Fusing Corn Nitrogen Recommendation Tools for an Improved Canopy Reflectance Sensor Performance

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Background

Canopy reflectance sensors are capable of capturing within-field variability. However, algorithms used to calculate nitrogen (N) recommendations may not always be as accurate at predicting corn N needs compared to other N recommendation methods. Therefore, integrating other nitrogen recommendation tools with the canopy reflectance sensor algorithm may improve the accuracy of canopy reflectance sensors.

Objectives

1. Identify which corn N recommendation tool most accurately predicted corn N need.
2. Assess how using the best performing N recommendation tool from the first objective could improve the Holland and Schepers (HS) crop canopy algorithm's N recommendation.
3. Determine if using soil or weather information could be used to adjust the management zone scaler (MZi) in the HS algorithm.

Methods

- Nitrogen plot trials conducted on 49 sites across the US Midwest from 2014 to 2016 (Fig. 1).
- Each site followed an RCBD with four replications.
- Eight N rates applied at-planting (0-315 kg N ha^{-1}).
- Eight N rates split applied at V9 (0-315 kg N ha^{-1}).
- EONR was calculated using a quadratic-plateau for each site using a 5.5:1 N to corn price ratio.
- N recommendation tools evaluated:
  - -**Farmer's N rate**
  - -**Generic Yield Goal** (YG) calculation; (1.2 lbs N bu^{-1} *YG –40 lbs N soybean credit)
  - - **'State' YG** each state's YG calculation used across all sites
  - -**State-Specific YG** each state used their own YG calculation
  - -**MRTN** (Maximum Return to Nitrogen)
  - -**Preplant Soil Nitrogen Test** (PPNT) as recommended by respective state's University
  - -**Maize-N** a crop growth model
  - -**Presidedress soil nitrogen test** (PSNT) from Iowa, Indiana, and Wisconsin
  - -**Canopy sensor** using the HS algorithm with the farmer's N rate as N_{opt}
- Residuals (Tool N recommendation - EONR) were used to calculate the RMSE and mean difference for each tool (Table 1).
- HS algorithm was modified by replacing N_{opt} with better performing N recommendations (Eq. 1).
- The management zone scaler was estimated using a random forest model using measured soil and weather information (Eq. 1).

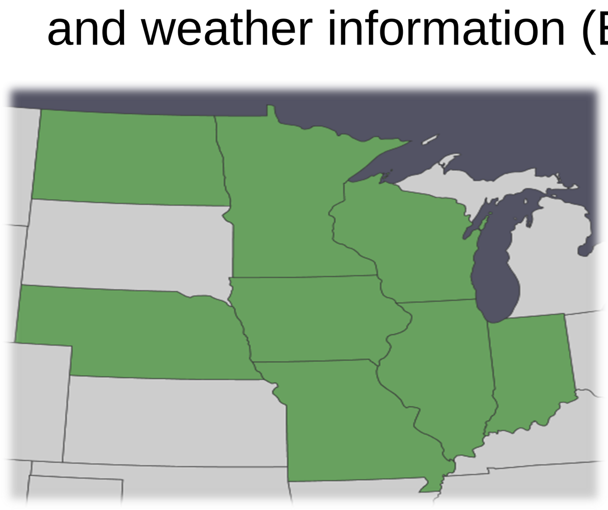

Fig. 1: Map of study locations.

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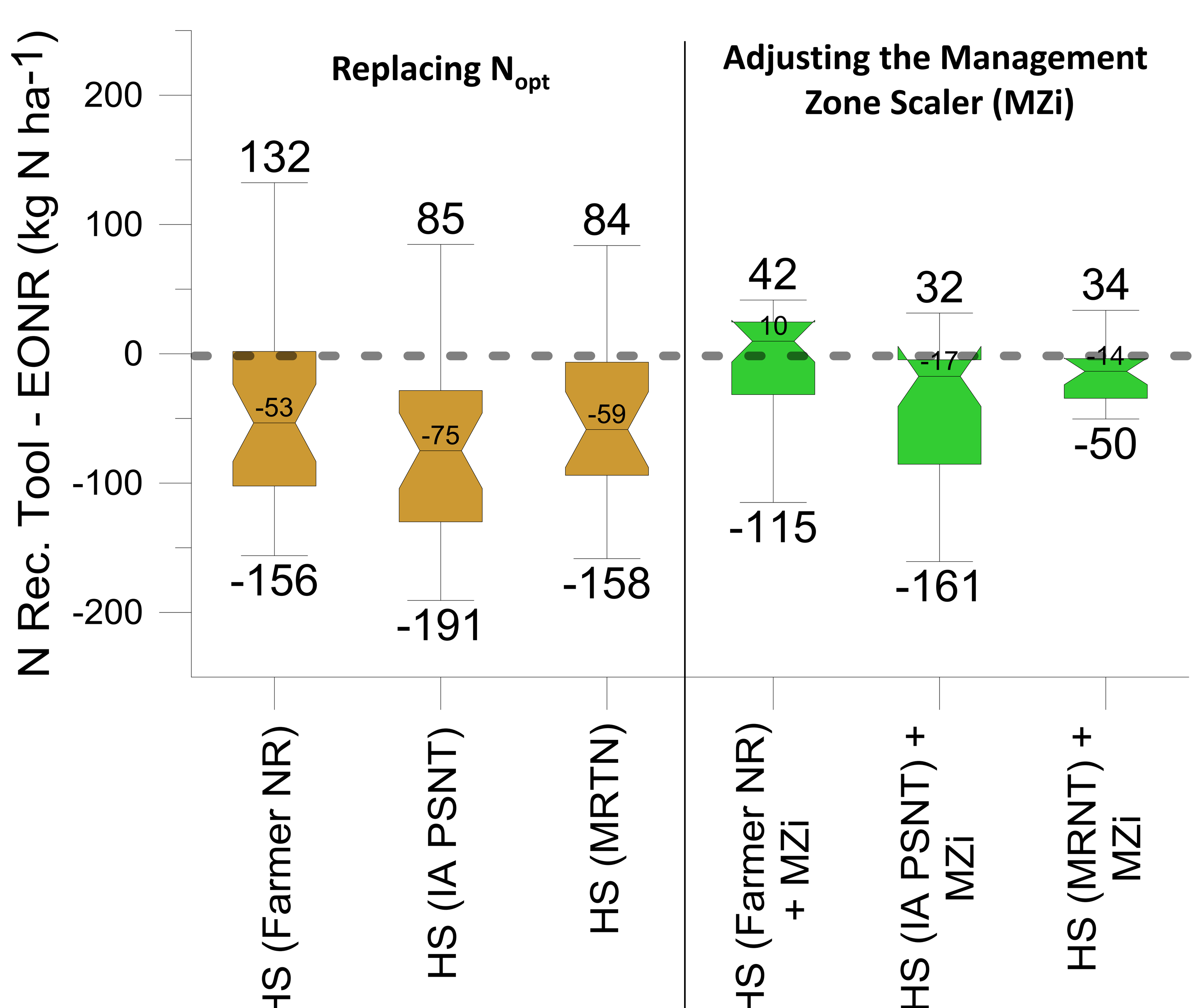
$$N_{Rec} = \left(MZ_i * N_{Opt} - N_{PreFert} - N_{CRD}\right) * \sqrt{\frac{(1-SI)}{\Delta SI}} \quad [1]$$

