Regional Corn Nitrogen Recommendation Models for Predicting EONR Are Improved Using Hydrologic Classification

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Introduction

Nitrogen (N) fertilizer recommendations that match corn (*Zea mays* L.) N need maximize grower profits and minimize environmental consequences. However, spatial and temporal variability make determining future N requirements difficult. Studies have shown no single active-optical reflectance, soil, or weather measurement is consistently accurate, especially when used on a regional scale, in predicting the economic optimal N rate (EONR). Grouping sites based on soil hydrological properties could help account for soil and weather variability and match in-season corn N need.

Objective

Derive an empirically based N fertilizer recommendation algorithm using active-optical reflectance, soil, and weather information collected on a regional scale.

Materials and Methods

- **Eight Midwestern states (Fig. 1) and 49 sites (2014 - 2016).**
- **Sites were separated into five groups based on USDA NRCS hydrologic group designation and drainage class.**
- **Canopy sensor measurements were taken at V9 with Holland Scientific's RapidSCAN (Fig. 2).**
- **Reflectance measurements were used to calculate the inverse simple ratio sufficiency index with red-edge.**
- **Profile soil samples were collected and characterized.**
- **SSURGO soil information was obtained from USDA NRCS.**
- **Soil variables measured and obtained from SSURGO include clay, om, plant available water content, total organic carbon, and pre-plant and pre-sidedress soil nitrate.**
- **Soil variables were analyzed at depths 0-30 and 0-60 cm.**
- **Weather variables analyzed included latitude, growing degree days, total precipitation, Shannon Diversity Index, and Abundant and Well Distributed Rainfall. Measurements used were from the time of planting to sidedress.**
- **Site-level EONR was determined with a quadratic-plateau regression and using $4.00/bu corn and $0.40/lb N.**
- **Soil and weather variables were regressed against EONR with single and two-way interactions.**
- **Cross validation analysis was performed to determine if one site was erroneously influencing the model.**
- **Selected parameters were used to develop the N fertilizer recommendation model.**

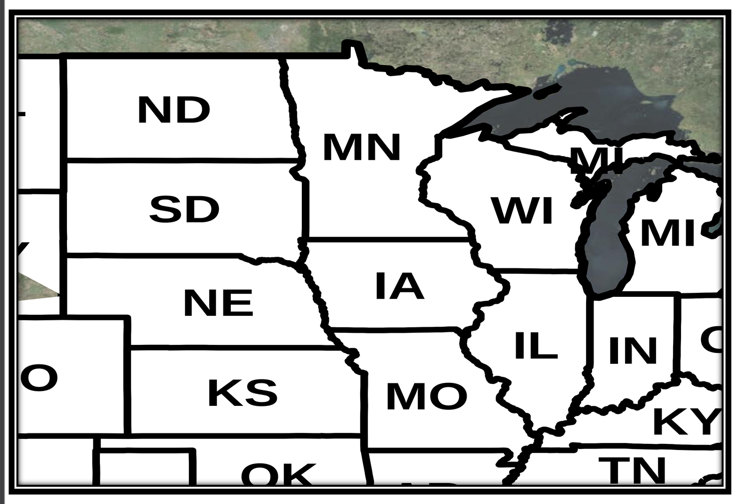

Fig. 1. State locations.

Fig. 2. Canopy Sensing at V9.

