The Data-Intensive Farm Management program

An On-Farm Research Program for Growers

University of Illinois Urbana-Champaign

Data Intensive Farm Management Program (DIFM)

An On-Farm Research Program for Growers

What is DIFM?

DIFM (Data-Intensive Farm Management Program) uses precision agriculture technology, with researchers and farmers working together conducting large-scale, on-farm “checkerboard” field trials, gathering vast amounts of data on how crop yields respond to input application rates, field characteristics, and weather. DIFM is funded by a grant from the USDA Natural Resources Conservation Service Innovation Grants (CIG) On-Farm Conservation Innovation Trials.

The goal of DIFM is to revolutionize farm management, working with farmers and crop consultants to implement scientific experiments on their own farms, enabling them to increase profits by making data-driven management decisions. The farmer conducted on-farm trials are part of a system that includes development of software

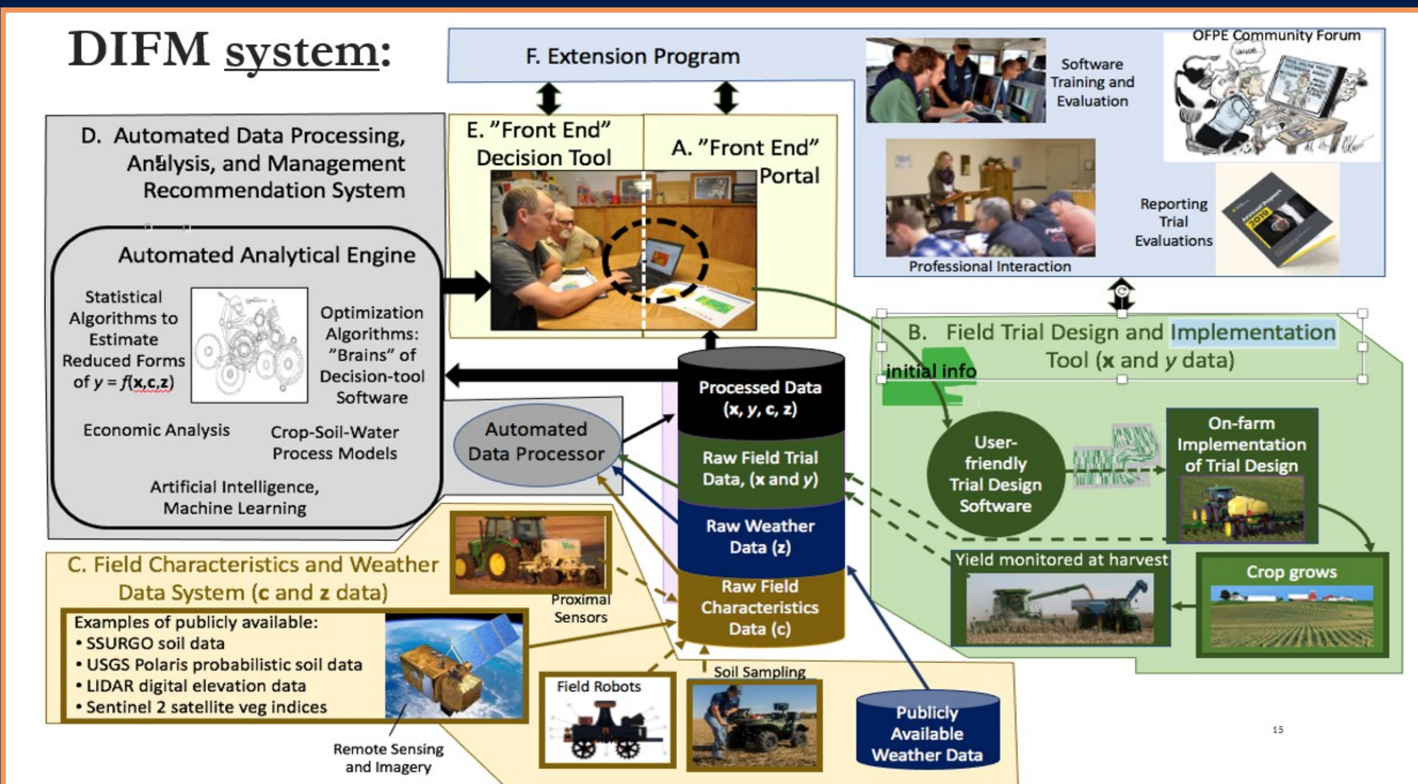
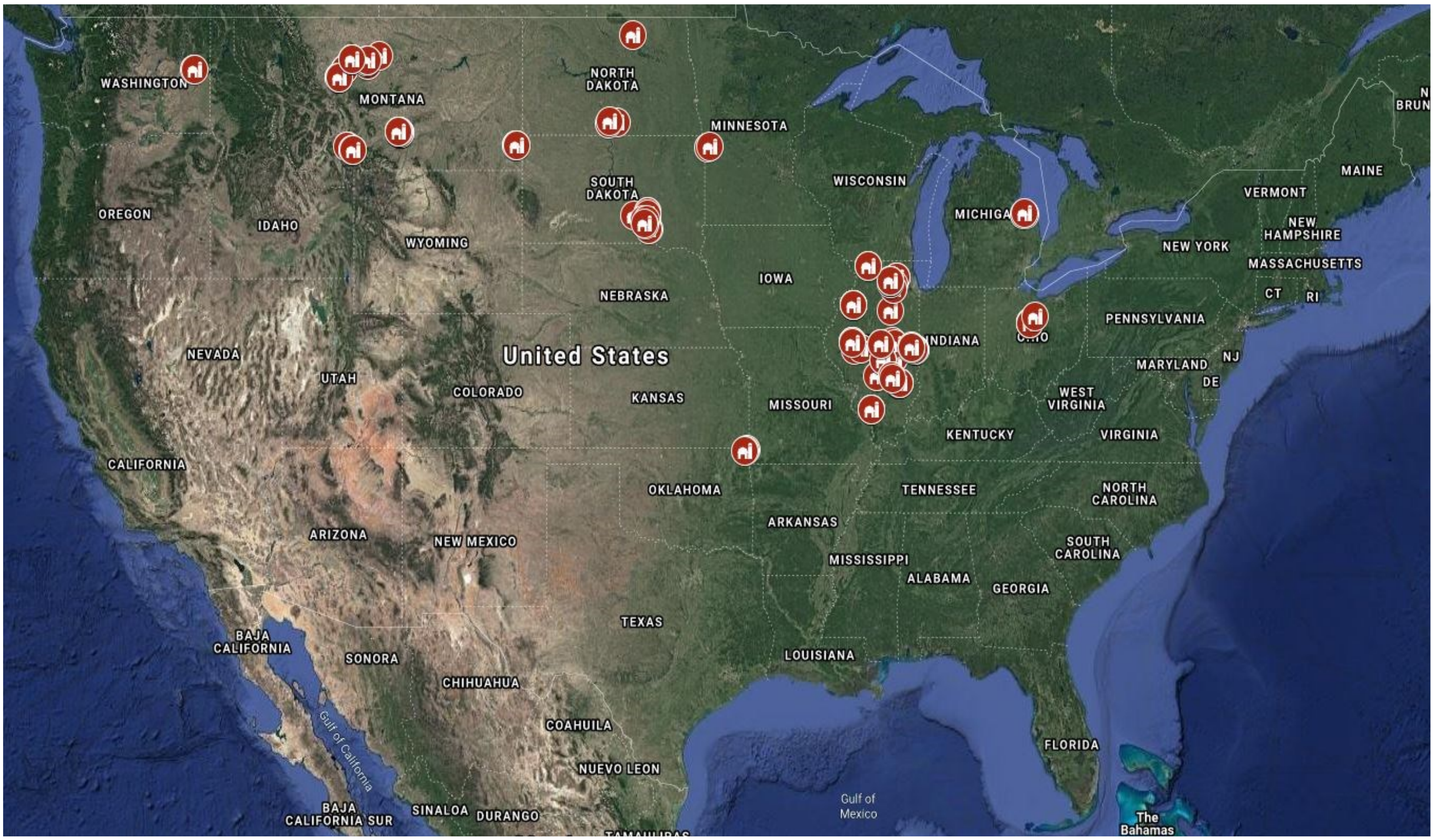


