ILLINOIS ACES

Data-Intensive Farm Management Project

Information for Participating Farmers

What is DIFM?

DIFM (Data Intensive Management Project) 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. The goal of DIFM is to revolutionize farm management, working with farmers and crop consulting to implement scientific experiments on their own farms, enabling them to increase profits by making data-driven management decisions.

DIFM Methodology

A DIFM field trial methods are highly computerized and automated, and meant 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 Own Their Data

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

On 2019, DIFM worked with a in central Illinois to evaluate the effects of variable seeding and variable nitrogen rates on a 172-acre cornfield, the boundary of which is shown in figure 1. The research was performed taking the following steps:

Step 1. The farmer supplied DIFM with some specific information about the field and management practices:

a. **Various shapefiles**. (A shapefile is a suite of 3-8 different files, all containing polygonized information about geographic aspects of the field.)

1) The field's boundary file, the contents of which are illustrated in figure 1. Had the farmer not already possessed a boundary file for the field, DIFM would have made one. The boundary file allows the DIFM team to gather information about field characteristics, such as soil types and topography. Figure 2 shows various field characteristic maps from the trial's field.

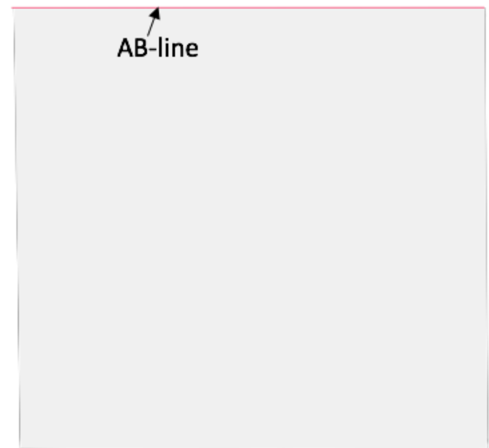

Figure 1. Boundary and AB-line of the 172-acre field that a central Illinois farmer used for a 2019 DIFM field trial

2) A-B or guidance lines for planting, fertilization, and harvest. If the farmer cannot supply these, DIFM can create them.
3) The latest soil fertility information available for the field (best as a shape file showing actual sample points and laboratory analysis). Figure 2 also shows the maps the field's latest soil organic matter data.
4) Other field characteristics data which the farmer can make available. The farmer of the field discussed here possessed electroconductivity data for the field, which is shown in figure 2.
5) Yield, "as-applied," and "as-planted" files from past years. Figure 3 illustrates the map of those files from the 2017 growing season. These files help DIFM researchers understand how the field was managed, including machinery entrance and exit points, and bearings of the routes used in planting, fertilizing, and harvest.

b. **A completed DIFM Equipment and Management Practices questionnaire.** This questionnaire asks for information about farm equipment sizes and various management practices. This questionnaire is a pdf fill-in form that DIFM needs to design a trial.