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Results

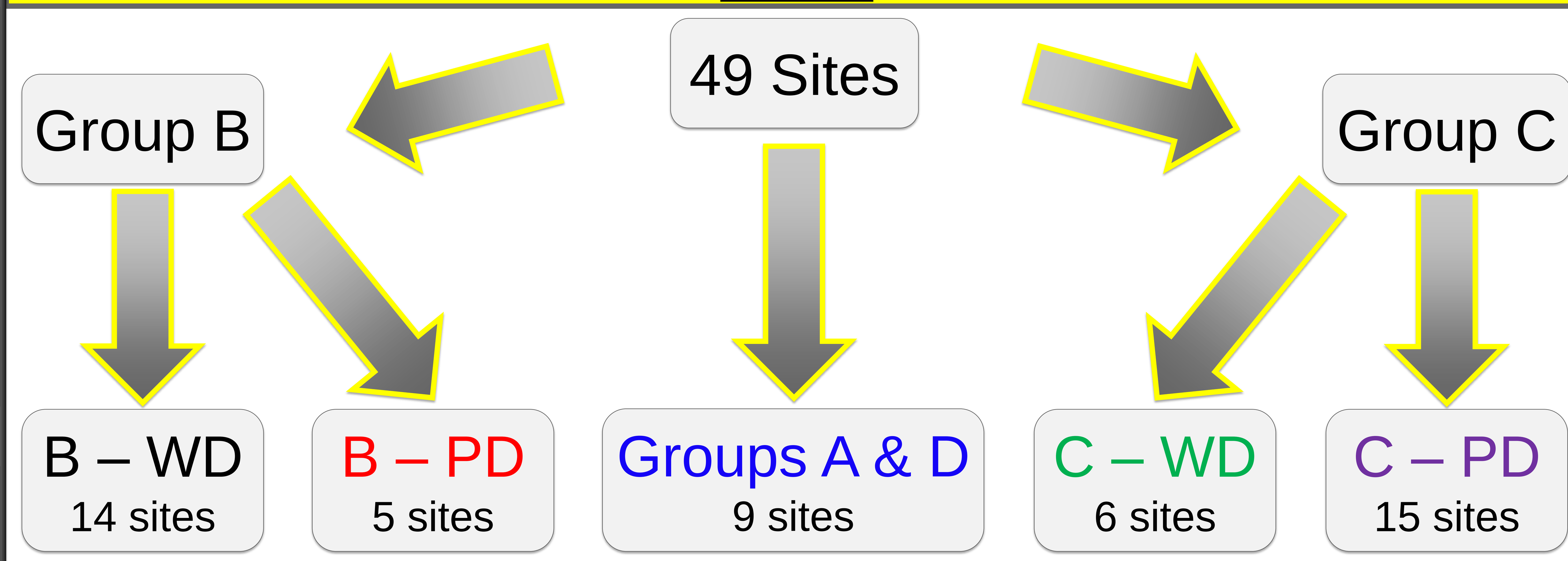

Fig. 3. Separation of sites based on both hydrologic group and drainage class. Groups A and D represent soils with a high probability of water loss (Group A = excessively drained, >90% sand; Group D = water transmission through soil is highly restricted, >40% clay). Group B represents sites that have moderately low runoff potential with 10-20% clay and 50-90% sand. Sites within group C are those with moderately high runoff potential with 20-40% clay and <50% sand. WD = well drained and PD = poorly drained sites within their designated hydrologic groups.

