# Predicting Corn Yield Based on Soil Nitrogen Supply

K-STATE Research and Extension

Department of Agronomy | MF3572 | Crop Production

## Nitrogen Problem in Corn

Addressing the uncertainty of nitrogen needs for corn (*Zea mays* L.) is a major concern for researchers, agricultural industries, and farmers. The importance of improving the understanding of the potential corn yield without nitrogen fertilization is related to the possibility of refining the selection of the optimal nitrogen fertilizer rate. For example, the yield without nitrogen fertilization reflects inherent soil productivity. Defining realistic expectations for optimum fertilizer nitrogen rates inevitably relies on more accurate predictions and understanding corn yield without nitrogen. Predicting yield without nitrogen fertilization is a difficult problem to solve due to the complex soil-plant-environment interactions governing nitrogen dynamics.

## Exploring Data for Finding a Solution

Following this rationale, the combination of mechanistic models for predicting non-nitrogen-limited yield and data-driven machine learning models for predicting yield without nitrogen fertilization could create opportunities to increase the predictability of complex systems. The integration of multiple studies expanding combinations of soil, crop management, and weather scenarios might lead to the use of yield prediction models with more focus on forecasting the nitrogen needs rather than an ex-post analysis. The main goal of this work was to use a large database (n=1,031) of corn fertilization studies performed in the United States and Canada (1999-2019) (Figure 1A) to develop a prediction model for corn yield without nitrogen fertilization, while ranking and identifying key soil, management, and weather features, and testing prediction performance varying the inclusion of seasonal weather : i) no-weather, ii) spring-weather (March-May), iii) full-weather (April-September).

## Main Key Takeaways

- Prediction errors ranged about 32 bushels per acre, which represents moderate performance and uncertainty. Contemplating the range of the nitrogen requirement to produce 1 bushel of grain yield per acre (Figure 1B), those values can be translated into an uncertainty on the prediction of soil nitrogen supply to corn from 20 to 40 pounds of nitrogen per acre.
- A large fraction of the variability on the corn yield without nitrogen fertilization (~50%) was explained by crop management and soil factors (Figure 2A), whereas weather contributed to improving the overall performance (+15%).
- Across all models, positive influence of legume residues into crop rotations and irrigation is clearly highlighted among the management factors (Figure 2B).
- Soil organic matter ranked as the most important soil variable (Figure 2B), and precipitation and mean temperature during April-May ranked as the most important weather variables.
- The proposed model for the yield without nitrogen fertilization presents implications for its use as a proxy of indigenous soil nitrogen supply. Available data on plant nitrogen uptake at crop maturity on this database indicates that a corn crop will need between 0.7 to 1.2 pounds of nitrogen per bushel of yield (Figure 1B).