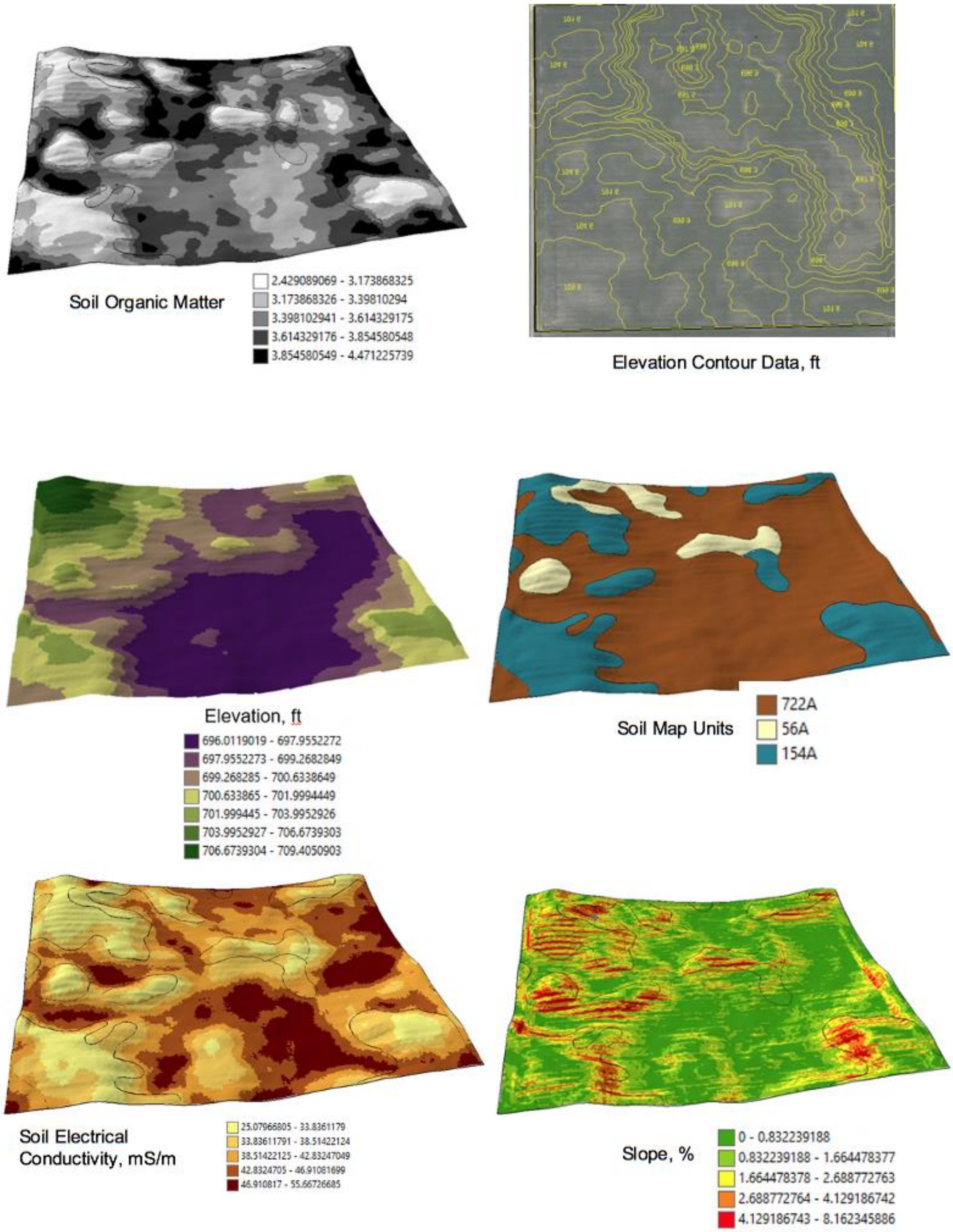

Figure 2. Maps of field characteristics data

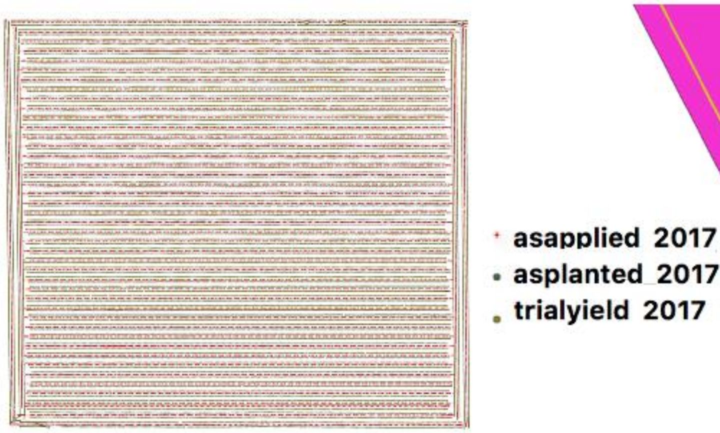

Figure 3. As-applied, as-planted, and yield data from a previous year

Figure 4. A trial's plot width depends on equipment sizes

Step 2. Trial Design: DIFM researchers have developed computer code that allows them to design field trials in minutes. Figure 5 features the seed trial design of the 2019 field trial. The trial's design targeted seed rates of 24, 27, 31, 34, 36, 38, and 42 thousand seeds per acre. All trial plots were the width of the planter, 60 feet. Plots were either 180 or 210 feet long. Seed rates were assigned to plots randomly, and in equal number. Headlands and sidelands were planted at the farmer's usual rate of 38 thousand seeds per acre, and were not included in the experiment. Figure 6 features the N fertilization trial, for which nitrogen in the form of UAN-32 was applied as side-dress. Before side-dressing, the farmer applied a 60 lb base N rate to the west half of the field, and an 55 lb base east half. Targeted UAN32 rates were 19.1, 26.5, 36.0, 44.5, 51.6, and 61.5 gallons per acre, which led to total N rates of 120,150,180, 210, 235, and 270 lbs per acre. The farmer's usual total N rate was 235 lb N/ac.

Step 3. Trial Implementation: The close matches of as-planted and as-applied rates to targeted rates shown in Figures 5 and 6 reveal how accurate field trials can be implemented when farmers and DIFM researchers work together. Both the seed rate trial and the N rate trial where "put in the ground" by the farmer, who understood the goal of the trial design, and was able upload and use the trial design shapefile in the same way he would upload and use any other variable rate application "prescription." After implementing the the planting and nitrogen applications, the farmer sent the as-planted and as-applied nitrogen files to DIFM, which cleaned and stored the data in its central database, to be used later for analysis.

