Performance Evaluation of Conventional and Model-based Irrigation and Nitrogen scheduling tools in Farmer's Fields

Anthony A. Amori, Haishun Yang

Department of Agronomy and Horticulture, University of Nebraska–Lincoln, Lincoln, Nebraska

2022 NITROGEN USE EFFICIENCY WORKSHOP

August 1-3

University of Nebraska-Lincoln

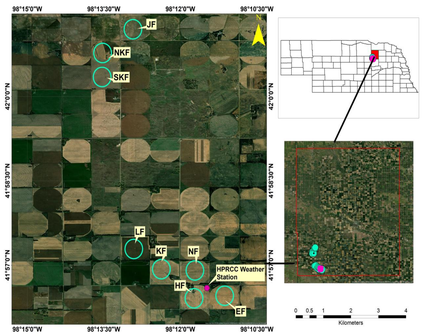
INTRODUCTION

- Excessive irrigation and nitrogen fertilizer (NF) applications are currently major environmental problems of surface and ground water bodies.
- Crop simulation models have the potentials to reduce the amount of irrigation water and NF applied with improved grain yield while protecting the environmental quality if properly used.
- Hence, there is the need to evaluate the effectiveness of the Hybrid-Maize model in improving irrigation water and nitrogen use efficiency for the possible inclusion of the models in grower's field management/decision toolbox.

OBJECTIVES

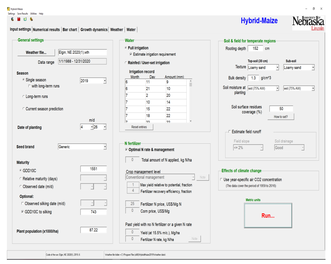
- To evaluate the current farmer's and optimal irrigation water management practices using Hybrid-Maize model
- To evaluate the current farmer's NF management practices and model-based NF recommendation tool using Maize-N model.

Figure 1: Map of fields in Elgin, northeastern Nebraska, consisting of eight privately owned fields.

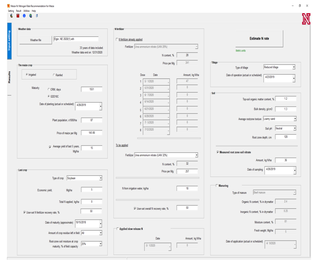


MATERIALS AND METHODS

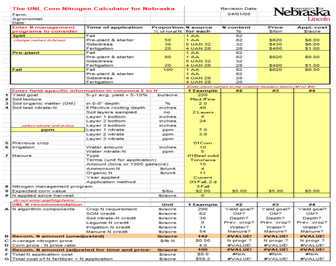
Hybrid-maize model



Maize-N model



UNL Maize N algorithm

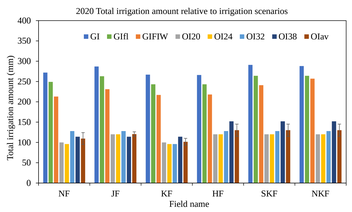


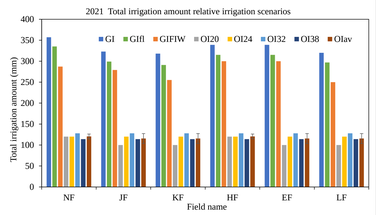
Procedures

- Six fields in each of the growing seasons of 2019, 2020 and 2021 were used in this experiment.
- Three farmer's irrigation management (GI, GI_{FL}, and GI_{FIW}) and four model-based irrigation (OI_{20}, OI_{24}, OI_{32}, and OI_{38}) scenarios were compared and evaluated by running the calibrated Hybrid-Maize model during 2020 and 2021 growing seasons.
- Grower's Irrigation (GI), Grower's Irrigation with the exclusion of the first and last irrigation events (GI_{FL}) and fertigation irrigation water (GI_{FIW}), and various maximum amount of irrigation (OI_{20}, OI_{24}, OI_{32}, and OI_{38}) that can be applied per irrigation event for the automated irrigation option.
- To fertilization approaches were compared (actual vs Maize-N model) during 2019, 2020, and 2021 growing seasons.
- Models' inputs were collected from farmer's records, excluding weather data.

RESULTS AND DISCUSSION

- On average, grower's applied 279 and 333 mm of irrigation across all fields during 2020 and 2021 growing seasons, respectively.
- The model recommended a total average of 123 and 117 mm irrigation water.
- Model–based scenarios OI_{24} and OI_{20} using the automated irrigation option had lowest average irrigation amount in 2020 and 2021 growing seasons, while maintaining the same grain yield across all the fields.
- The higher the maximum irrigation amount in the model setting, the lower the number of irrigation events.





- Actual grower's irrigation management practice had the lowest IWUE, while model-based scenario OI_{20} had the highest IWUE for the two growing seasons.

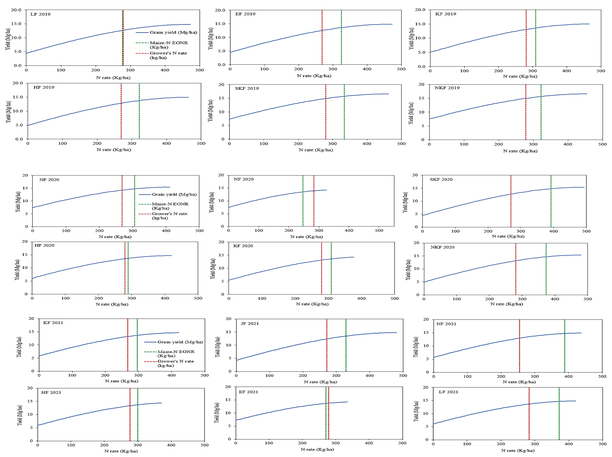
Table 1: Irrigation water use efficiency relative to irrigation scenarios for 2020 and 2021 growing seasons

