Yield Prediction Using High-throughput Phenotyping in Wheat Breeding Nurseries in Bangladesh

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Introduction

- A 2% genetic gain is required to satisfy wheat demand by 2050.
- A primary selection target for wheat improvement is grain yield.
- Selection for yield is limited by cost, land, labor, time, etc.
- Yield can be predicted by secondary traits like vegetation indices like normalized difference vegetation index (NDVI) and canopy temperatures (CT).

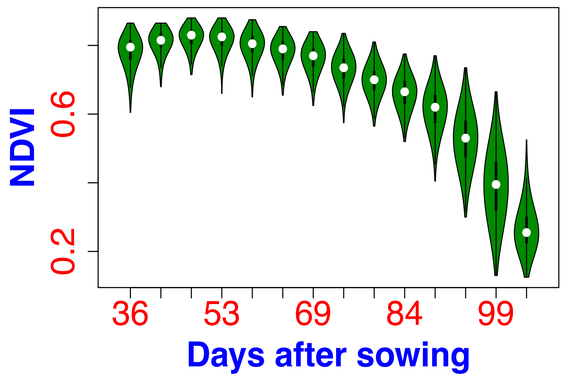

Fig 1: Frequently measured NDVI throughout the growing season 2016-17.

Objective

To monitor plant growth and estimate grain yield using secondary traits like NDVI, and CT, and other agronomic traits.

Materials and Methods

Plant material

A set of 660 spring wheat lines were evaluated in the Regional Agricultural Research Station, Jamalpur, Bangladesh.

Fig 2: Sensors and tools used for data collection

Traits measurement

- We used handheld GreenSeeker, and IRT along with Phenocart as HTP platform.
- We collected NDVI and CT 8-14 times throughout the growing season.
- All other agronomic data were recorded using the electronic field book.

Data Analysis

Data were analyzed using the R program. An 11 fold cross-validation was used for model accuracy.

Results and Discussion

Heritability ranged from 0.20 to 0.93 in different traits. The highest heritability was observed in days to heading in both the years. The heritability for NDVI was more consistent than CT across the years. Grain yield heritability was recorded from 0.2 to 0.79.

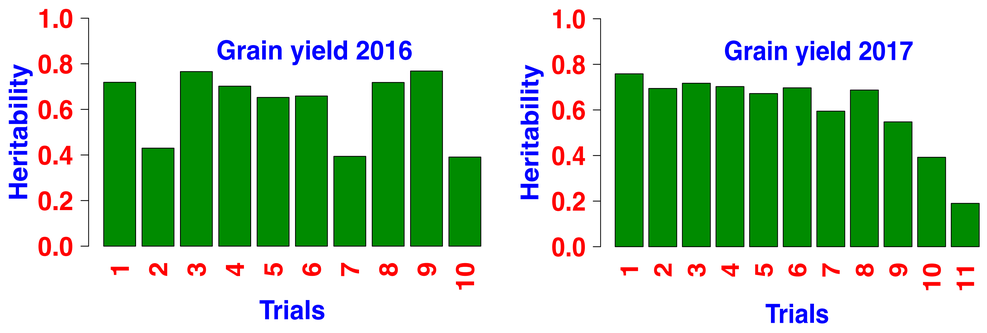

Fig 3: Broad-sense heritability of grain yield in different trials. Left and right panel show heritability from 2015-16 and 2016-17 growing season respectively.