Fig. 1 Data Intensive Farm Management Program Activities

DIFM has conducted 184 trials in 10 states in the US from 2016-2021



Why do DIFM On-Farm Research?

On-Farm research allows growers to evaluate and answer questions about specific management practices on their own farm. Every farm field is unique in its characteristics and variability of soils and soils properties, landscape, and plant available water potential.

DIFM field trial methods are highly computerized and automated, and designed to be user-friendly, allowing participating farmers and consultants to play active roles in the research. Specialized software "instructs" variable rate equipment to work with GPS technologies to implement the experiment while the farmer simply drives through the field. With initial field information from the farmer/grower the DIFM trial design team will create a design "prescription," which assigns a range of input application rates to the experiment's many plots. An experiment can examine the yield impact of varying nitrogen rates, seeding rates or any other input that can be applied by a variable rate controller. DIFM researchers combine and analyze the as-applied input data and harvest data, along with data describing field characteristics and weather, to look for profit-enhancing site-specific management strategies. DIFM then works with farmers and their crop consultants to discuss the causes and practical management implications of the analytical results. Participating farmers take on certain responsibilities in the research, including attending an organizational meeting (either in-person or virtual) in the winter of their first year of participation in order to discuss project methods and roles.

Farmers who participate in the DIFM project own the data generated by field trials run on their farms. DIFM researchers reserve the right to use that data in perpetuity, for research purposes only. However, DIFM personnel will not sell the data to other parties, nor share the data with other parties without the express written consent of the farmer to whom that data belongs.

Trial Implementation and Conduct

In designing trials, DIFM will request some initial information from the cooperator about equipment and farm operations. This is important to make sure the plot size is compatible with the widths of all equipment used in the trial. DIFM can design a trial for any input or inputs that can be variably applied. For instance, a farmer may want to evaluate corn yield response to varying seed population rates and nitrogen application rates. A gridded trial is designed where all combinations of seed rates and nitrogen rates are replicated throughout the field (Fig. 2). A seed rate trial design shapefile and a nitrogen rate trial design shapefile will be created to apply the treatments of the trial. In this way, implementation of a DIFM trial will not require a time commitment beyond the time the farmer customarily commits to field operations.