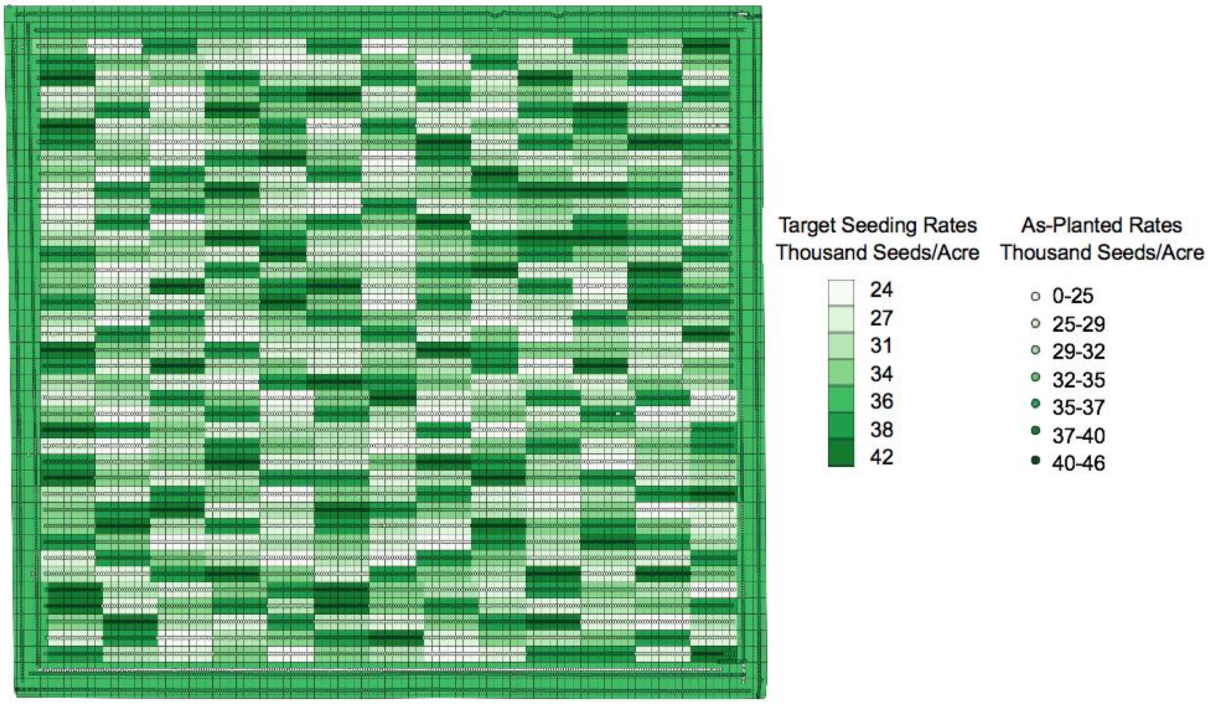

Figure 5. Seed rate trial design and as-planted maps of 2019 DIFM trial

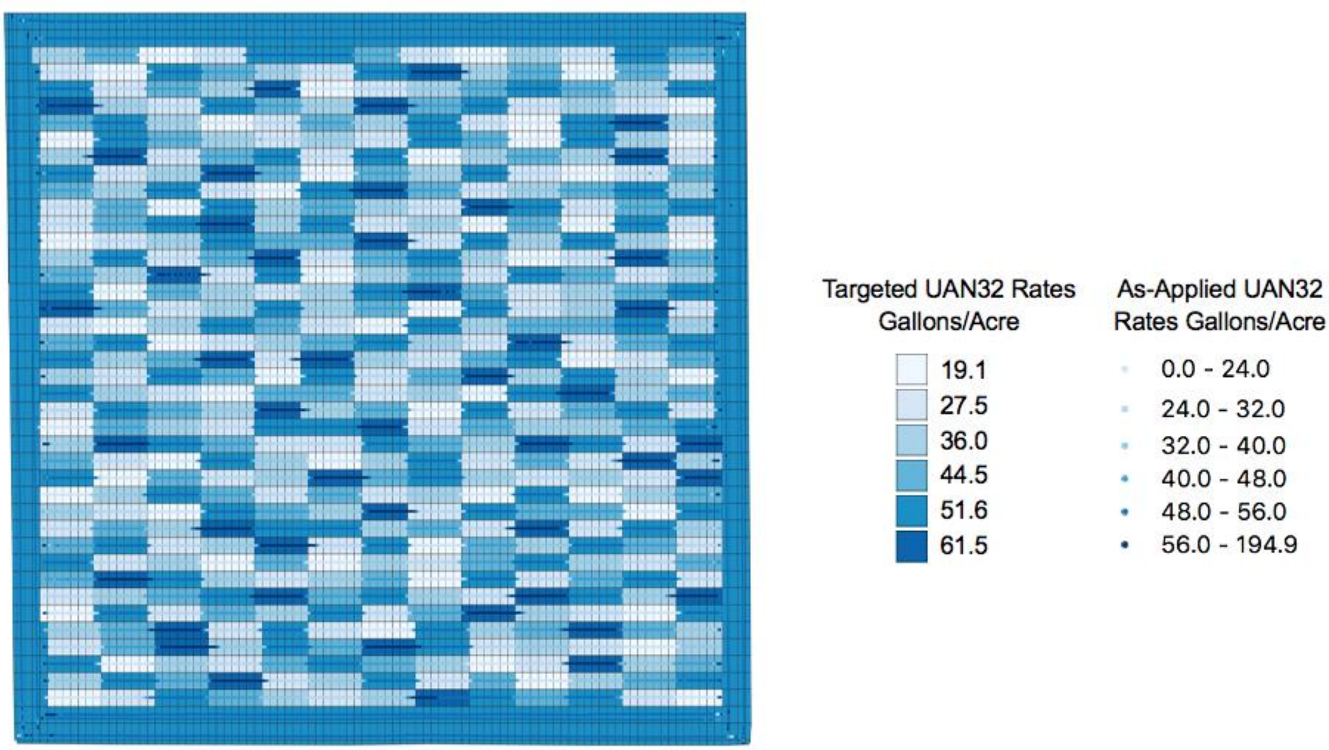

Figure 6. Nitrogen rate trial design and as-applied maps of 2019 DIFM trial

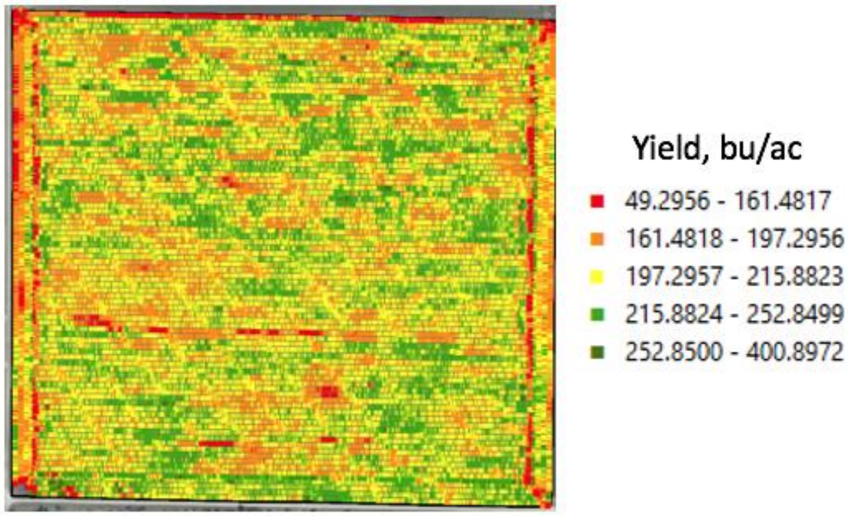

Figure 7. Yield monitor data

<u>Step 4</u>. Harvest: At harvest, the farmer made sure that he lined up the combine according to the correct AB lines to ensure that the data was collected properly within the plot boundaries. He then sent the raw yield map data will be sent to DIFM. Figure 7 displays the raw yield data.

<u>Additional Spatial Data</u>

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. For example, the National Agriculture Imagery Program (NAIP) acquires imagery during the agricultural growing seasons in the continental U.S. A primary goal of the NAIP program is to enable availability of digital orthophotography within a year of acquisition. On average, digital images of Illinois Counties are acquired every 2-3 years. These images are mostly acquired using natural color (RGB) photography. In some years images are acquired using color-infrared imagery (CIR). Color-infrared imagery provides a more detailed view by incorporating reflectance invisible to the human eye. CIR is especially useful for evaluating plant health and field conditions. This imagery is available to the public at no charge from the USDA Geospatial Gateway website at http://datagateway.nrcs.usda.gov CIR imagery offers growers a comprehensive first look at a recently planted field by revealing which areas of a field experience the first plant emergence, as well as the uniformity of that initial growth. On bare ground, CIR imagery also offers a quick and cost-effective method of soil mapping. Color infrared sensors are widely used to evaluate plant stress from things like drought and nitrogen deficiency. The greener the plant, the higher the reflectance.

In September 2019 Illinois imagery was acquired using color infrared photography. Figure 8 shows plant reflectance from the DIFM trials discussed in this document, alongside the UAN32 trial design. The photo was taken three weeks before harvested. Certain plots with various nitrogen treatments are highlighted. The effects of differing N rates are clear, even from outer space.