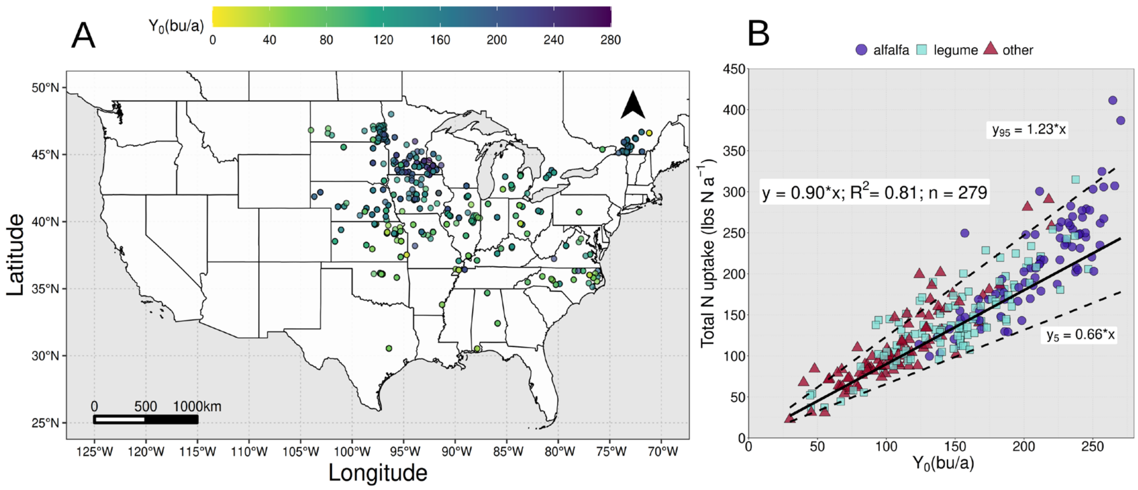


**Figure 1A.** *Geographical distribution of corn nitrogen (N) fertilization trials under study (1031 $Y_0$ observations from 679 site-years).* **B**: *Relationship between total above-ground nitrogen uptake at crop maturity (R6, n = 279) and yield without nitrogen fertilizer ($Y_0$).*

- It is noteworthy that collecting field data on initial soil characteristics and obtaining precise spring weather data for building a simple prediction of the yield level of corn without nitrogen fertilization would be fairly scalable.
- In combination with crop simulation models, the proposed data science approach (machine learning algorithm) could be used to improve decision making in nitrogen fertilization.
- Further efforts should recognize the value of combining collaborative research with increasing computational resources, data sources, and type of models.

## Summary

This collaborative work represents a step toward more forecast-based agronomic guidelines for nitrogen recommendations in corn. Previous crop and irrigation, in combination with topsoil organic matter accounted for the largest portion of variation in corn yield without nitrogen fertilization. A simple framework considering weather variables of spring (March-May) might result in comparable performance.

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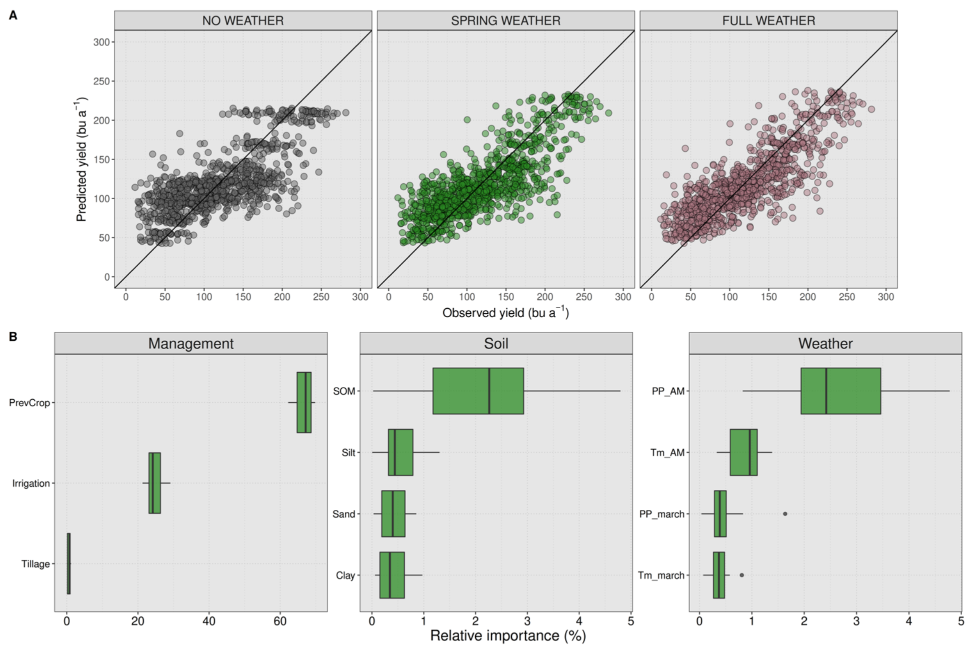


**Figure 2A.** *Prediction performance of three alternative models: NW – No weather; Spring weather – (March to May); and Full weather – (April-September).* **2B.** *Relative importance of explanatory management (PrevCrop = Previous Crop), soil (SOM = Soil Organic Matter), and weather (PP_AM = Precipitation April-May; Tm_AM = Temperature April-May) variables all considering the Spring Weather model.*

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