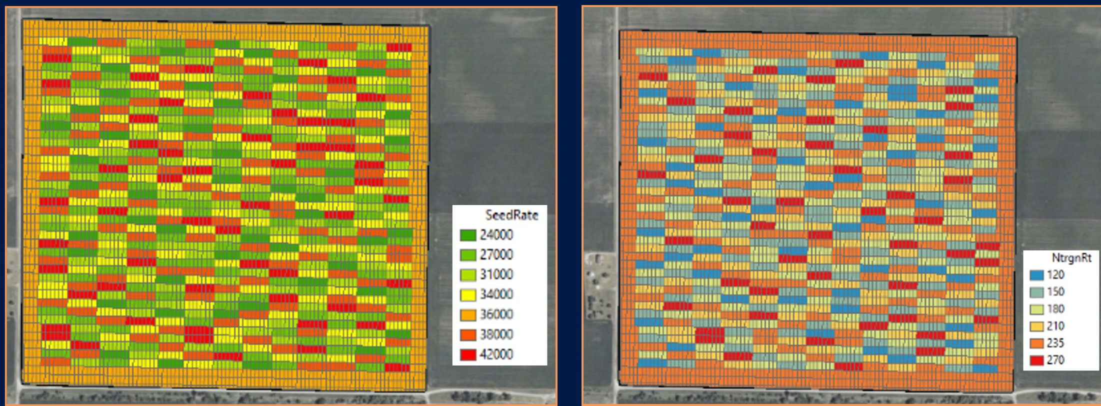


Fig 3. Seed rate and nitrogen rate trial prescription replicated over the entire field to allow for spatial analysis.

Additional Spatial Data and Processing

Any additional information available either from the farmer or from public access can be added to the dataset to help explain the variability or response of yield to the data. Relationships and interactions of the various attributes in the experiment can be very important to understanding the results. DIFM aggregates the input application, yield, and field characteristics the data described above into an integrated spatial data grid **(Fig.3).**

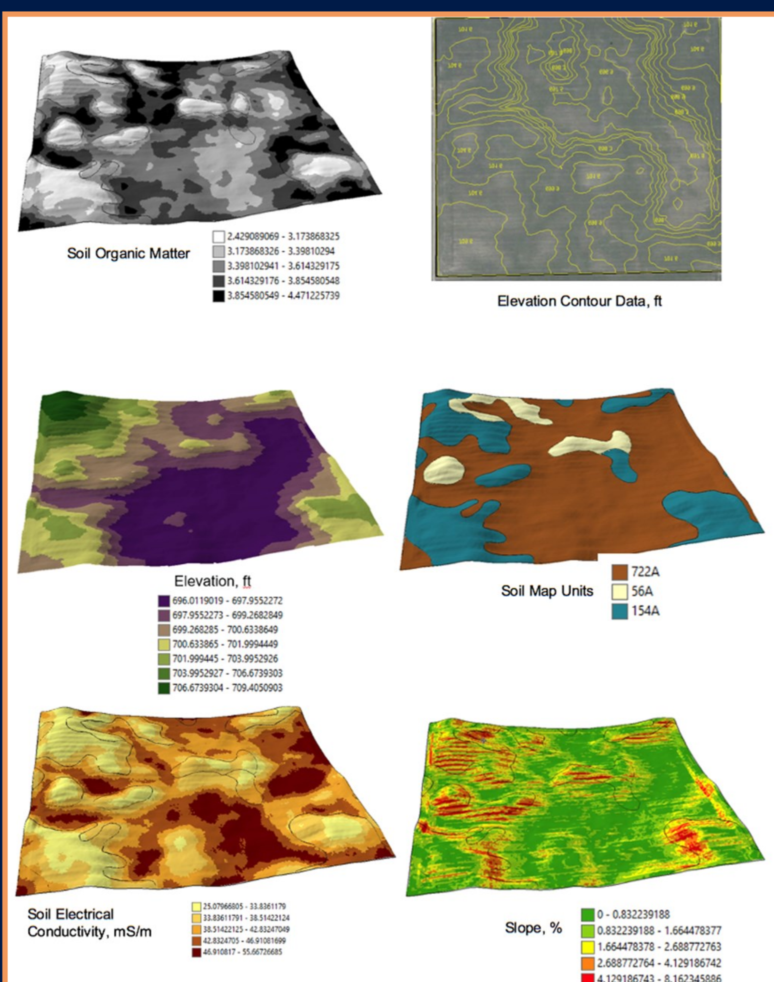


Fig. 3. Available soil and landscape attributes used in the trial analysis may be an important factor in interpreting results.

Analytical Results

DIFM uses statistical analysis, crop modeling, and artificial intelligence in its data analysis. Data analysis is challenging. Some trials provide clear evidence that a farmer's profits could be increase by following a new recommended management strategies. Some trials provide no such evidence. DIFM researchers are working hard to learn which data are most important, and the most effective ways to analyze that data. DIFM will create a report based on all the attributes included in the study.

Economic Analysis

Results will include estimates of the field's site-specific agronomic maximum input levels and site-specific economically optimal input levels. Net revenue and profits are based on how input levels yield above or below the typical levels that a farmer would use if not participating in the trial. For instance if a farmer would normally plant 33,000 seeds per acre and a total nitrogen rate of 180 lbs. per acre the resulting yield for that treatment would be the base revenue for analysis. Seed costs and crop prices are reported by the farmer.

Farmers will not lose crop revenues by participating in DIFM. DIFM will pay the farmer if the average revenues from the trial are lower than result from the base rates that the farmer would typically apply. For example a farmer who would normally apply a total nitrogen rate of 200 lbs. per acre would implement a trial designed with nitrogen rate treatments from 130 to 275 lbs. per acre. Assuming a nitrogen price of $0.414 per pound. Figure 4 shows that yield increases almost linearly to the maximum nitrogen rate of 275 lbs. per acre. Increasing the nitrogen rate from the status quo rate of 200 lbs./ac to 275 lbs./ac raises costs by $31per acre. However, the increase in yield is 30 bu/ac and with his crop price of $3.81 per bushel, an increase of net revenue (includes increased nitrogen

