Fusarium Head Blight and Barley Yellow Dwarf Virus Incidence and Severity Among Winter Wheat Association Mapping Population

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Introduction

- Fusarium Head Blight (FHB) has caused an estimated $2.7 billion of damage to wheat over a period from 1998-2000 in the United States (Nganje et al. 2002).
- Barley Yellow Dwarf Virus (BYD) has caused an estimated 0.4-0.67 bushels per acre of yield loss (Burnett and Ranerai 1991).
- FHB and BYD both threaten yield and global food security.
- Currently, resistance is the most effective way of disease prevention.
- Disease resistance is quantitative and only a few of resistance genes are found for each. Fhb1 is the major resistance gene for FHB.
- There is a need to identify more resistance genes and develop markers critical for breeding.

Methods

- 270 US winter wheat lines were planted in replicate at Rocky Ford KSU nursery in a randomized complete block design (RCBD) (Figure 1).
- Each plot was inoculated for FHB via corn spawn three times on: 4/15, 4/30, 5/1 (Figure 1) and irrigated for 15 minutes every 4 hours.
- BYD infection was naturally vectored by aphids.
- Starting 6/1, disease incidence and severity was measured (Figure 2):
  - BYD was measured from 0-5.
  - FHB was measured from 0-100.
- Area Under the Disease Curve (AUDPC) was calculated for FHB and normalized based on heading date.
- Both BYD and FHB resistance phenotypes were correlated to exome capture genomic data using a Mixed Linear Model Genome Wide Association Study (GWAS).
- A KASP assay was run to identify lines carrying the FHB1 gene.

Figure 1: Wheat field at Rocky Ford Research Farm. Shows wheat pre-inoculation (left), corn spawn used to inoculate (middle), and after inoculation (right). Source: Lawrence Tidakbi

Figure 2 (left)**:** FHB disease severity levels shown from least severe to most severe. Source: Michigan State Extension.
Figure 2 (right)**:** BYD disease severity shown. Least severe and most severe shown are compared. Source: Oklahoma State Extension

Results

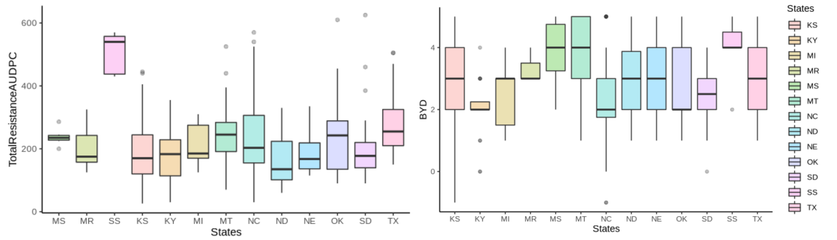

Figure 3: Boxplots show the total AUDPC (left) for FHB susceptibility score and BYD score (right) per state. FHB controls (only left) are MS (Moderate Susceptible), MR (Moderate Resistance), SS (Extremely Susceptible). The 10 states represents phenotypic variation in US wheat breeding programs.

Figure 4: Genome Wide Association Study of SNPs (n=454,075) of normalized AUDPC for FHB susceptibility (top) and BYD Score for BYD susceptibility (bottom). Manhattan plots show mapping using mixed linear models and modeling using a kinship in Tassel. The line denotes p values are $<10^{-5}$ and $<10^{-4}$ for BYD and FHB respectively.

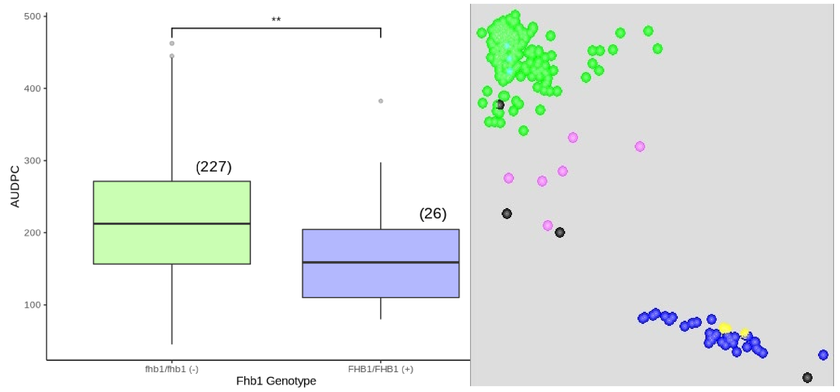

Figure 5: Boxplots (left) show FHB AUDPC for each Genotype (*fhb1/fhb1, FHB1/FHB1*). Effect Size of FHB1 allele is 27.5 AUDPC units, significant at ** meaning p=0.001 (t-test). KASP assay (right) Green: *fhb1* negative; Blue: *FBH1* Positive; Pink: Unknown or possible heterozygotes for 253 lines.

Summary and Future Studies

- There was variation in the phenotypes (Figure 3) for both FHB and BYD.
- FHB SNPs (Figure 4) show 9 ($p<10^{-4}$) significant SNPs and BYD SNPs (Figure 4) show 30 ($p<10^{-5}$) significant SNPs.
- KASP assay found that the FHB1+ allele decreases AUDPC by 12.7% with respect to overall mean (Figure 5).
- Significant associations represent potential new markers. Future Studies should aim to design markers around these SNPs to design diagnostic KASP assays for wheat breeders.

References

- Burnett, P A, and R Ranieri. “The Effect of a MAV Serotype of Barley Yellow Dwarf Virus on the Yield of Wheat in Mexico.” *Barley Yellow Dwarf Newsletter*, vol. 4, p. 60.
- Nganje, William E., et al. "Estimating the economic impact of a crop disease: the case of Fusarium head blight in US wheat and barley." *National Fusarium Head Blight Forum Proceedings*. Vol. 2002. 2002.

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