of this pathogen. These new races have a wide virulence spectrum, and are adopted to cause infection under higher temperatures. In this study, the pathogen population in Canada, representing a time period from 1984 to 2017, was analysed for virulence diversity and geographical distribution.

Objectives

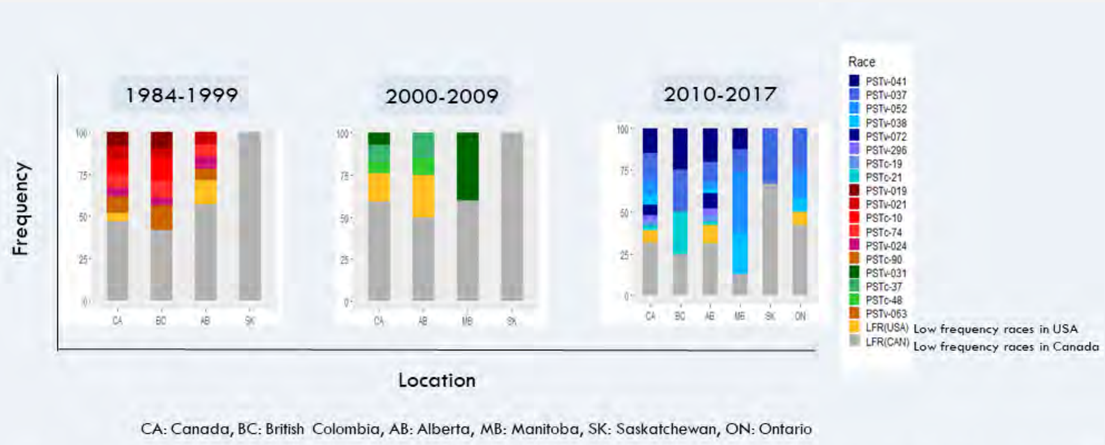
Determine how the pathogen changed its virulence over the last 30 years in Canada? Are changes similar to the USA? Is there any variation between isolates from the eastern vs the western provinces of Canada.

Methods

- A total of 140 isolates of *Pst* representing a collection from 1984-2017 were tested by inoculating a set of 18 wheat isogenic lines in the 'Avocet' background.
- The seedlings were inoculated with a urediniospores/talc mixture, and infection types (ITs) on the second leaf, were recorded 18–21 days after inoculation based on a scale of 0–9.
- The major phylogenetic groups of isolates were identified based on unweighted pair-group method and two-dimensional ordination of *Pst* on linear discriminant (LD) axes. The LD analysis was performed on principle component variables.

Results

- In total, 89 *Pst* races were identified, and 45% of all tested isolates were identical to 24 of the previously identified USA races. Yet, 55% of the isolates are unique to Canada. The most predominant races in Canada (PSTc) and their equivalent US races (PSTv) are shown in Fig. 1.



CA: Canada, BC: British Colombia, AB: Alberta, MB: Manitoba, SK: Saskatchewan, ON: Ontario

Fig. 1. The most predominant *Pst* races in Canada (PSTc), collected between 1984-2017 and their equivalent USA races (PSTv)

- The *Pst* virulence in Canada shifted twice, once around 2000, and once again around 2010 (Figs, 1, 2, 3).
- The *Yr*-genes defeated by time range are shown in Fig. 3 and below:
  - 1984-1999: *Yr6,Yr17, YrTr1* and *YrExp2*
  - 2000-2009: *Yr6*, *Yr17*, *YrTr1*, *YrExp2*, *Yr7*, *Yr8*, *Yr9*, *Yr24*, *Yr44*
  - 2010-2017:*Yr6*, *Yr17*, *YrTr1*, *YrExp2*, *Yr7*, *Yr8*, *Yr9*, *Yr24*, *Yr44, Yr10, Yr27, Yr32, Yr43*
- Three major distinct phylogenetic groups of isolates (G1 to G3) were identified based on their virulence profile. Isolates in G2 and G3 are more closely related than isolates in G1, where G1 represents *Pst* before 2000 (Fig. 4).
- Analysis of β-diversity values among different provinces and states, in Canada and the USA, showed that isolates in Alberta, and British Columbia are similar to isolates in the Pacific North-west of the USA. Isolates from Manitoba and Ontario are similar to isolates in eastern and central regions of the USA (Fig. 5).