2020 IWUE (kg ha $^{-1}$mm $^{-1}$)						
	Field Name					
	NF	JF	KF	HF	SKF	NKF
GI	13	14	10	15	17	17
GI_{fl}	14	15	11	16	19	19
GI_{fiw}	16	17	12	18	20	19
OI_{20}	34	33	27	33	41	41
OI_{24}	35	33	28	33	41	41
OI_{32}	27	31	28	31	38	38
OI_{38}	30	34	24	26	32	32

2021 IWUE (kg ha $^{-1}$mm $^{-1}$)						
	Field Name					
	NF	JF	KF	HF	EF	LE
GI	17	18	18	20	17	18
GI_{fl}	18	19	20	21	18	19
GI_{fiw}	21	20	22	22	19	23
OI_{20}	51	57	57	55	57	57
OI_{24}	51	48	48	55	48	48
OI_{32}	48	45	45	52	45	45
OI_{38}	54	50	50	58	50	50

- 2019 average observed yield of 14.1 ± 1.2 Mg/ha correspond to grower's average EONR of 276 ± 5.9 kg/ha and Maize-N average EONR of 315 ± 20 kg/ha
- 2020 average observed yield of 14.1 ± 0.8 Mg/ha correspond to grower's average EONR of 276 ± 6.2 kg/ha and Maize-N average EONR of 319 ± 54 kg/ha
- 2021 average observed grain yield of 13.9 +- 0.6 Mg/ha correspond to grower's average EONR of 271 ± 9.7 kg/ha and Maize-N average EONR of 325 ± 46 kg/ha
- For overall average observed grain yield of 14.0 ± 0.9 Mg/ha correspond to grower's overall average EONR of 274 ± 7.5 kg/ha and Maize-N average EONR of 319 ± 40 kg/ha.

Figure 3. Yield response to NF approach.



- Average PFP for Maize-N recommended and grower's applied fertilization was 44.8 kg/kg N and 51 kg/kg N.
- Grower's PFP consistently higher than Maize-N PFP across all fields and years, except for LF, JF, and EF in 2019, 2020, and 2021 growing seasons, respectively.

Figure 4. 2019 Partial Factor Productivity (PFP) relative to fertilization approach

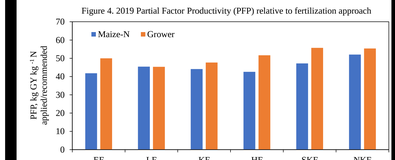


Figure 5. 2020 Partial Factor Productivity (PFP) relative to fertilization approach

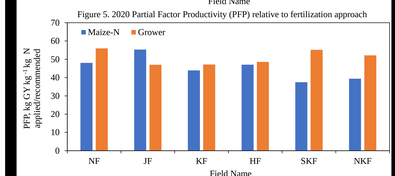
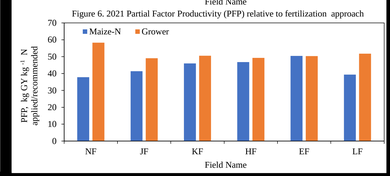


Figure 6. 2021 Partial Factor Productivity (PFP) relative to fertilization approach



- Average AE for maize-N recommended and grower's applied fertilization was 26 kg/kg N and 30 kg/kg N.
- Grower's AE is consistently higher than Maize-N AE across all fields and years, except for LF and JF in 2019 and 2029 growing seasons.

Figure 7. 2019 Agronomy Efficiency (AE) relative to fertilization approach

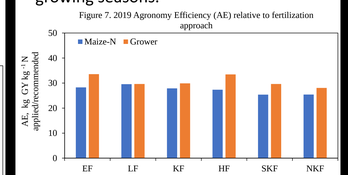


Figure 8. 2020 Agronomy Efficiency (AE) relative to fertilization approach

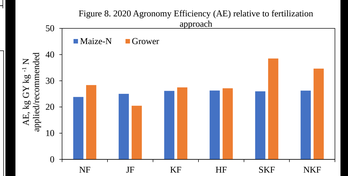
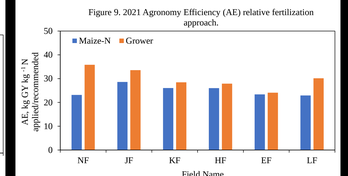


Figure 9. 2021 Agronomy Efficiency (AE) relative fertilization approach.



CONCLUSIONS

- Averaging across fields in each growing season, 24 mm and 20 mm maximum irrigation amount scenarios for the automated irrigation option had the lowest recommended irrigation water in 2020 and 2021, respectively, while maintaining the highest average irrigation water use efficiency (kg/ha mm) in each of the growing season.
- For the nitrogen fertilizer scenarios, results showed that both partial factor productivity (kg/kg N) and agronomy efficiency (kg/kg N) for grower's applied nitrogen fertilizer were consistently higher than the recommended dose of NF by Maize-N tool for all fields across the three growing seasons.
- These findings demonstrated that growers cannot adopt the current version of Maize-N program considering the high propensity of over-estimation of NF and suggested further structural modification to improve the current Maize-N program in terms of its potential to recommended N fertilizer within reasonable range that would lead to a significant decrease in N fertilizer leaching.

ACKNOWLEDGEMENTS

- Funding for this research was provided by National Science Foundation (NSF) under the project number 1739705 and graduate student support was provided by Daugherty Water for Food Global Institute.

The University of Nebraska does not discriminate based upon any protected status. Please see go.unl.edu/nondiscrimination. ©2020. PL2022.