Two types of resistance against a major wheat disease

Protection from Septoria tritici blotch is best achieved by suppressing both host damage and pathogen reproduction

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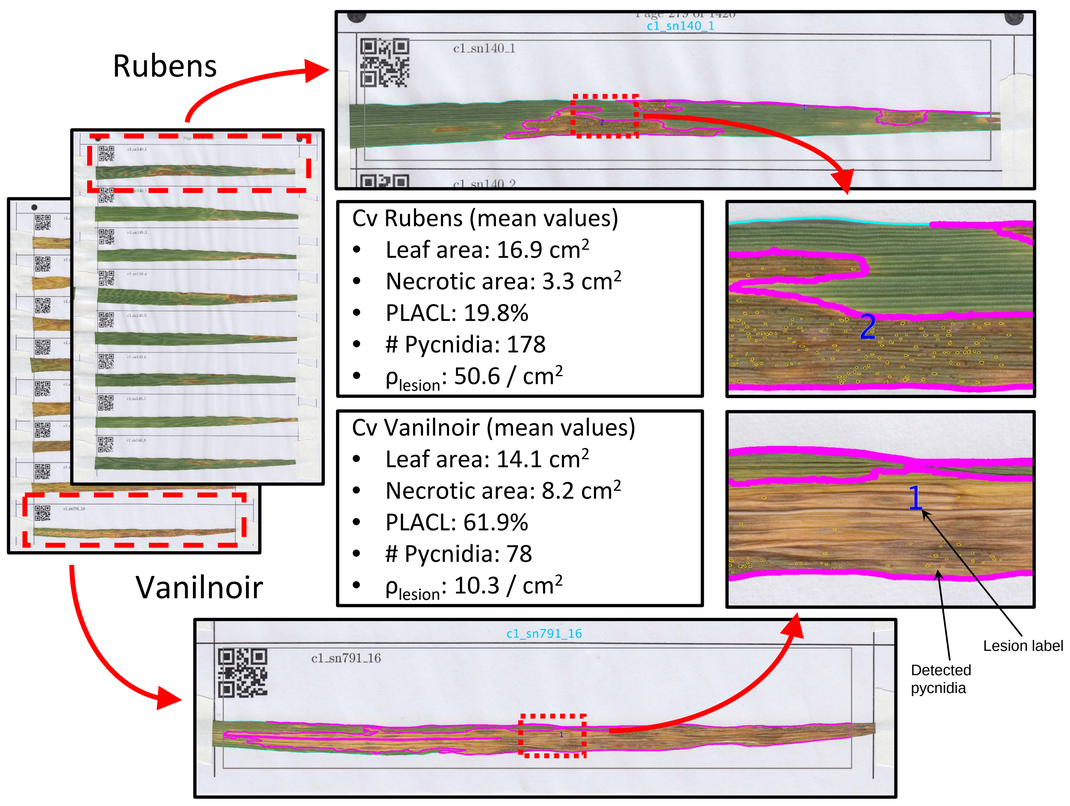
1 Introduction

Septoria Tritici Blotch (STB) caused by the fungus *Zymoseptoria tritici* is the most damaging wheat disease in Europe. It causes brown lesions on wheat leaves leading to lower yield. Over 50% of all the fungicide use in Europe is targeted against STB. **Effective host resistance** is needed in **the integrated pest management** to suppress pathogen populations and limit the need for fungicides. This will lead to sustainable pest control and **increased food security**. Quantitative resistance is more likely to provide durable disease control, but selection for multiple genes with small individual effects is challenging.

2 Method overview

We used **automated image analysis** (AIA) on a collection of 21420 **naturally infected leaves** from 335 elite European winter wheat cultivars to obtain precise and objective quantitative measures of conditional STB intensity [1]. Our AIA method is based on an ImageJ macro [2] which determines healthy and damaged leaf area and counts fungal fruiting bodies (pycnidia) from scanned leaf images. Individual leaf data is reported based on the leaf labels encoded in the QR-code.