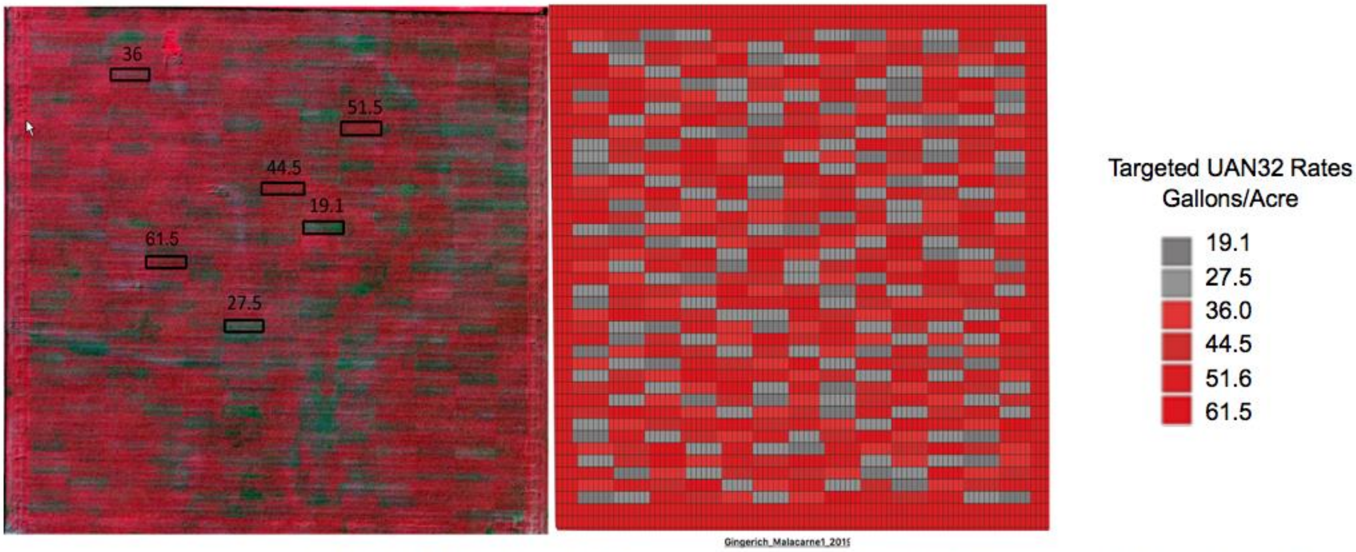

Figure 8. Comparison of a USDA NAIP infrared photograph of the field, taken September 19, 2019, and the N rate trial design of the same field. Numbers in the left-hand panel show median as-applied UAN32 rates in selected plots.

Data Processing

DIFM aggregates the input application, yield, and field characteristics the data described above into an integrated spatial data grid. Figure 9 shows the grid used in the analysis of the experiment described in this guide. Each cell shown in figure 9 was assigned the values of each variable shown in table 1.

Table 1. 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	Cation Exchange Capacity
Soil Electrical Conductivity	USDA Soil Map Unit	GPS location

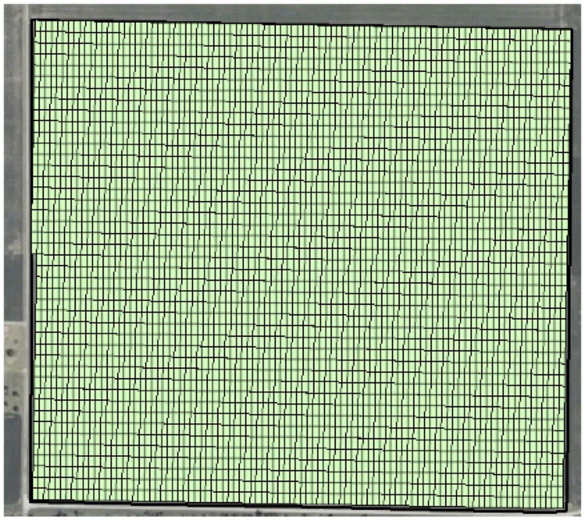

Figure 9. DIFM "stacked and packed" the experiment spatial data into an integrated spatial data grid, with each cell serving as an "observation."

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. The analytical research is in its early stages, but DIFM researchers are extremely enthusiastic about the potential they see for using their on-farm precision experiment methodology to help farmers manage their inputs more efficiently.

Figure 10 illustrates why the data generated in the trial discussed in this guide did provide some clear evidence for management recommendations. 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. But repeating experiments in this and nearby fields over a period of years, much might be learned about how the results vary by weather.

