On-Harvester NIRS for Predicting Forage Quality

Micah Robinson, Matthew Digman, Aaron Timm
Department of Biological Systems Engineering, University of Wisconsin–Madison
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Introduction

Near-Infrared Spectroscopy (NIRS) is widely used to measure nutritional properties of dried and ground forage crops in laboratory settings. Recently, smaller NIR sensors have enabled handheld and on-harvester use to predict the moisture content and nutritional composition of forage crops in the field, in real time. However, this convenience comes with some challenges.

Key challenges for on-harvester NIRS

- High moisture content hinders predictions of crop composition
- Sensor exposure to different parts of the plant will result in different readings
- Vibration, heat, dust, residue can impede the sensor
- Must maintain contact between sensor window and crop

This project evaluates on-harvester NIRS for predicting six properties of alfalfa using the default manufacturer calibrations: moisture content (MC), acid-detergent fiber (ADF), neutral-detergent fiber (NDF) , crude protein (CP), crude fat (CF), and ash.

Research Questions

1. How does NIR predictive accuracy compare across mowing, baling, and forage harvesting applications?
2. Which forage crop properties can be reliably predicted using on-harvester NIRS?
3. What are the next steps for advancing the predictive accuracy of on-harvester NIR systems?

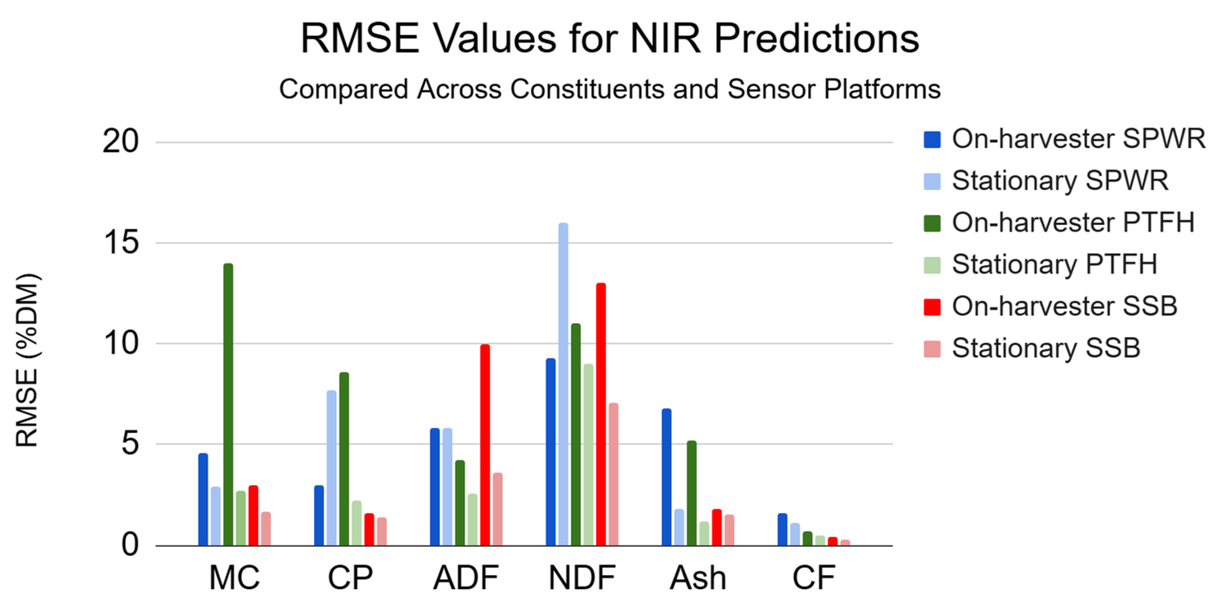
Methods

An EvoNIR 4.0 sensor was used to predict six properties of alfalfa in four configurations: mounted on a self-propelled windrower (SPWR), a pull-type forage harvester (PTFH), a small square baler (SSB), and in a stationary setup for comparison.



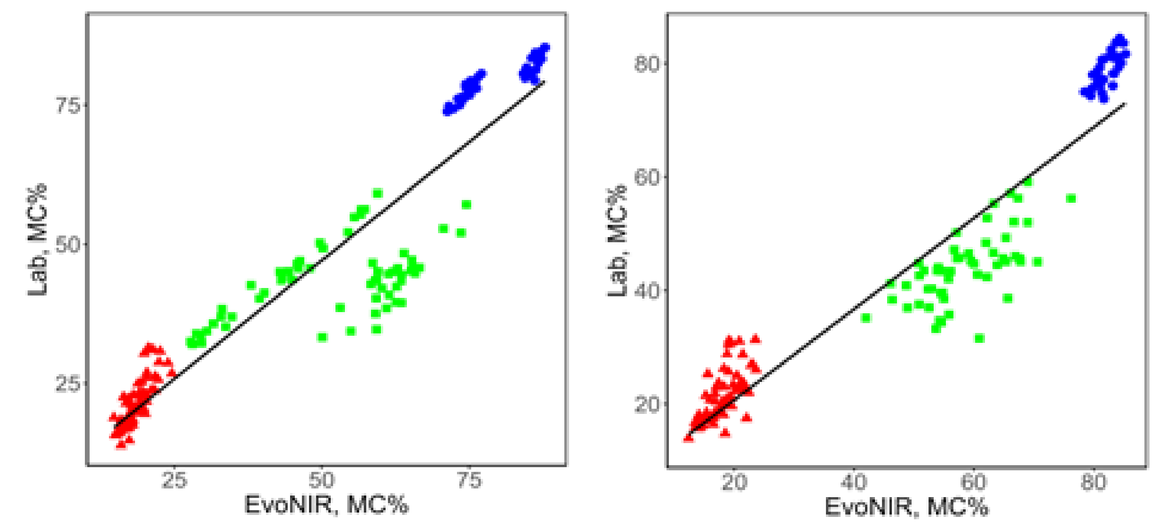

- Field site: Arlington, WI; alfalfa staged into four maturity levels
- Two cuttings in summer 2023, 168 total samples collected
- Each sample scanned on-harvester and with stationary EvoNIR setup
- Samples oven-dried, ground, then analyzed by benchtop NIRS for moisture content and nutritional composition reference data

Results



Performance Metrics for all On-Harvester NIR Predictions

	MC	CP	ADF	NDF	CF	Ash
R^2	0.89	0.14	0.13	0.21	0.46	0.20
RMSEP	10	5.46	8.39	11.79	0.85	4.78
RPD	2.2	0.44	0.42	0.37	0.45	0.27
n	147	147	147	147	147	147



Scatterplots showing NIR predicted moisture content vs reference values for stationary (left) and all on-harvester platforms (right).

Conclusion

1. Sensor integration on the PTFH presented the greatest challenges, with high RMSE values observed for on-harvester predictions compared to stationary configuration. Residue accumulation on the sensor lens likely impacted prediction accuracy. In contrast, the SSB consistently yielded the lowest RMSE values for most constituent predictions.
2. Currently, on-harvester NIRS can effectively support real-time forage crop production decisions by reliably predicting moisture content. However, predictive accuracy for other nutritional constituents requires improvement.
3. Calibration model development, particularly in region-specific models, is essential to improve prediction accuracy. Implementing a system to monitor model suitability to crops, possibly through a distance metric, would increase transparency in prediction accuracy and assist continued calibration development.

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Biological Systems Engineering
COLLEGE OF AGRICULTURAL & LIFE SCIENCES
UNIVERSITY OF WISCONSIN–MADISON