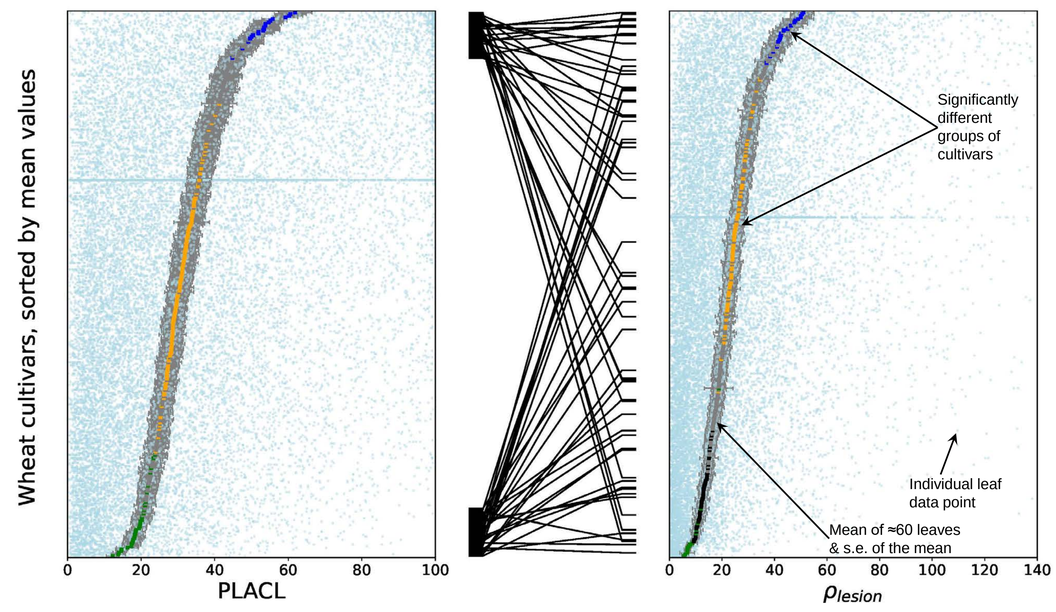


3 Host damage vs. Pathogen reproduction

From the raw data we calculated two quantities: percentage of leaf area covered by lesions (**PLACL**) and density of pycnidia within lesions ($\boldsymbol{\rho_{lesion}}$). These reflect **host damage** and **pathogen reproduction**, respectively. **Host damage** is the factor that determines yield losses in the field and reflects the pathogen's ability to invade and damage the host tissue. **Pathogen reproduction**, on the other hand, is the factor that predicts disease spread in the field and reflects the pathogen's ability to convert invaded and damaged host tissue into offspring.

4 Results and Discussion

We ranked the 335 wheat cultivars based on **host damage** (left panel) and **pathogen reproduction** (right panel). The two rankings differ significantly as reflected by the black lines that map the 30 most resistant and the 30 most susceptible cultivars based on host damage to the pathogen reproduction ranking. The correlation between the two rankings is weak ($r_s = 0.17$, $p = 0.0022$) indicating that the components of resistance that suppress host damage and pathogen reproduction are independent.



Additionally, we found that pathogen reproduction measured early in the season is the best predictor of host damage late in the season. Our results combined with unpublished results of a genome-wide association study [3] indicate that the genetic bases for the two types of resistance are separate from each other.

5 Conclusion

Resistance suppressing pathogen reproduction is independent from resistance suppressing host damage and should be taken into account in breeding programs.

–Our AIA method allows for precise, objective and reproducible measurement of host damage and pathogen reproduction.

–Resistance against pathogen reproduction will lead to suppression of epidemics within the field and thus higher yields.

–Pathogen reproduction is a more stable measure of quantitative resistance than host damage and allows for more precise predictions.

6 References

1. Petteri Karisto, Andreas Hund, Kang Yu, Jonas Anderegg, Achim Walter, Fabio Mascher, Bruce A. McDonald, Alexey Mikaberidze. 2017. Ranking quantitative resistance to Septoria tritici blotch in elite wheat cultivars using automated image analysis. Pre-print in bioRxiv; doi: https://doi.org/10.1101/129353
2. Ethan L. Stewart, Christina H. Hagerty, Alexey Mikaberidze, Christopher C. Mundt, Ziming Zhong, and Bruce A. McDonald. 2016. An improved method for measuring quantitative resistance to the wheat pathogen Zymoseptoria tritici using high-throughput automated image analysis. Phytopathology 106: 782-788.
3. Steven Yates, personal communication.