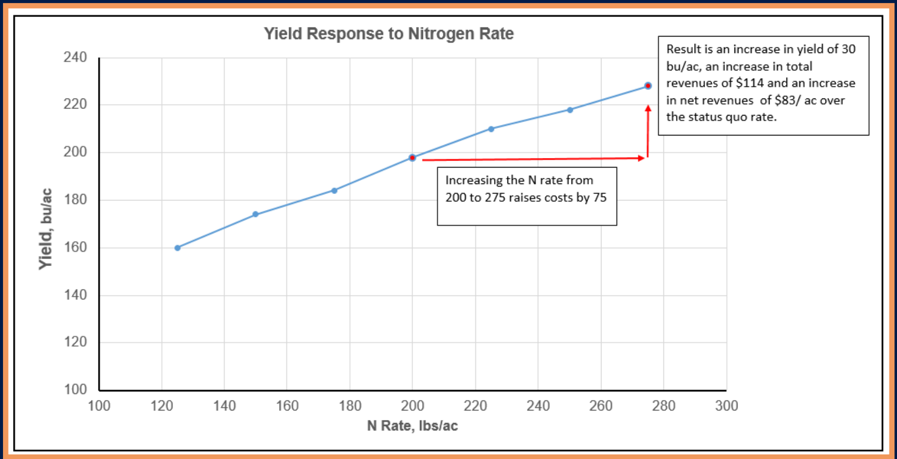


Fig. 4 Corn yield response to increasing nitrogen rates and resulting net revenue.

Spatial Analysis

DIFM aggregates the input application, yield, and field characteristics into an integrated spatial data grid. Management zones are identified using a statistical model in which a yield response to seed rate function is calculated. A generalized additive model (GAM) regression is used to model yield as a function of the variable in each zone, and then given that model estimation, the profit-maximizing rate is found for each zone.

Example Trials

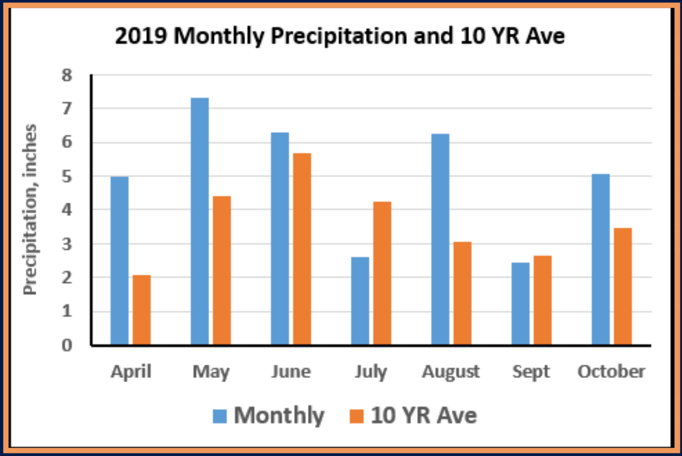
Following are three factsheets of trials previously conducted by DIFM.

DIFM Field Trial — Seed Rate by Nitrogen Rate

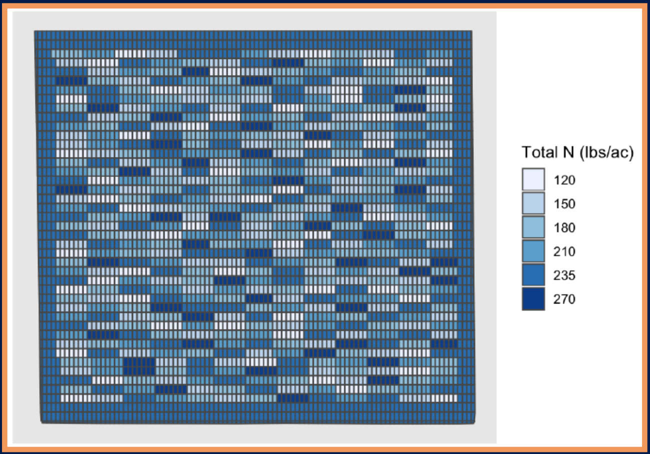
OBJECTIVE: Yield Response to variable seeding rates and variable nitrogen rates on corn.

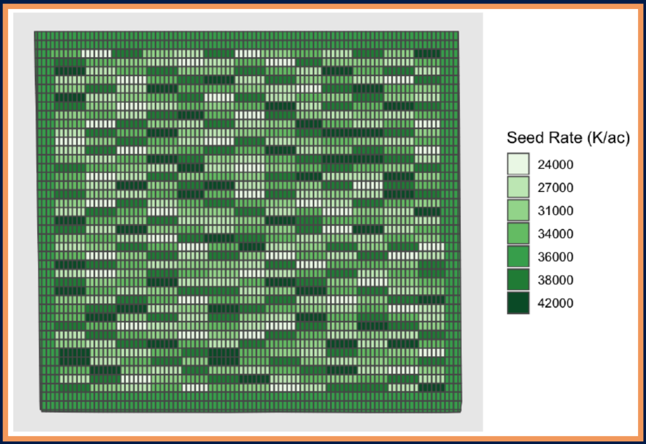
Moultrie County, IL

Study Information	
Location	Moultrie County, IL
Acres	172
Planting Date	16-May-19
Harvest Date	14-Oct-19
Hybrid	P1309WAM
Soil Type	Dana silt loam
	Flanagan silt loam
	Drummer-Milford silty clay loam
Previous Crop	Soybeans
Row Spacing	30 in
Nitrogen Rate, lbs/acre	120, 150, 180, 210, 235, 270
Seeding Rates, k/ac	24, 27, 31, 38, 42
Experimental Design	Checkerboard design with all combinations of Seeding Rates and Nitrogen Rates