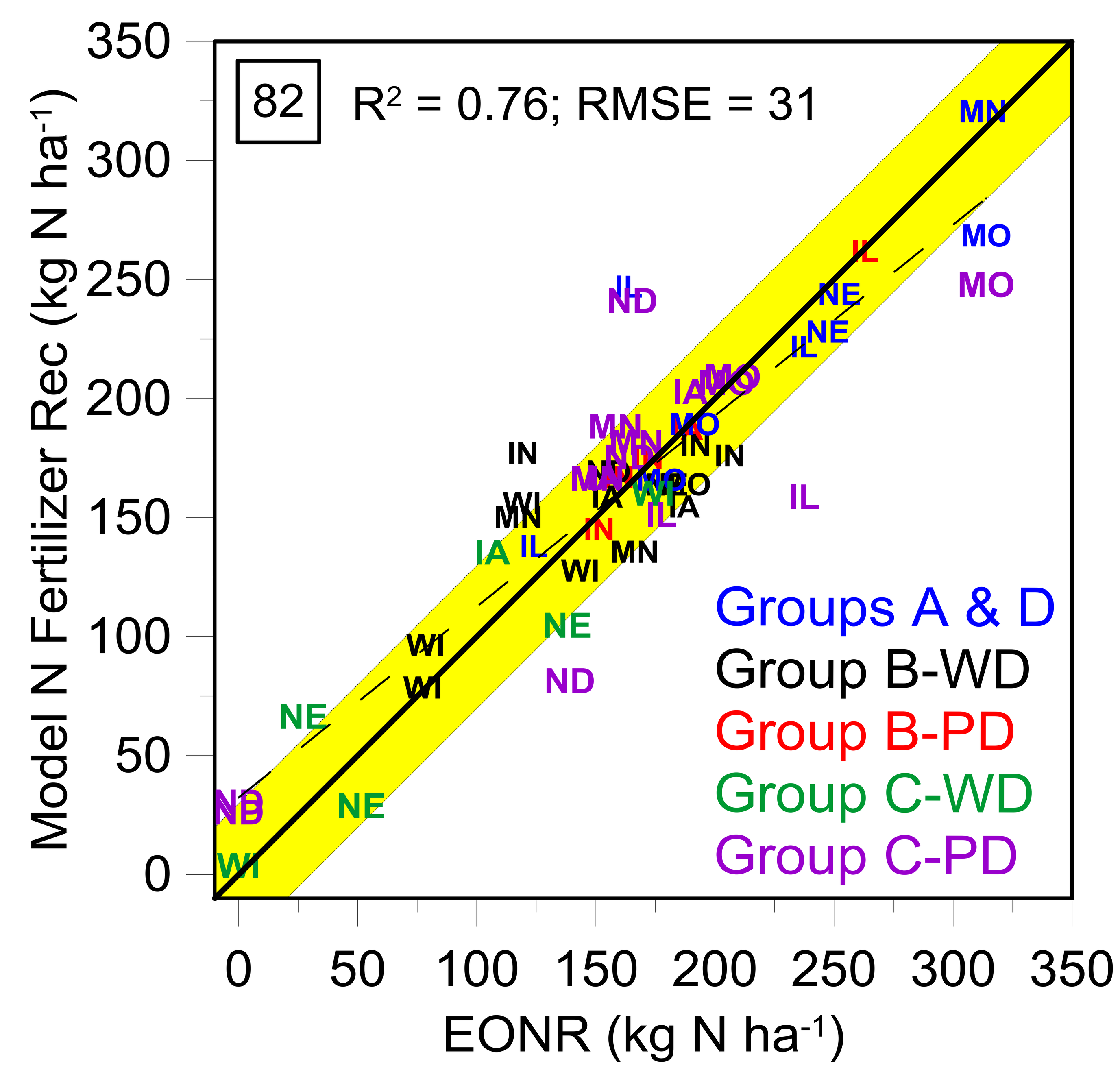

Fig. 4. Model N fertilizer recommendations compared to end-of-season calculated EONR. The performance was measured with root-mean-square-error (RMSE) and the percentage of sites within 34 kg of N/ha of EONR (sites within the yellow shaded areas with the percentage in the white box in the top left corner of the graph). Ideally, all sites would have fallen on the 1:1 line suggesting the model perfectly predicted EONR. While there were some sites that EONR was either under or over-predicted for, the model generally did well in estimating EONR (RMSE = 31; 82% of sites within 34 kg N/ha of EONR).

Table 1. Regression equations and number of sites for each group. Slope values closer to one and intercept values approaching zero represent better EONR estimating capability.

Group	# of sites	Regression Equation
A & D	9	y = 0.71x + 66
B-WD	14	y = 0.53x + 70
B-PD	5	y = 0.99x + 2
C-WD	6	y = 0.82x + 15
C-PD	15	y = 0.73x + 44

Table 2. The most significant active-optical reflectance, soil, and or weather variable as determined by linear regression for each respective group. Greater R^2, and smaller RMSE and *p*-values represent better performance. Lat = latitude, SDI = the Shannon Diversity Index, TOC = total organic carbon, PAWC = plant available water content, PPNT = pre-plant soil nitrate, and Refl = the inverse simple ratio using the red-edge waveband.

Group	X-Variable	*p*-value	R^2	RMSE kg/ha
A & D	Lat × SDI	0.005	0.66	34
B-WD	TOC × PAWC	0.003	0.49	26
B-PD	PPNT × PAWC	0.0006	0.98	5.2
C-WD	SDI × Clay	0.014	0.77	29
C-PD	Lat × Refl	0.0001	0.71	38

Conclusions

- **Across states and years, the N recommendations from the models did well in estimating the actual EONR, suggesting that soil hydrological properties can assist in determining which soil and weather interaction will affect EONR the most. The RMSE of estimating EONR was 31 kg N ha^{-1} (Fig. 4).**
- **This approach could be used to determine when to use active-optical reflectance sensors to assist in recommending N fertilizer. Combined with latitude, reflectance measurements were found most significant in predicting EONR on 31% of the sites (Group C-PD, 15 sites).**

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