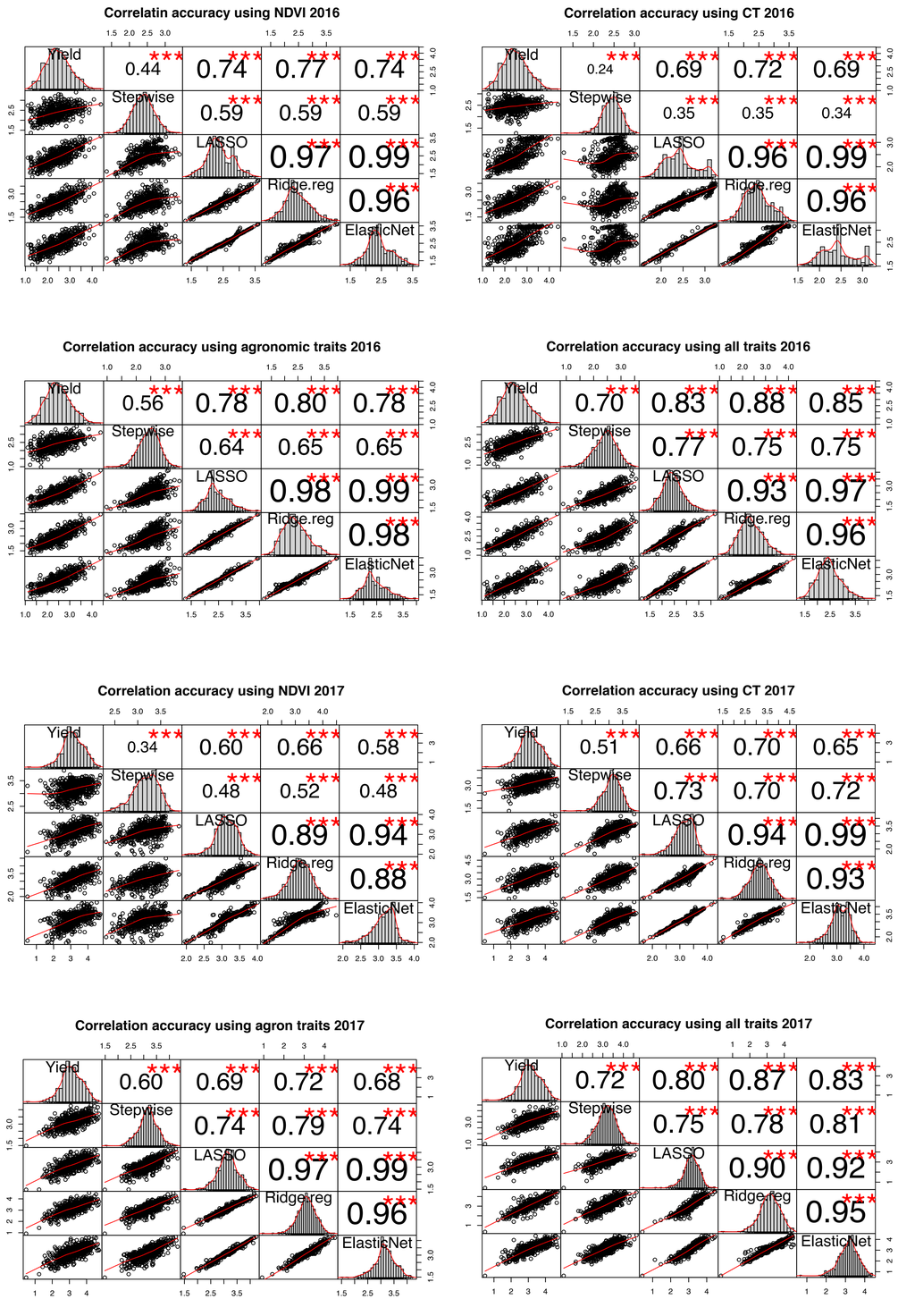

Fig 4: Yield prediction accuracy using secondary traits in 2015-16 and 2016-17 growing season. Stepwise regression, LASSO, Ridge regression and ElasticNet statistical models were compared.

Results and Discussion cont.

Adding more traits increased prediction accuracies across the years. Also, among the statistical models, ridge regression showed the highest prediction power than any other statistical models deployed. Both NDVI and CT together can increase the accuracy up to 0.81. Adding other agronomic traits increased the prediction to 0.88. The results were consistent both the growing seasons.

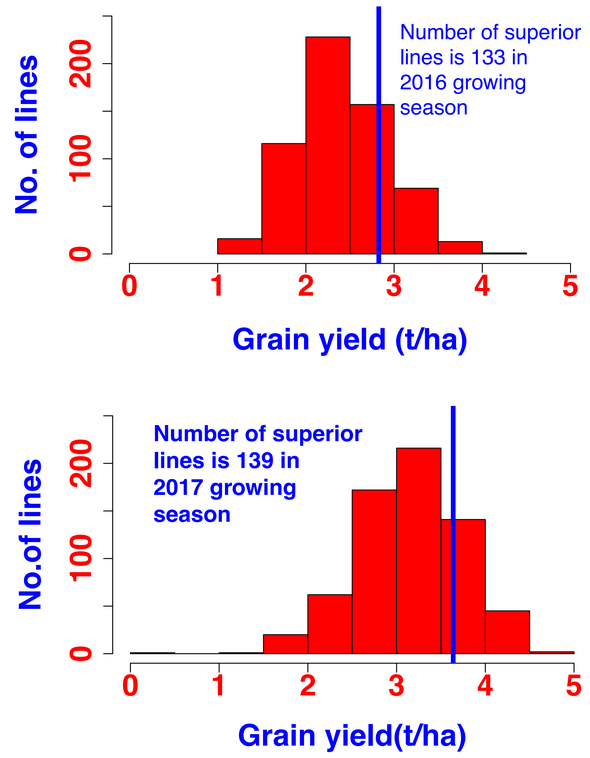

Fig 5: Histogram showing lines outperformed the check varieties (vertical bar).

Conclusion

The statistical models varied in predicting yield. Wheat lines showing superior grain yield than the check were ranked in order. Fifty three of the superior lines were selected and will be tested in 2017-18 growing season. Application of advanced statistical models and incorporating secondary traits can increase grain yield prediction accuracy. Our plan is to introduce precise phenotyping techniques and use genomic selection in the Bangladesh wheat breeding program, with the ultimate goal to accelerate genetics gains and improve wheat production in Bangladesh.

Acknowledgements

Applied Wheat Genomics
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