Opportunities in On-Farm Precision Experimentation with the Data-Intensive Farm Management Project

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L'Agriculture de Précision au Coeur de L'innovation en Grandes Culture
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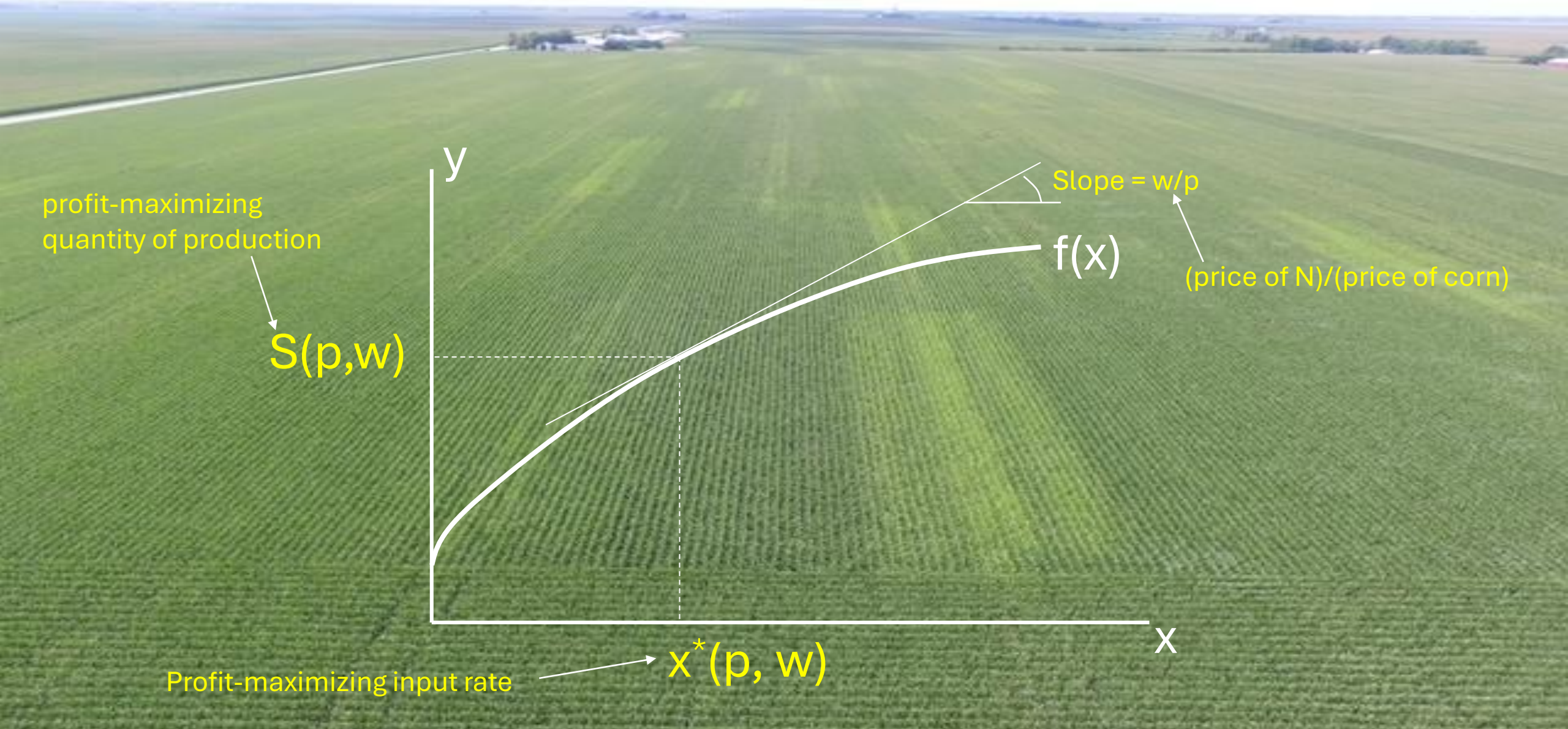
The main points I'm going to make:

- On-farm precision experimentation (OFPE) is revolutionizing agronomic research, bringing it striaght to farmers' own fields.
- Farmers and crop advisors can work with the Data-Intensive Farm Management Project to run OFPEs.
- Those experiments create great data from farmers' own fields that can be used to improve management of those same fields.
- This all done through the user-friendly difm.farm platform ("cyber-infrastructure").
- The data belong to the farmers (but DIFM reserves the right to use the data for academic purposes).