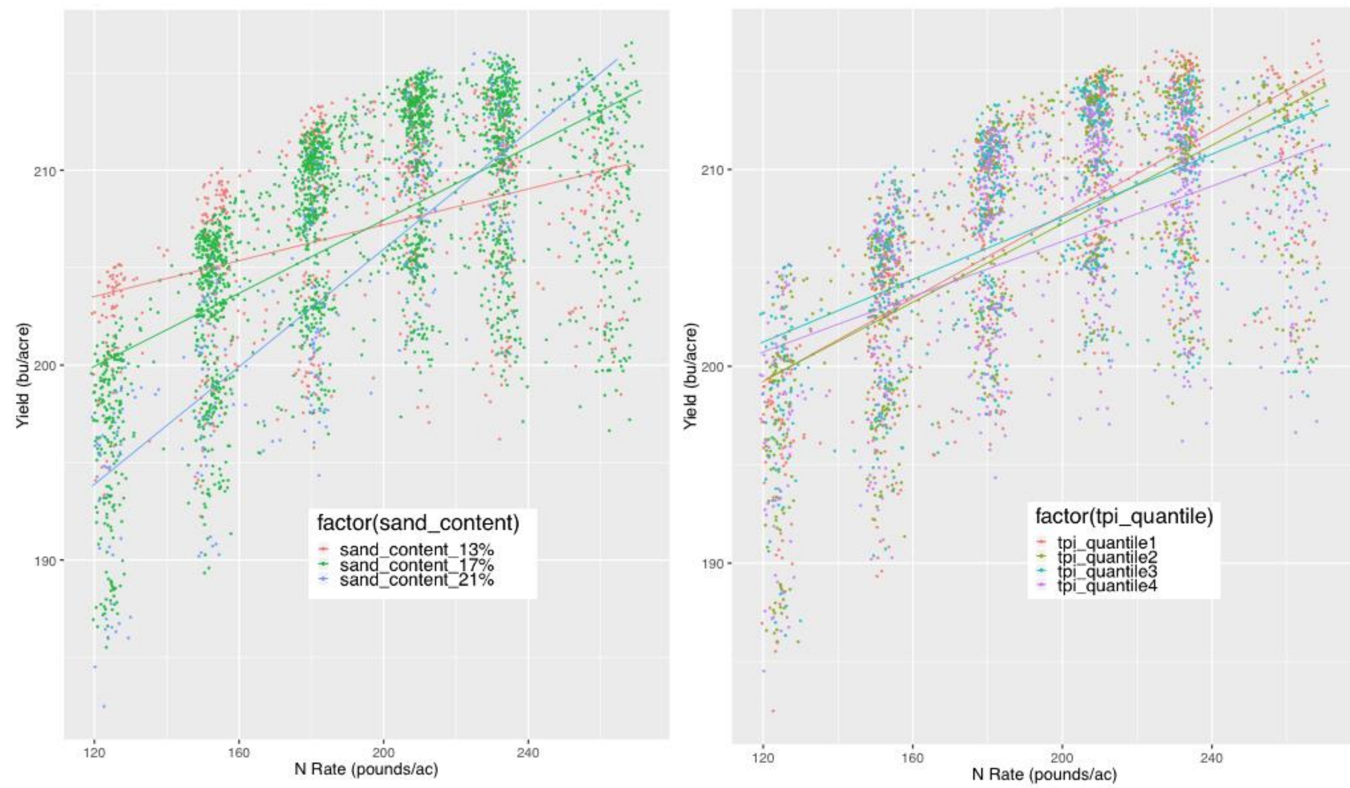

Figure 10. The data provided strong evidence that yield response to N varied by sand content and topographical position index.

The scatterplot in figure 11 shows the trial's yield response to seed rate. 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. Figure 12 illustrates the analysis's "point estimate" 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. Figure 12 shows that 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.

