Leveraging UAV Multispectral Imagery and Machine Learning for High-Throughput Phenotyping in Winter Wheat

Kaden R Spencer[1], Dr. Romulo Pisa Lollato, Dr. Andres Patrignani and Dr. Deepak R Joshi
Department of Agronomy, Kansas State University, Manhattan, KS, US

INTRODUCTION

- Accurate and timely assessment of wheat yield and grain protein content is critical for improving management decisions and optimizing profitability in Kansas wheat (*Triticum aestivum*) production.
- Can Unmanned Aerial Systems (UAS) based remote sensing accurately estimate grain yield and protein content across different cultivars with varying nitrogen (N) rates?

OBJECTIVES

- To assess the application of UAV-based multispectral remote sensing on the in-season crop growth monitoring of winter wheat.
- To develop a machine learning (ML) based workflow to predict wheat yield and grain protein using UAV-derived vegetation indices (VIs).

METHODS

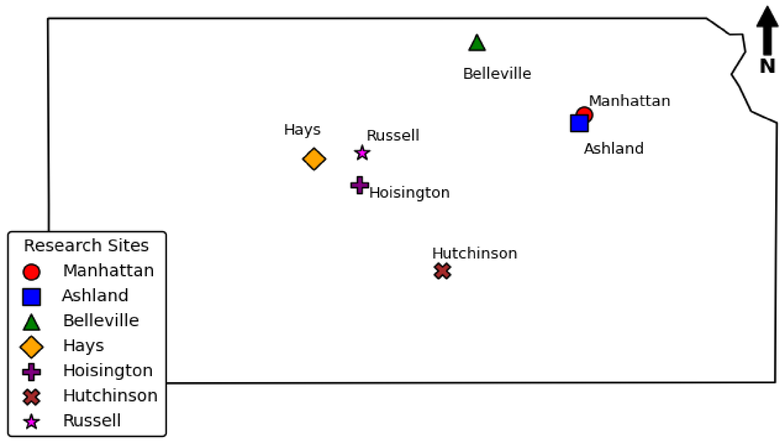

Figure 1. Seven research study sites across Kansas State.

1. Field Experiment

- Seven N Rates
- Eight Cultivars

2. UAV data collection

- Spectral: RGB & Multispectral
- Spatial : 4 cm/pixel
- Temporal: 6 different stages

3. Feature Selection

- Ten Vegetation Indices (VIs)

4. ML model Implementation & Evaluation

- Training : 80% & Test: 20%
- RF, GPM, MLP, PLS
- R-square & MAPE

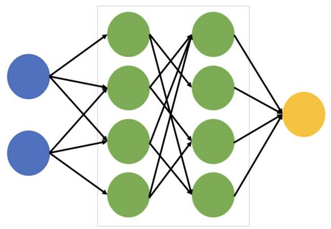

Figure 2. Activities and workflow of the project

RESULTS

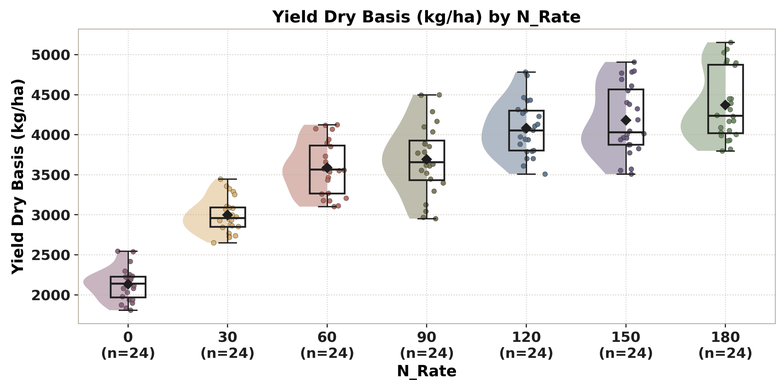

Figure 3. Distribution of wheat grain yield across nitrogen rate treatments.

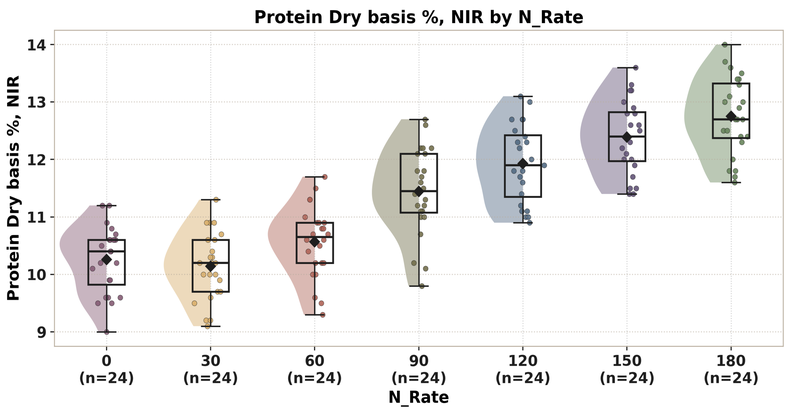

Figure 4. Distribution of wheat grain protein across nitrogen rate treatments.