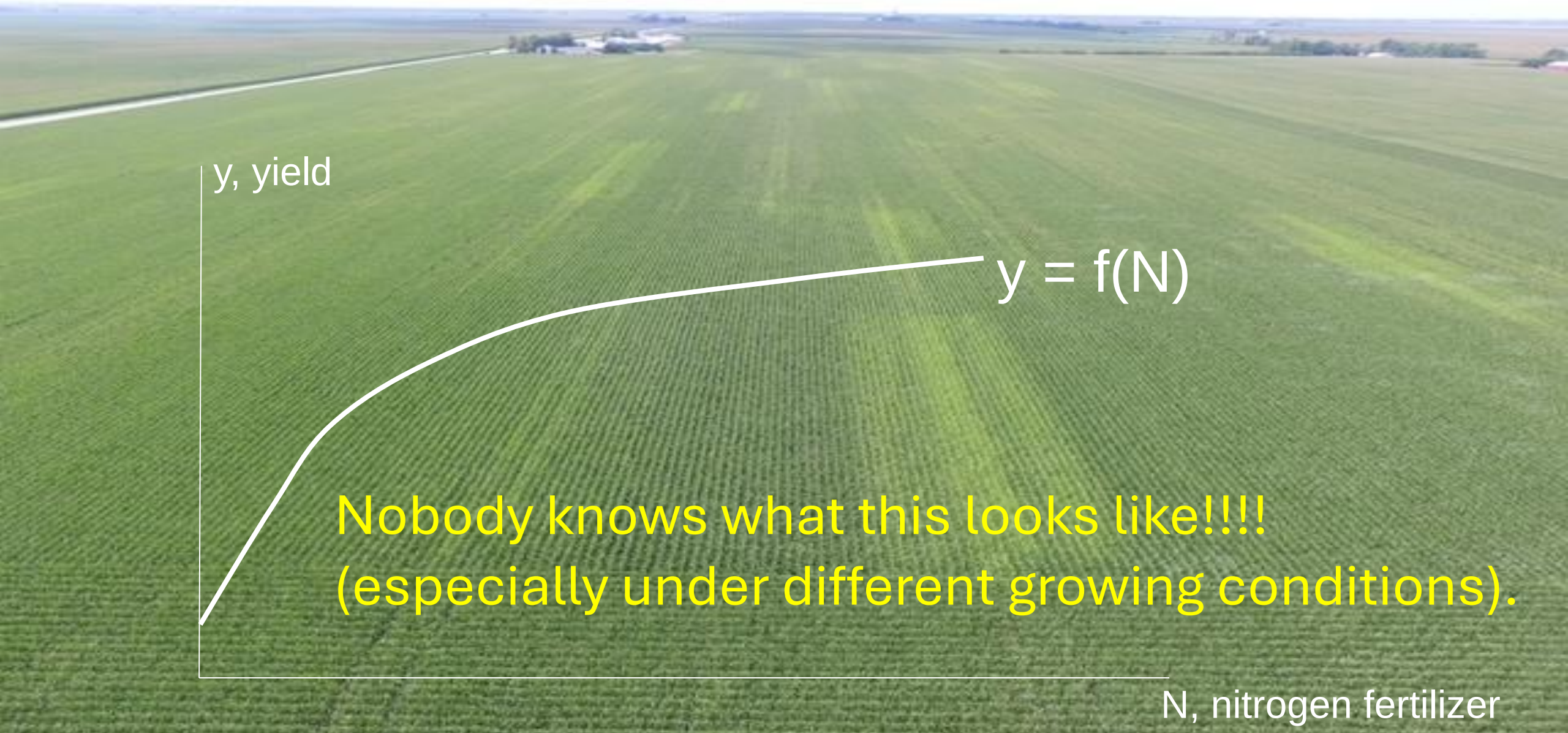
If you take a first-year university course in economics, you will see this:

And you will learn a piece of microeconomic theory:

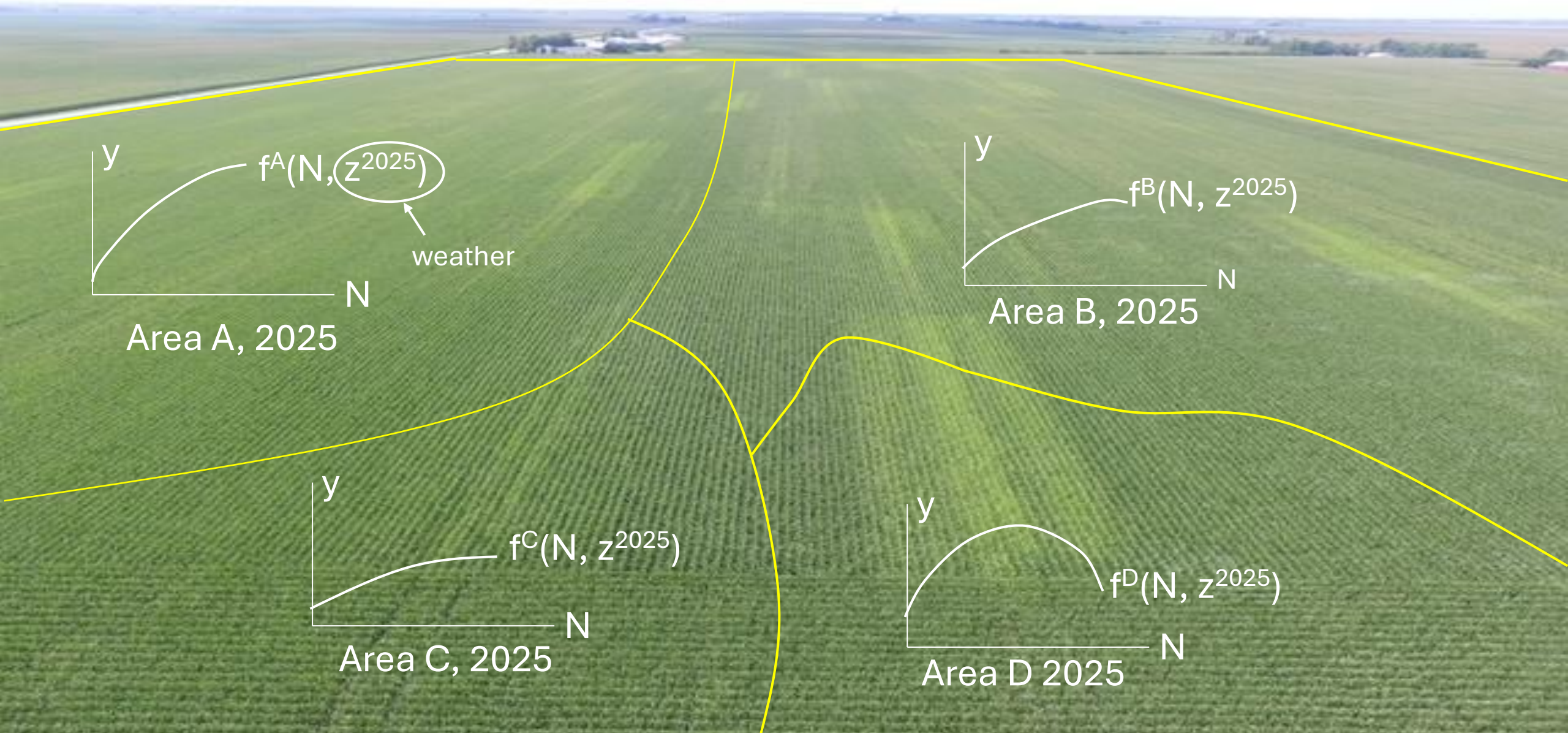
Profit maximization requires the value of the slope of the yield response curve to equal the ratio of the input and output prices:

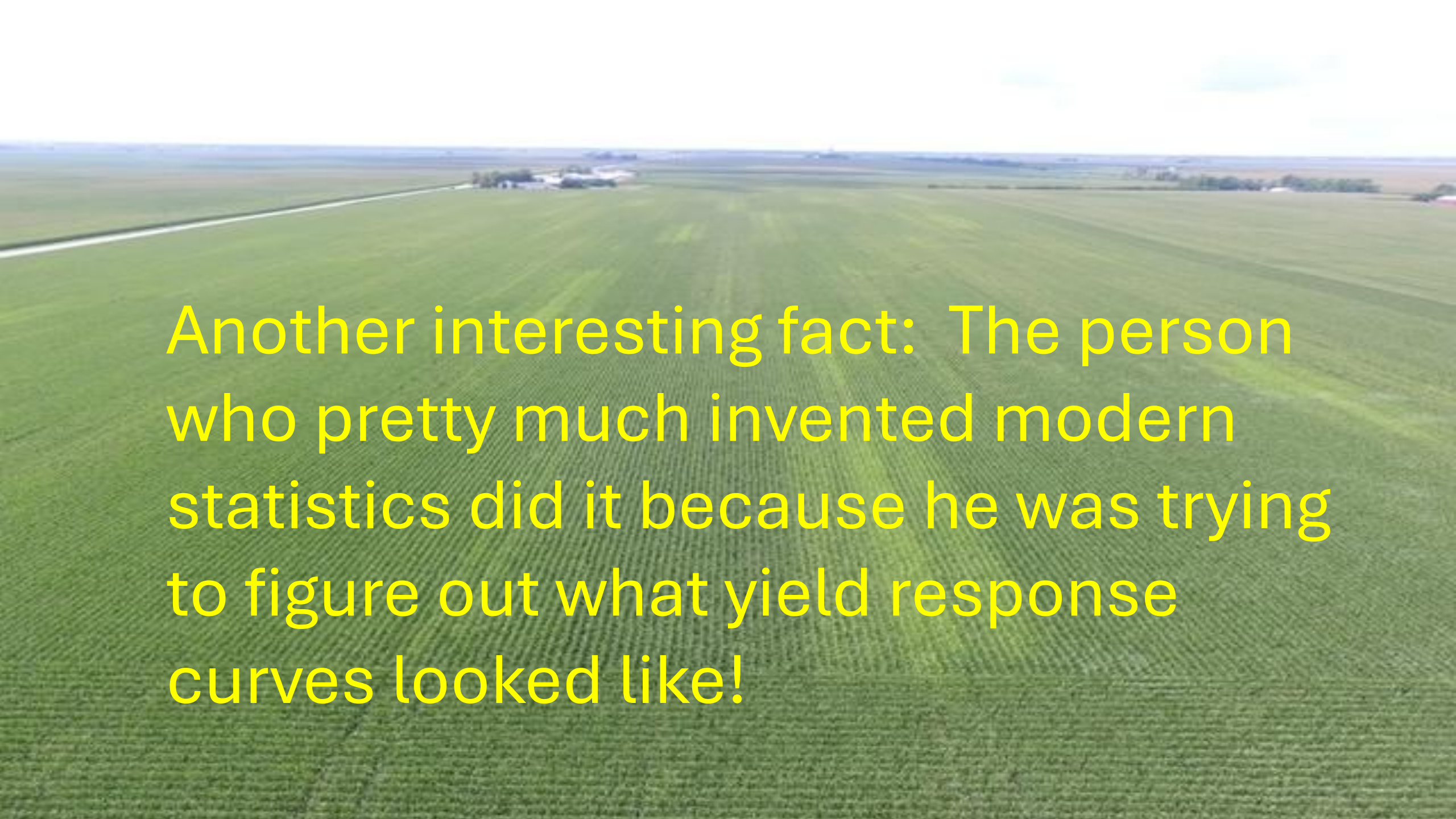


What they didn’t tell you (or at least nobody told me):

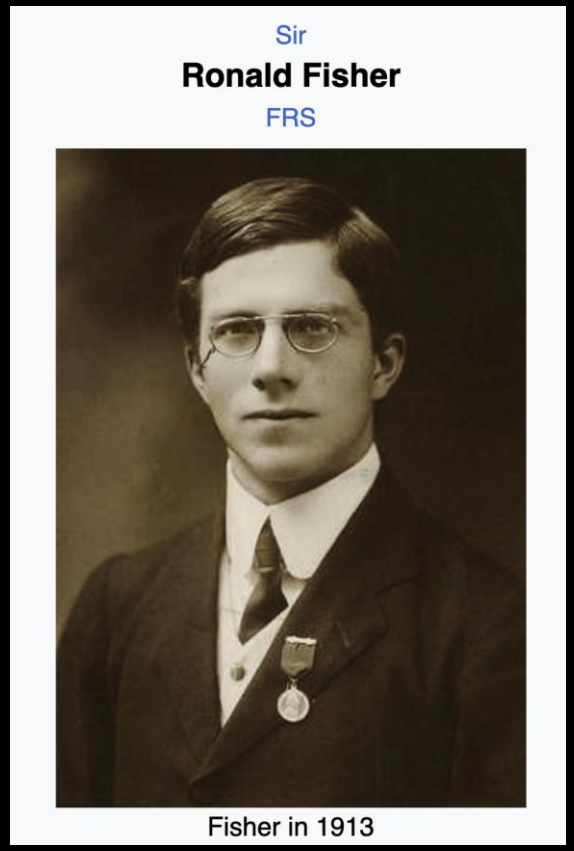


Key challenge to precision agriculture: We don't know *site-specific yield responses*, so we don't know the picture:




Another interesting fact: The person who pretty much invented modern statistics did it because he was trying to figure out what yield response curves looked like!