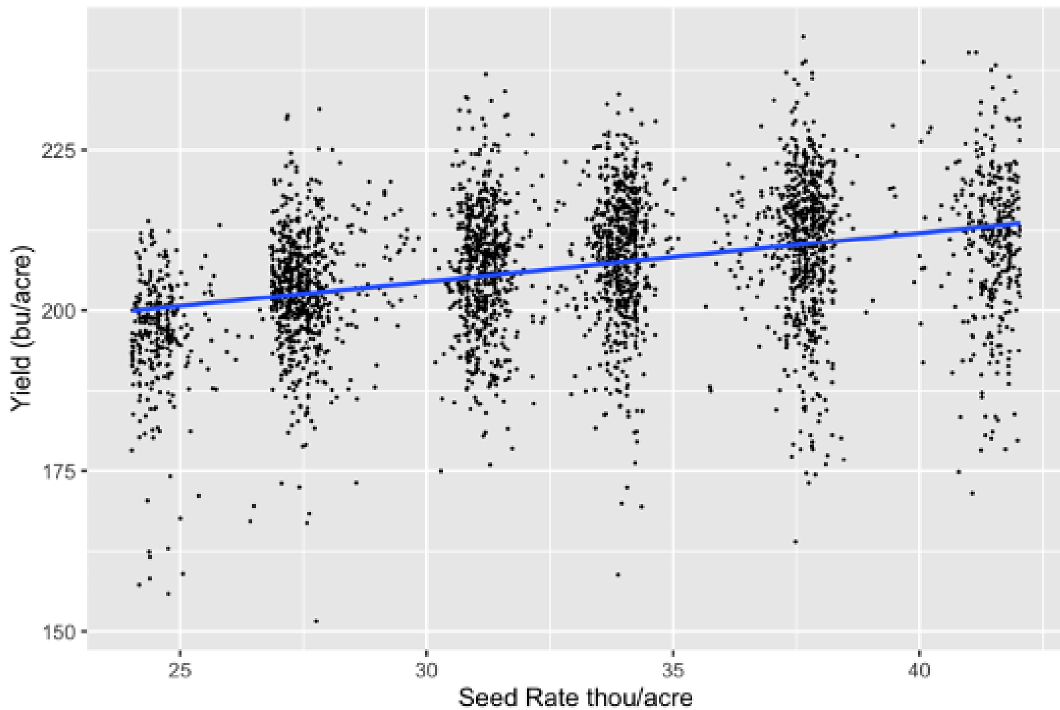

Figure 11. Yield response to seed rate

Using the algorithims from these respnse curves allows up to develop optimum rate maps for nitrogen and seed (Figure 12).

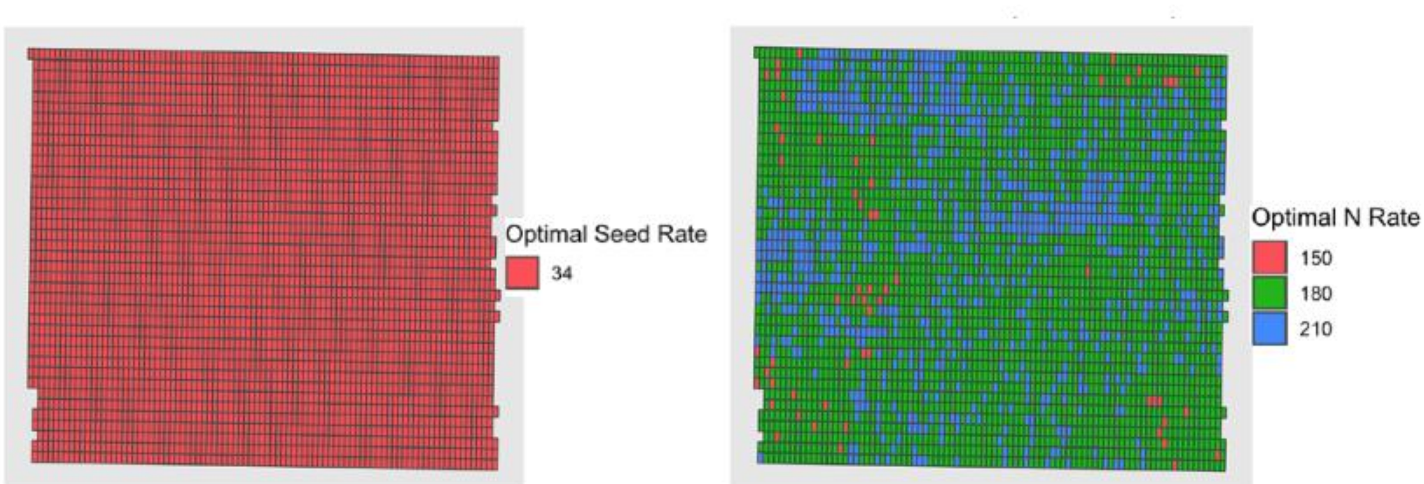

Figure 12. Seed rate and N rate recommendations

For more information about DIFM go to our project website.
https://publish.illinois.edu/data-intensive-farm-managment/

To receive more information about how to participate in the DIFM on-farm research program contact:

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