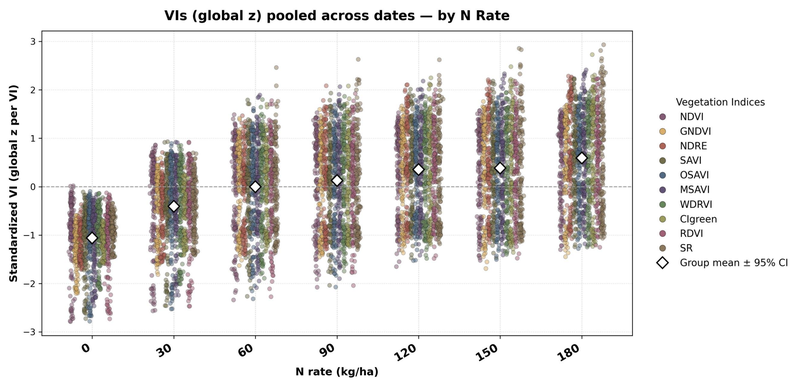

Figure 5. Standardized UAV-derived vegetation indices pooled across six flight dates by nitrogen rate.

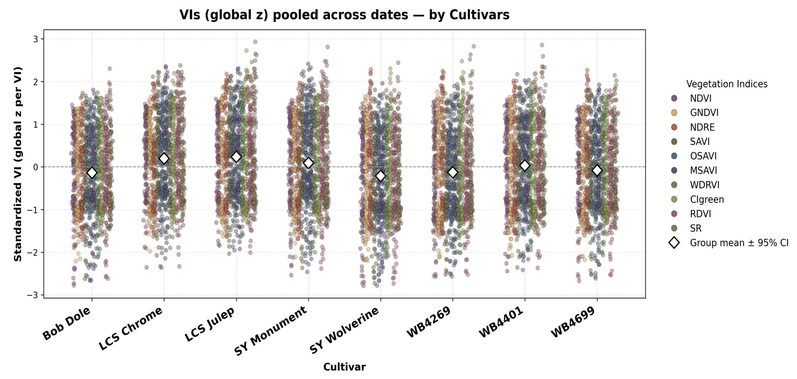

Figure 6. Standardized UAV-derived vegetation indices pooled across six flight dates by cultivar.

RESULTS CONTD.

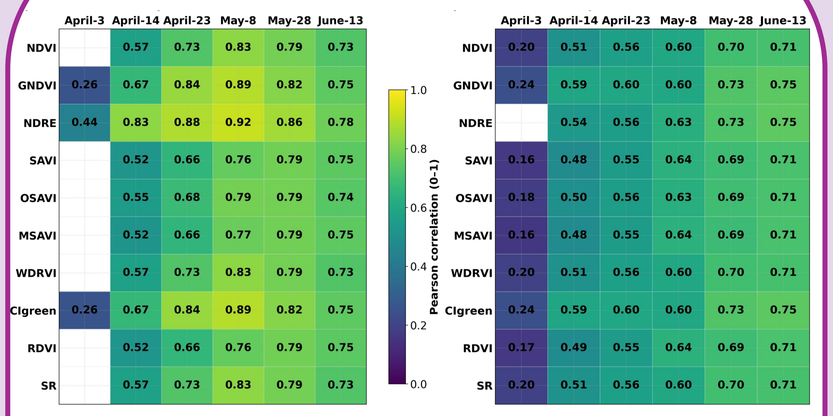

Figure 7. Pearson correlation for VIs at varying dates throughout the season with yield (left) and protein (right).

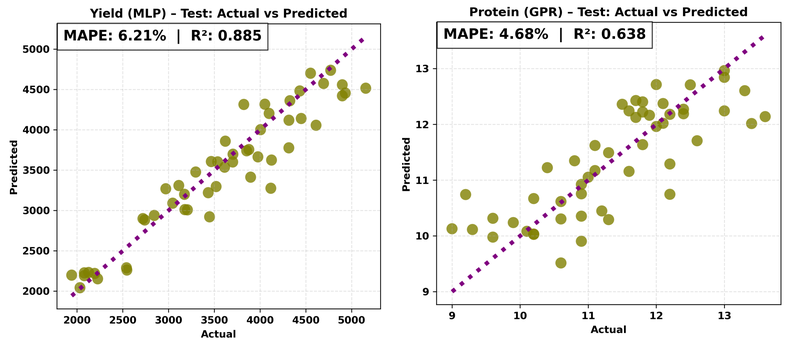

Figure 8. The Multilayer Perceptron model (MLP) achieved the highest accuracy in predicting yield, while the Gaussian Process Regression (GPR) achieved the highest at predicting grain protein content.

DISCUSSION

- Increasing the N application rate resulted in an increase in yield and protein content.
- There is a positive relationship with the UAV-derived VIs and an increase in N rate.
- Correlation between VIs and protein tends to be higher at Feekes 11.2 – 11.4.
- Correlation between VIs and yield tends to be higher at the Feekes 9.

CONCLUSIONS

- MLP model performed best in predicting wheat yield.
- GPR model performed best in predicting wheat protein content.
- There is a positive relationship with the UAV-derived VIs and an increase in N rate.
- Further analysis of the other six locations will be necessary to validate the models.

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