Results

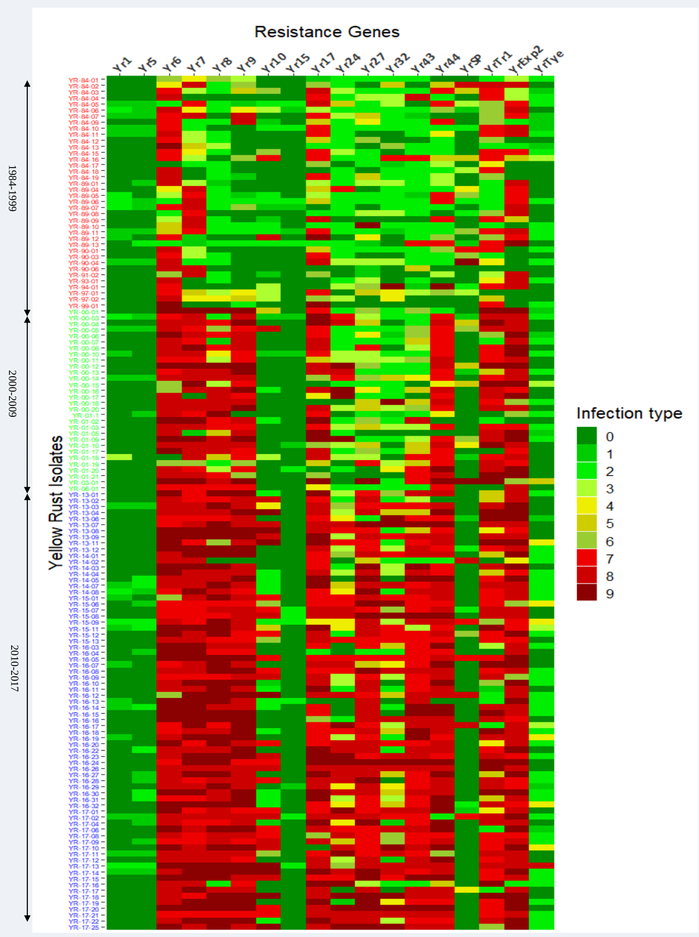


Fig. 2. Heatmap based on virulence phenotype of *Pst* isolates on eighteen single *Yr*-gene lines. Phenotypic interaction highlighted in green represent resistance and those in red represent susceptibility.

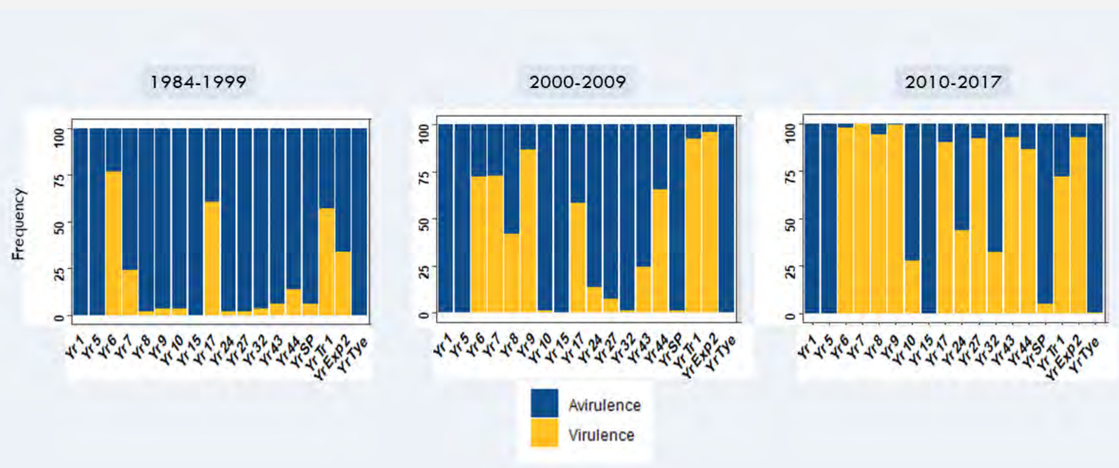
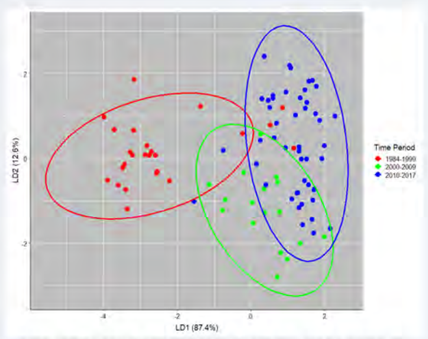


Fig. 3. Frequencies of virulence of the stripe rust isolates on single *Yr*-gene wheat lines in Canada (1984-2017)



G1: 1984-1999, G2: 2000-2009, G3: 2010-2017

Fig. 4. Two-dimensional cluster analysis based on phenotypic interaction of *Pst* isolates on YR-isogenic differential lines

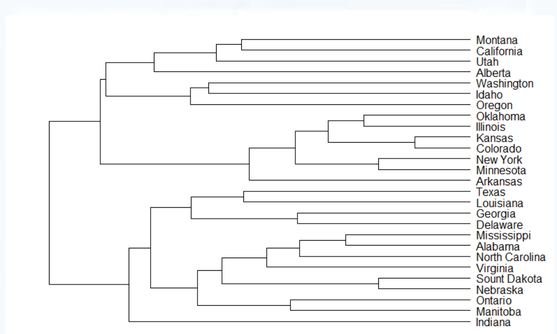


Fig. 5. Dendrogram showing the relationship of regional diversity of stripe rust races between Canadian provinces and USA states

Conclusions

Pst virulence changed in Canada twice, once around 2000, and again in 2010.

Predominant races in USA and Canada are the same, indicating long distance migration of these races.

Canada has its own unique races occurring at low frequencies. This supports the hypothesis that mutations occur at a local level in *Pst* populations.

Acknowledgements

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