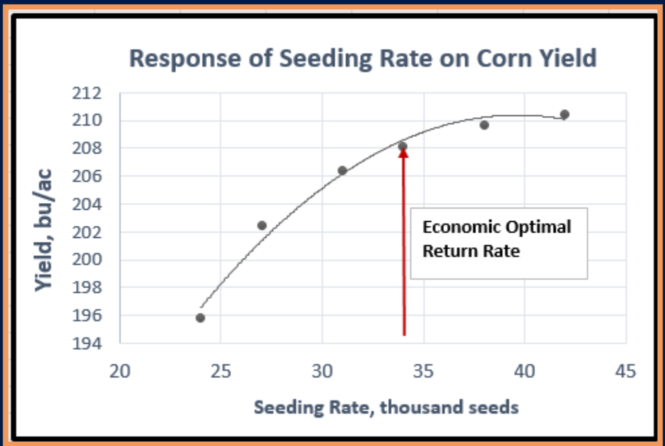
STUDY DESIGN:
Experimental checkerboard design for spatial analysis of seeding rate and nitrogen rate.



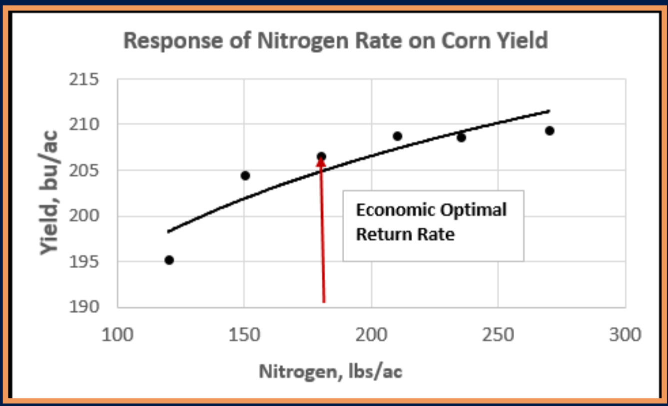


RESULTS:

Yield response to seeding rate and nitrogen rate



The economical optimal seeding rate is 34,000 seeds per acre.



The economical optimal nitrogen rate is 180 lbs. per acre.

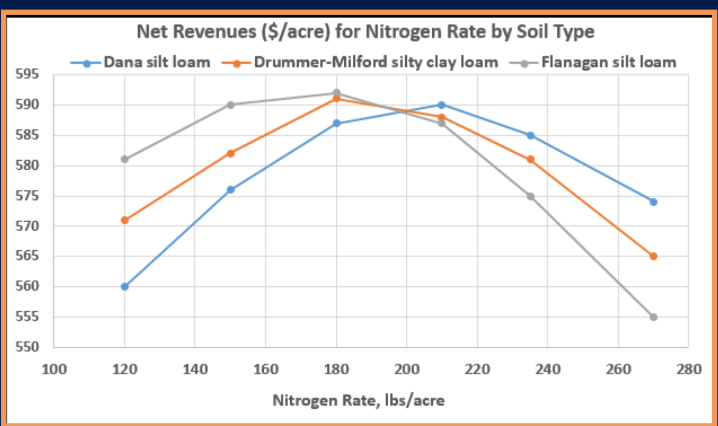
SPATIAL DATA ANALYSIS

The checkerboard grid design where each cell is an observation. DIFM aggregates the input application, yield, and field characteristics described below into an integrated spatial data grid. Each cell was assigned the values of each of the following variables

Data variables generated and collected for the 2019 corn trial:

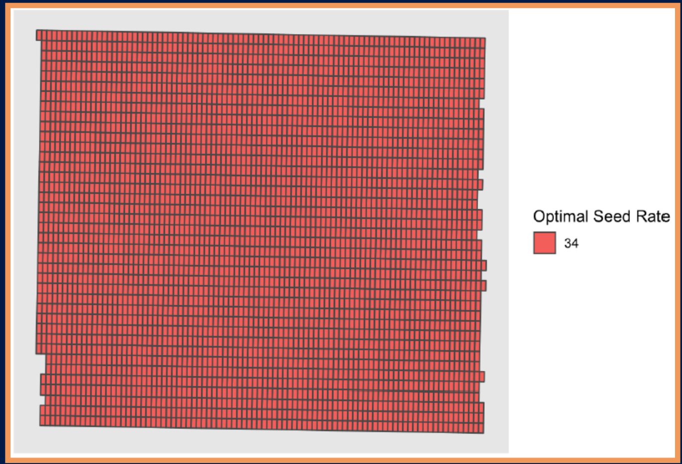
Target Seeding Rate	Target Nitrogen Rate	Applied Seeding Rate
Applied Nitrogen Rate	Crop Yield	Grain Moisture
Elevation	Slope	Aspect
Curvature	Soil Organic Matter	CEC
Soil Electrical Conductivity	USDA Soil Map Unit	GPS location