R.A. Fisher:



Fisher in 1913

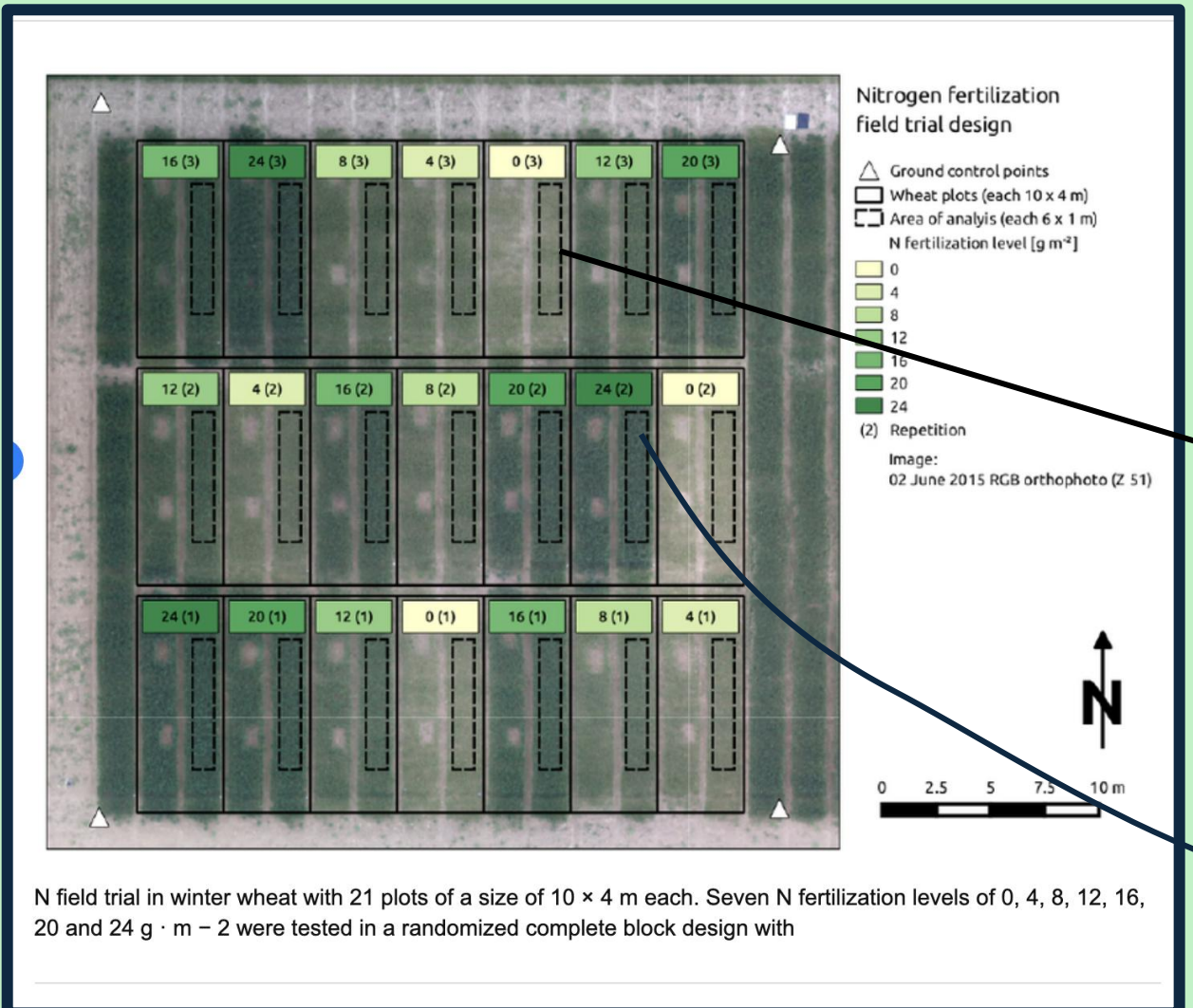
"a genius who almost single-handedly created the foundations for modern statistical science"

