Comparing Performance of 4A QTL on Agronomic and Spectral Traits in Wheat Varieties

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INTRODUCTION

- On a wheat's 4A chromosome, it is found that the long arm region may be connected to yield components. Genetic markers for this region, or quantitative trait loci (QTL), identifies if the spring wheat contains the QTL of interest that was crossed in from its desired parent, the wheat variety Scarlet, which is presumed to be beneficial for overall yield.
- The Scarlet 4A QTL was crossed into high biomass backgrounds so that the potential impact of the genes could be most visible.
- In each background, there consisted of a "twin" pair– almost identical except that one plant had the Scarlet region intentionally crossed in, and the other did not.

PURPOSE

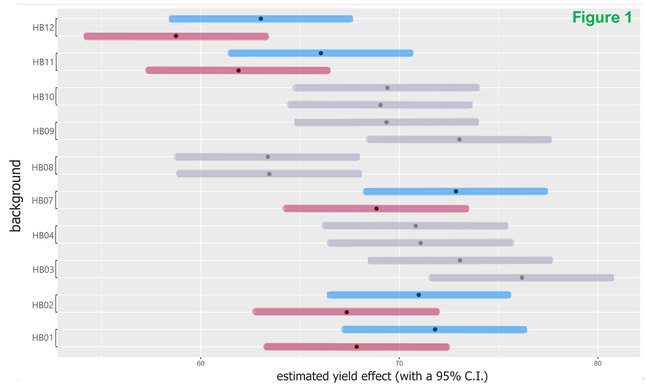
In this study, we focused on the trait impacts that the Scarlet parent had on these different backgrounds using agronomic and field data. We analyzed correlations between certain vegetation indices at flight dates and the traits to observe the change when the Scarlet is crossed in.

METHODS & PROCEDURES

- Drone images were captured on a DJI Inspire 2 with a Sentera 6X Sensor over two locations, Kincaid and Spillman during June and July of 2022, captured weekly and centered around heading dates
- The harvesting data was taken from the final 2022 data collections over all fields, with replicated experiments
- The drone flights were stitched together using PIX4DMapper, plot areas were drawn using QGIS, and index extractions were done using several R code packages
- Statistical analysis such as analysis of variance were performed using R

Initial Anova Yield Estimates for Background+Scarlet QTL Presence

Figure 1

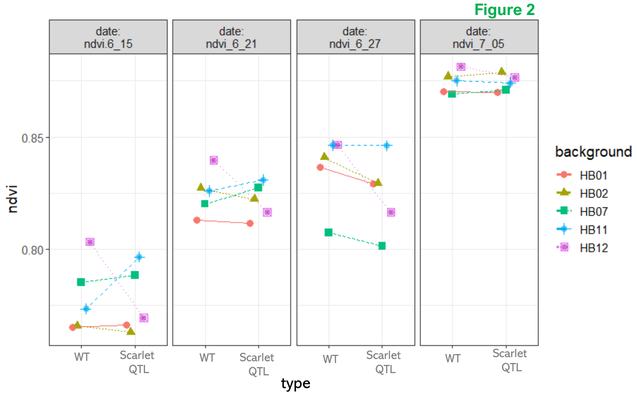


SELECTED BACKGROUNDS

The following backgrounds were selected because the presence of the Scarlet region (blue) had a higher yield than those without (the wild types, which are red)

- HB01
- HB07
- HB12
- HB02
- HB11

Figure 2



- The Normalized Difference Vegetation Index (NDVI) is a measure of plant growth and healthy vegetation (calculated by a normalized ratio of red and near infrared spectral reflectance)
- Fig. 2 is a plot that demonstrates the NDVI over the four flights, along with the difference of NDVI within each background and those with/without the Scarlet region
- A heatwave was observed on the flight date of 6/27

SIGNIFICANT DIFFERENCES WITHIN POST HOC ANALYSIS

A fixed effect linear model (anova) was created by estimating the effect of the scarlet region in each background, the effect of each background, and impact of flight date. This model was selected over others because of its high adjusted r squared value and low AIC value.

- The gene in background effect (QTL presence) was significant in the impact of NDVI for HB12
- Additionally, each flight date was significantly different from each other

The test of significance for the above statements was conducted using the Fisher LSD with p=0.05

Figure 3

Significant NDVI differences when comparing the selected backgrounds

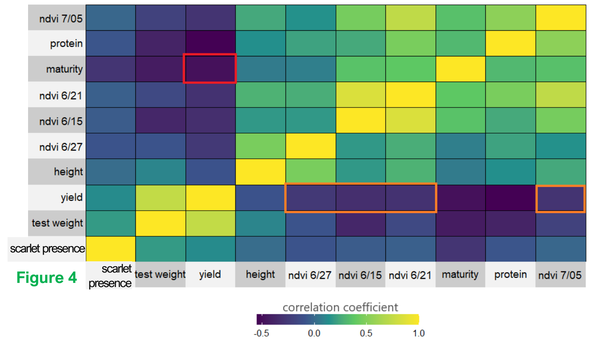
background	estimate	letter signif.
HB01	0.8201821	a
HB02	0.8255249	ab
HB07	0.8211930	abc
HB11	0.8335440	bc
HB12	0.8311811	c

If two backgrounds share the same letter, then we cannot show them to be statistically significantly different

CORRELATION HEATMAP WITH TRAITS AND NDVI FLIGHT DATES

This type of analysis uses a heatmap to represent the how correlated the variables are with the use of colors.

Figure 4



The maturity and yield has negative correlation, which is not typically seen in wheat varieties.

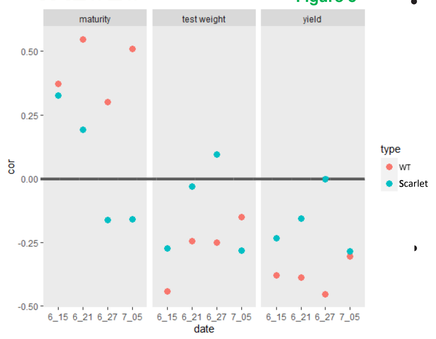
The same is occurring when looking at the yield correlation with the NDVI. At each flight date, there is a negative correlation, when usually the higher NDVI means a greater yield.

- *A control variety matured an average of 2 days earlier & above average yield*

The DJI Inspire 2 drone flying over a spring wheat field at the Spillman site.

QTL PRESENCE IMPACT ON CORRELATION VALUES

Figure 5



- The wildtype's NDVI has a stronger correlation with maturity, test weight, and yield than Scarlet QTL
- Possibly due to variability of Scarlet QTL

CONCLUSION

- We notice that the Scarlet region has the most noticeable impact on HB12, and that HB07's NDVI is most sensitive to changes in weather
- There is a negative correlation when looking at NDVI vs yield, and maturity vs yield (contrary to expectation)
- Variability of the Scarlet impact on different backgrounds leads to a less of correlation on NDVI when compared to the wild types

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FACT: Research Experience for Undergraduates on Phenomics Big Data Management

SOURCES

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[2] Kurz, A.S (2023) Applied longitudinal data analysis in brms and the tidyverse, Bookdown.org/content/4253