Management zone scaler — Optimal N rate — Reflectance information

Eq. 1: The Holland and Schepers canopy reflectance algorithm requires several farmer inputs. The optimal N rate (N_{opt}) and management zone scaler (Mz_i) provide flexibility for this algorithm to function on a regional scale under varying soil and weather conditions. Other inputs include previous fertilizer applications ($N_{PreFert}$) and N credits (N_{CRD}).

Table 1: The performance of 18 N recommendation tools used either at planting and/or split applied. Sites close to EONR (% of sites within 30 kg N ha^{-1} of EONR).

N Recommendation Tool	n	Planting Mean	Planting RMSE	Planting Sites close to EONR	Split Mean	Split RMSE	Split Sites close to EONR
		-- kg N ha^{-1} --		%	--kg N ha^{-1} --		%
Farmer NR	49	27	88	31	34	84	33
General YG	49	58	117	14	65	113	18
IN YG	49	73	127	14	80	125	14
MN YG	49	-6	90	24	2	81	41
MO YG	49	65	120	16	72	117	20
NE YG	49	-12	86	35	-27	81	37
State-Specific YG	43	21	84	23	23	74	37
General PPNT	47	-43	88	19	-	-	-
MN PPNT	47	-28	82	26	-	-	-
ND PPNT	47	7	93	13	-	-	-
WI PPNT	47	-8	73	32	-	-	-
MRTN	36	12	79	36	16	74	36
Maize-N	49	-44	116	18	-31	112	24
General PSNT	49	-	-	-	-7	72	39
IA PSNT	49	-	-	-	-25	68	41
IN PSNT	49	-	-	-	40	83	24
WI PSNT	49	-	-	-	-7	75	37
Canopy Reflectance	49	-	-	-	-48	84	29



	HS (Farmer NR)	HS (IA PSNT)	HS (MRTN)	HS (Farmer NR) + MZi	HS (IA PSNT) + MZi	HS (MRNT) + MZi
Mean Diff.	-48	-71	-54	-7	-39	-23
RMSE	84	95	85	45	62	50
Sites Close to EONR (%)	29	22	36	53	51	53

Fig. 2: Box and whisker plots evaluating the performance of canopy reflectance sensor when the farmer's N rate (N_{opt}) in the HS algorithm was replaced with the N recommendations of other N recommendation tools with and without using the management zone scaler (MZ_i).

Results

Tool Performance (Obj. 1)

- Tools used for split applications, in general, better matched EONR than at-planting tools.
- The canopy sensor underestimated EONR by 48 kg N ha^{-1}, possible due to minimal N stress at the time of sensing (Table 1).
- Many of the tools were better estimators of EONR than the HS algorithm using the farmer's N rate as N_{opt} (Table 1).

HS Algorithm Improvement (Obj. 2 & 3)

- Using better performing tools (IA PSNT and MRTN) as the N_{opt} did not improve the performance of the HS algorithm (Fig. 2).
- Replacing N_{opt} with a tool that underestimates EONR (IA PSNT) decreased performance compared to the Farmer's NR.
- The most improvement occurred when adjusting the MZi.
- The MZi was best estimated using the measured evenness of rainfall between planting and the time of sensing, soil pH, soil texture, and bulk density (0-30 cm).

Conclusions

- Adjusting the MZi in the HS algorithm outperforms all other field-based tools.
- The MZi factor could be adjusted within a field based on within-field soil and weather variability or management zones, allowing for a more accurate variable rate applications.
- Further improvements to the HS algorithm could be made by 1) including management factors (i.e. tillage, tile drainage, cover crop) in the MZi adjustments or 2) adjusting the "cut of" value (ΔSI; Eq. 1) of the HS algorithm.

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