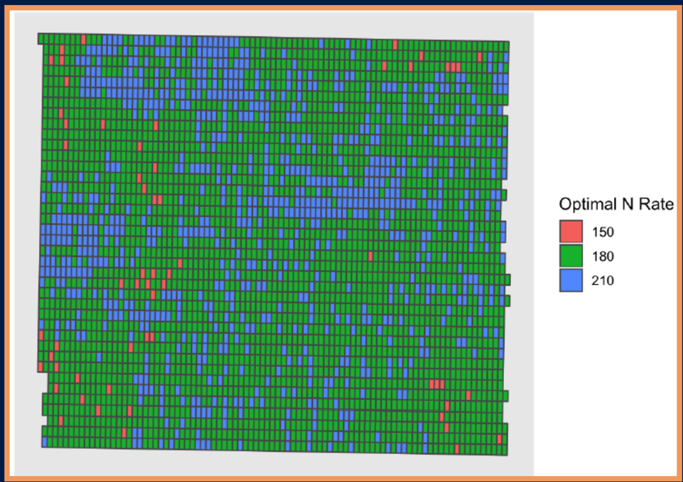
Statistical analysis of the data provided strong evidence that two field characteristics variables “interacted” with N rate to effect how yield responded to N. Slopes of the lines show that, on average, yield response to N increased with the sand content of the soil, and for the most part decreased with topographical position index (tpi). The Topographic Position Index (TPI) compares the elevation of each cell in a digital elevation model to the mean elevation of a specified neighborhood around that cell. The tpi is negative in valleys, and positive pm ridges. So, the data may be interpreted as indicating that, given the weather events of the 2019 growing season, yield was more responsive to N in the field’s valley than on the its ridges. Of course, all of these results were weather dependent. In different years, yield response would vary.



Net revenues ($/acre) response to nitrogen rate on soil type

In general, yields increased with seed rate. But none of the spatial field characteristic variables showed statistical significant “interaction” with seed rate. That is, the data provided little evidence that planting at site-specific rats would have increased profits. of the economically optimal seed rate was uniform throughout the field at 34,000 seeds per acre. However the data provided little evidence that this rate was actually more profitable than the farmer’s usual rate of 36,000 seeds per acre. This result provided the farmer assurance that, at least for 2019’s weather condition, his usual seed rate management was working well. The analysis’s “point estimate” of optimal N rate applications was site specific, chiefly calling for increased N rates on sandier parts of the field. Estimates of optimal N rates varied by site, and were 150, 180, and 210 pounds per acre. The data therefore provided strong evidence that, at least given 2019 weather conditions, the farmer’s usual N application rate of 235 pounds per acre was too high.





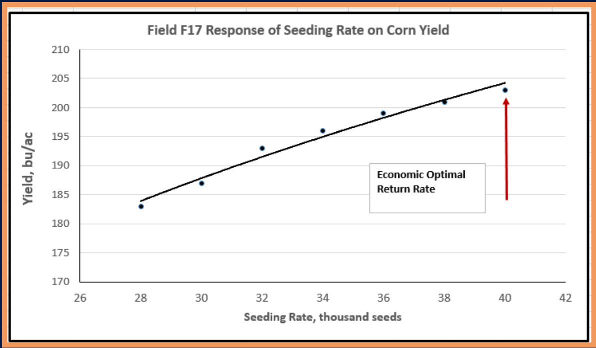
DIFM Field Trial — Seed Rate by Nitrogen Rate Study

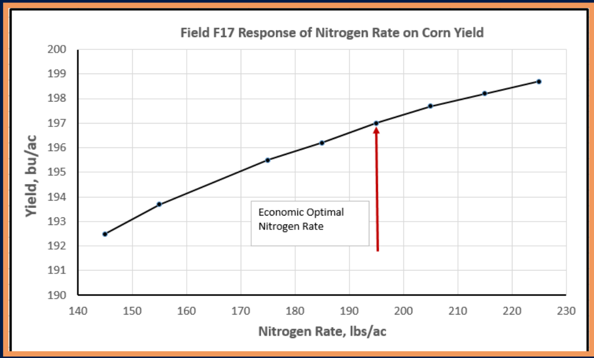
OBJECTIVE: Yield Response to variable seeding rates and variable nitrogen rates on corn.

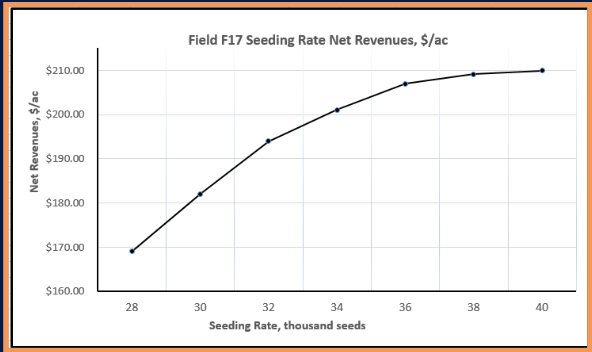
Crawford County, Ohio

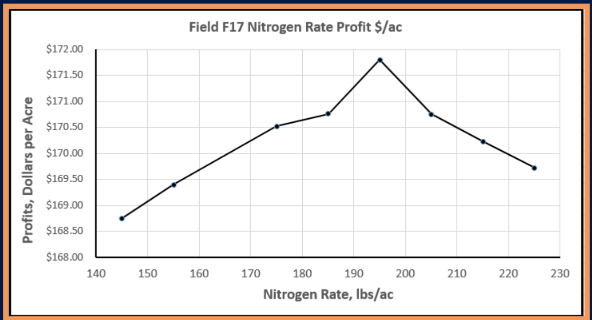
Study Information	
Location	Crawford County, Ohio
Acres	77
Planting Date	30-Apr-18
Harvest Date	16-Oct-18
Hybrid	DKC63-60RIB
Soil Type	Bennington silt loam 2-6 % slope
	Elliott silt loam, 0-3 % slope
	Luray silty clay loam
	Tiro silt loam 2-6 % slope
Previous Crop	Soybeans
Row Spacing	30 in
Nitrogen Rate, lbs/acre	145, 155, 175, 185, 195, 205, 215, 225
Seeding Rates, k/ac	28, 30, 32, 34, 36, 38, 40
Experimental Design	Checkerboard design with all combinations of Seeding Rates and Nitrogen Rates

RESULTS:





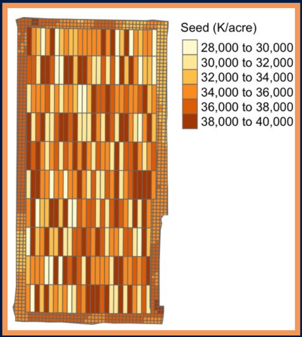


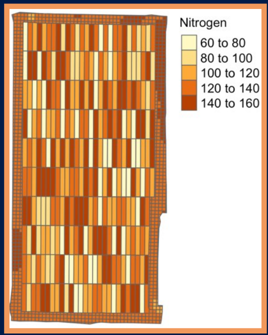


The maximum profit levels for conditions and prices occurring in for this field in 2018 was at a seeding rate of 40,000 seeds and 195 lbs. of nitrogen per acre.

