Utility of Anthesis-Silk Interval Information to Improve Maize Grain Yield Predictability under Nitrogen Limited Conditions

Dayane C Lima[1], Rachel Perry[1], Natalia de Leon[1] and Shawn Kaeppler[1]
Department of Agronomy, University of Wisconsin - Madison

WISCONSIN
UNIVERSITY OF WISCONSIN-MADISON

Motivation

Lower grain production is expected under nitrogen (N) deficient conditions (Bänziger et al., 2000, Taiz et al., 2015). Yield losses are most pronounced when there is a decline of reproductive success, attribute to a degree to the reduction between anthesis and silking synchrony (Debruin et al., 2018). Therefore, Anthesis-silk interval (ASI - the period between pollen shed and silking) is a good indicator of response to N stress in maize (*Zea mays* L.). The magnitude of ASI variation is higher under low N compared to grain yield, indicating more genetic variance available and higher accuracy under this condition. Consequently, ASI may help predict the response grain yield under low N availability in an indirect genomic prediction. Thus, we evaluated the utility of ASI as an indirect genomic predictor of grain yield. We compared the result with the selection that would be practiced using grain yield in optimal N (direct prediction), low N (indirect prediction), and the harmonic mean of grain yield in the two environments (simultaneously performed under both conditions) as predictors.

Material and Methods

- 410 bi-parental hybrids from 13 populations.
- Field evaluation in optimal and low nitrogen availability in 2018 and 2019.
- Traits:
  - Anthesis: Time in growing degree days (GDD) from planting until 50% of the plot have extruded anthers/shed pollen.
  - Silking: Time (GDD) from planting until 50% of the plot have silks exposed.
  - Anthesis-silk interval: period in GDD between anthesis and silking.
  - Grain yield adjusted to moisture in bu a^{-1}.
  - Harmonic mean of grain yield under optimal and low Nitrogen.
- 4 different scenarios of prediction and 3 responses.

Genotypic Info
- GBS with 2 restrictions enzymes
- SNPs called using GBSv2 Discovery Pipeline in Tassel 5.0
- Quality control
- Total: 20,981 SNPs

Analysis - 2 stages
1- Linear mixed models to calculate BLUEs for the hybrids in each condition, combining both years of evaluation.

2- GBLUP model to predict genomic values.

Cross validation
(to validate the breeding values)

80% TP
20% VP

Predictive ability
Correlation between predicted and observed genotypic values

References.
- Debruin et al. 2018. Silk development and kernel set in maize as related to nitrogen stress. doi: 10.2135/cropsci2018.03.0160
- Bänziger et al. Breeding for Drought and Nitrogen Stress Tolerance in Maize: From Theory to Practice. doi:
- Taiz, L., E. Zeiger, I. Moller, and A. Murphy. 2015. Abiotic Stress - Chapter 24. Plant Physiology and Development. 6th ed. p. 731–760

Results and Conclusions

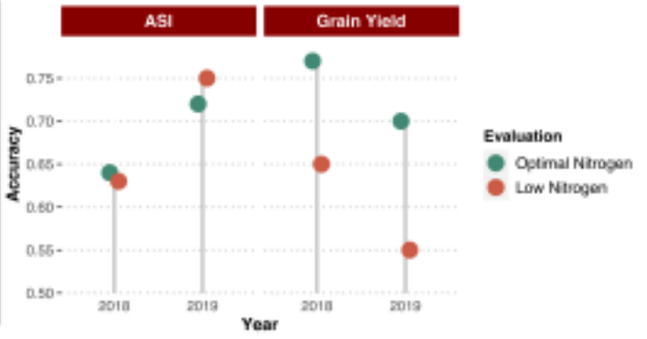

Figure 1. *Accuracy for Anthesis-Silking interval (ASI) in growing degree days, and Grain Yield in bushels per acre evaluations in 2018 and 2019.*

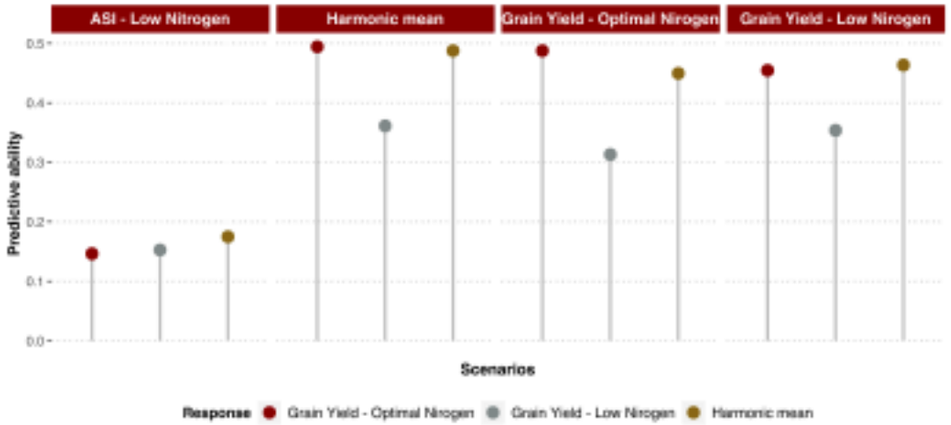

Figure 2. *Predictive ability for grain yield under optimal Nitrogen and low Nitrogen availability, and harmonic mean of grain yield in both conditions using indirect Genomic Prediction. Four different scenarios: Anthesis-Silking interval under low Nitrogen, grain yield under optimal Nitrogen and low Nitrogen availability, and harmonic mean of grain yield in both conditions as predictor. Values are mean and standard error estimated from 100 independent cross-validation.*

- ASI is a good indicator of stress. Limiting N significantly increased ASI, an increase in 53% was observed.
- The predictive ability using ASI was inferior for all responses in the different scenarios. The use of this information to predict grain yield has not been well explored. Adding more years of evaluation will help to understand better the use of this trait in the context of Nitrogen stress.
- The prediction for stress conditions can be practiced in optimal conditions. The similar predictive ability using harmonic mean and the grain yield under optimal nitrogen availability, as predictors, confirms that.

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