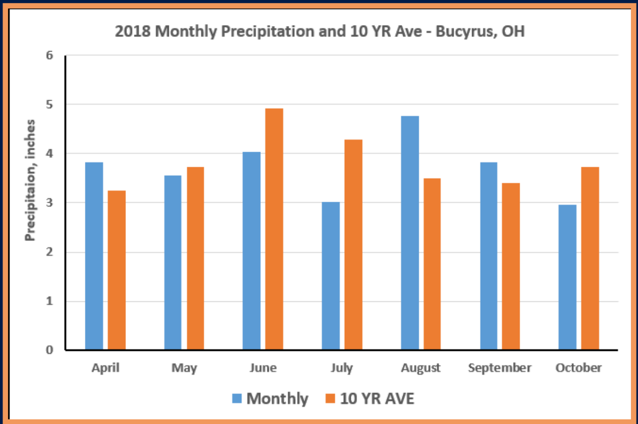
STUDY DESIGN:

Experimental checkerboard design for spatial analysis of seeding rate and nitrogen rate.





WEATHER:



Precipitation for 2018 was near normal for the growing season. June and July were 1 to 1 1/2 inches below normal but did not result in moisture stress of the plant.

DIFM Field Trial — Seed Rate Study on Corn

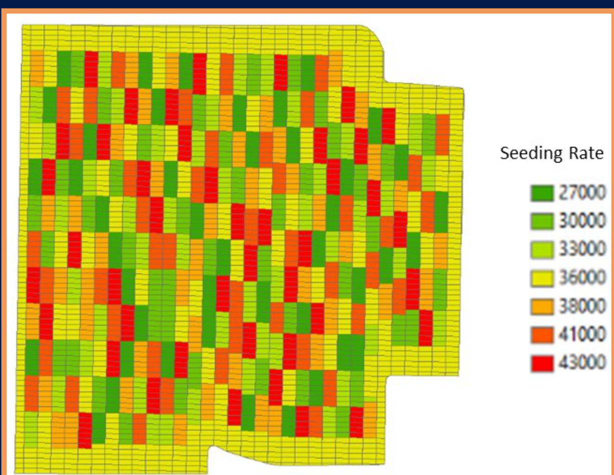
OBJECTIVE: Yield response to variable seeding rates on corn yield.

DeKalb County, IL

Study Information	
Location	DeKalb County, Illinois
Acres	145
Planting Date	8-May-20
Harvest Date	11-Nov-20
Hybrid	DKC63-90RIB
Soil Type	Drummer silty clay loam, 0-2% slope
	Flanagan silt loam, 0-2% slope
	Catlin silt loam, 2-5% slope
	Weingate silt loam, 2-5% slope
	Elpaso silty clay loam, 0-2% slope
	Danabrook silt loam, 2-5% slope
Previous Crop	Corn
Row Spacing	30 inches
Seeding Rates, k/ac	27K, 30K, 33K, 36K, 38K, 41K, 43K
Experimental Design	Checkerboard design with all combinations of Seeding Rates

STUDY DESIGN:

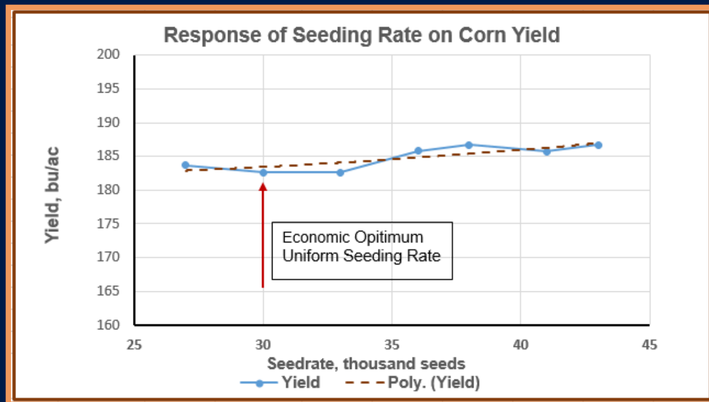
Experimental checkerboard design for spatial analysis of seeding rate.



RESULTS:

UNIFORM RATE STATEGY ANALYSIS

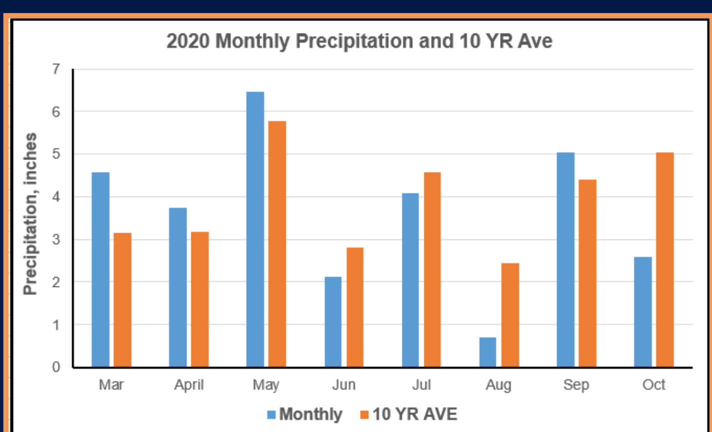
This analysis will calculate the yield results of various uniform seeding rates of the entire field.

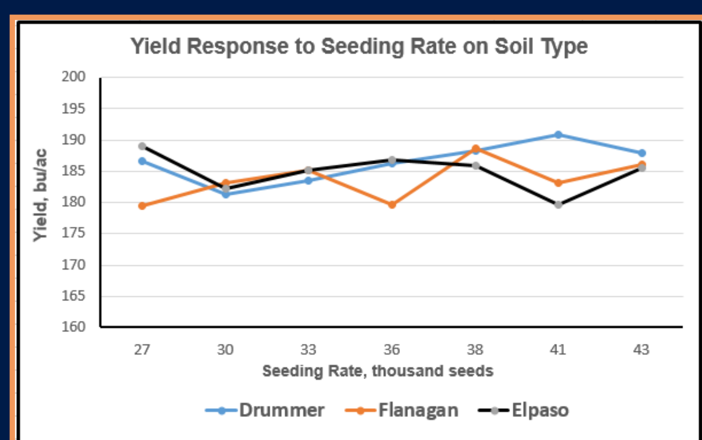


Results indicated that an economically optimal uniform seeding rate was 29,000 seeds per acre. This economic uniform rate for 2020 is 7,000 seeds lower than the usual seeding rate of 36,000. Economic analysis uses the assumed crop price at $5.50 per bushel and seed price of $3.81 per thousand seeds.

Yield response to seeding rate was similar for the majority of the three major soils occurring in this field.

WEATHER:





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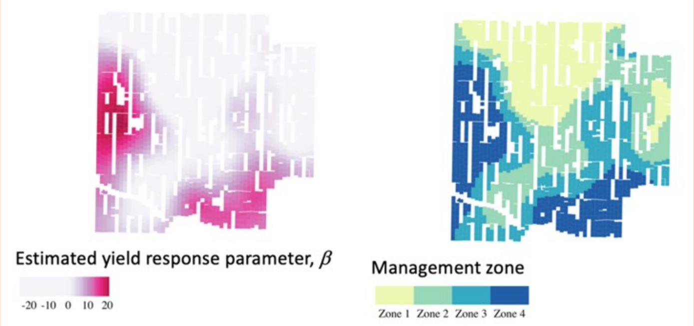


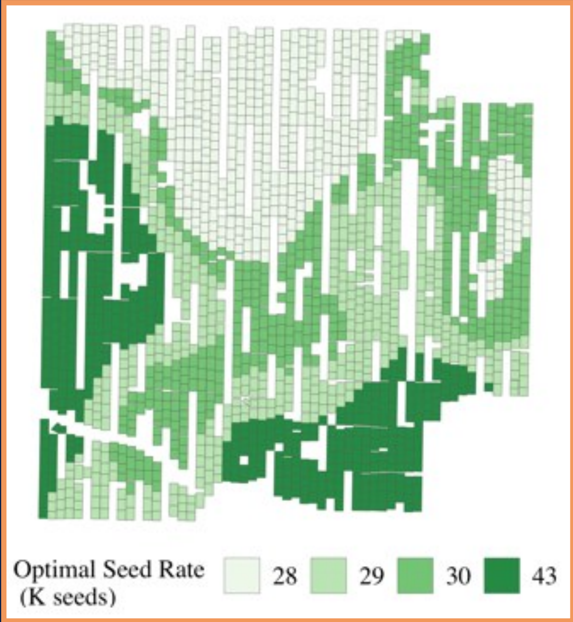
A generalized additive model (GAM) regression was used to model yield as a function of seed rate in each zone, and then given that model estimation, the profit-maximizing seed rate was found for each zone. The following table lists for each zone the estimated per-acre yields that would have resulted, given the year's growing conditions, from applying the grower-chosen seeding strategy and the estimated optimal seed rate derived from the data and model.

Yield and Seed rate data by zone

Zone	Strategy	Yield (bu/acre)	Seed Rate
Zone 1	Grower-chosen	180.7	36.0
	Optimal site-specific	187.5	28.2
Zone 2	Grower-chosen	184.1	36.0
	Optimal site-specific	188.6	29.5
Zone 3	Grower-chosen	186.8	36.0
	Optimal site-specific	183.3	28.5
Zone 4	Grower-chosen	177.4	36.0
	Optimal site-specific	189.1	43.1

If the grower had not participated in the experiment, the chosen strategy would have been to apply seed uniformly across the field at 36,000 seeds per acre. The model predicts that this strategy was approximately 8,000 seeds per acre too high in Zone 1, 6,000 seeds per acre too high in Zone 2, 7,000 seeds per acre too high in Zone 3, and 7,000 seeds per acre too low in Zone 4.

Statistical analysis of the yield response data for each zone is used to generate an optimal site specific seed rate *Rx* for the field.



The best estimate provided by the data and model is that, under growing conditions identical to those of the field in 2020, implementing the recommended site-specific seeding rate strategy would have increased profits by approximately $22 per acre.

How Can You Participate?

If you are interested in participating, please complete the online information form we need to design your custom on-farm trial. This form can be accessed at:

https://forms.gle/zcEz2BPUK31v9dSt5

Ready to upload your data to design a trial? Use this link: https://uofi.app.box.com/f/855c7f48df8a41b6a10c393f038d096e

If you want additional information or have questions please use the following contact Information:

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