Rothamsted Research Station England, 1843-2025

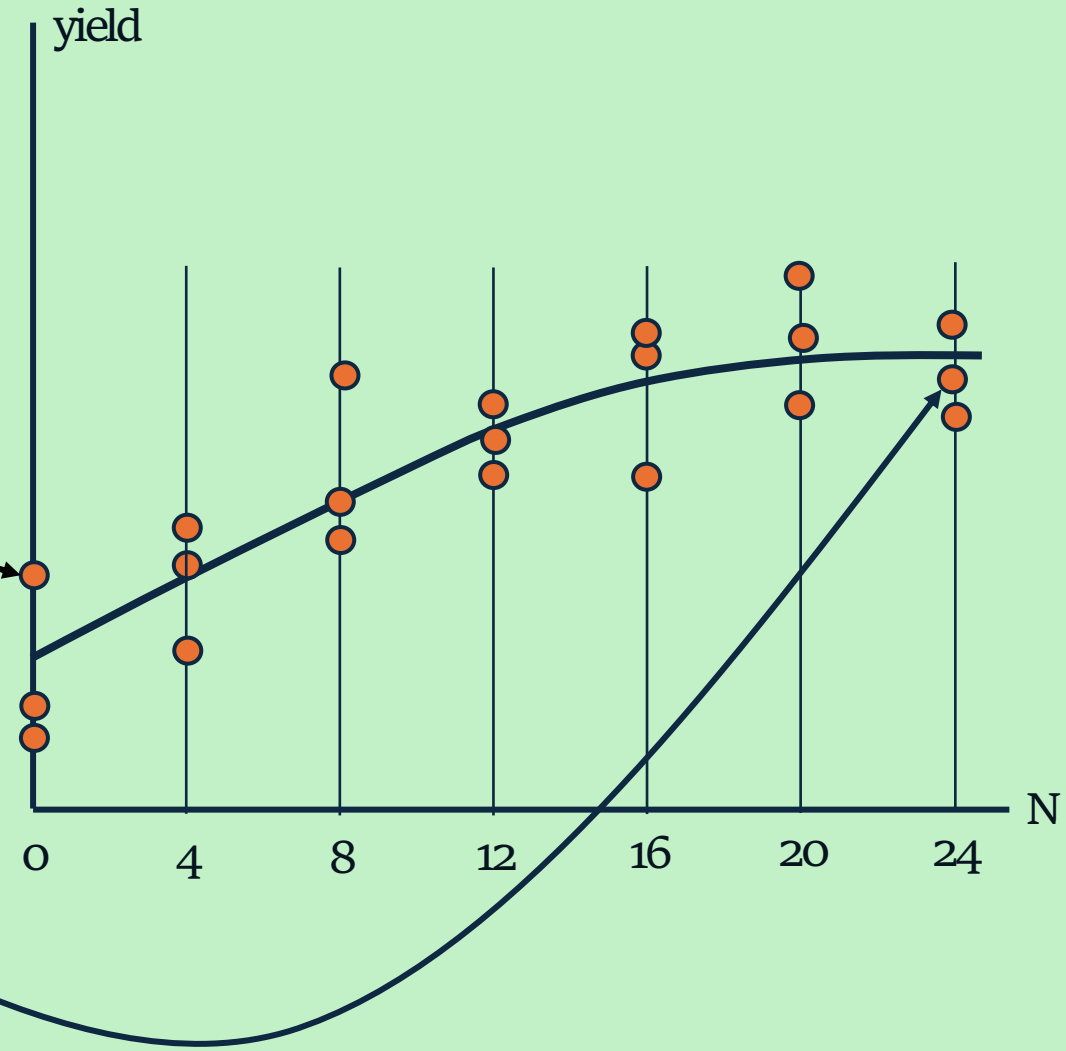
Rothamsted

Long-term Experiments

Fisher worked with data from *small-plot field trials* to estimate yield response curves:



N field trial in winter wheat with 21 plots of a size of 10 × 4 m each. Seven N fertilization levels of 0, 4, 8, 12, 16, 20 and 24 g · m − 2 were tested in a randomized complete block design with



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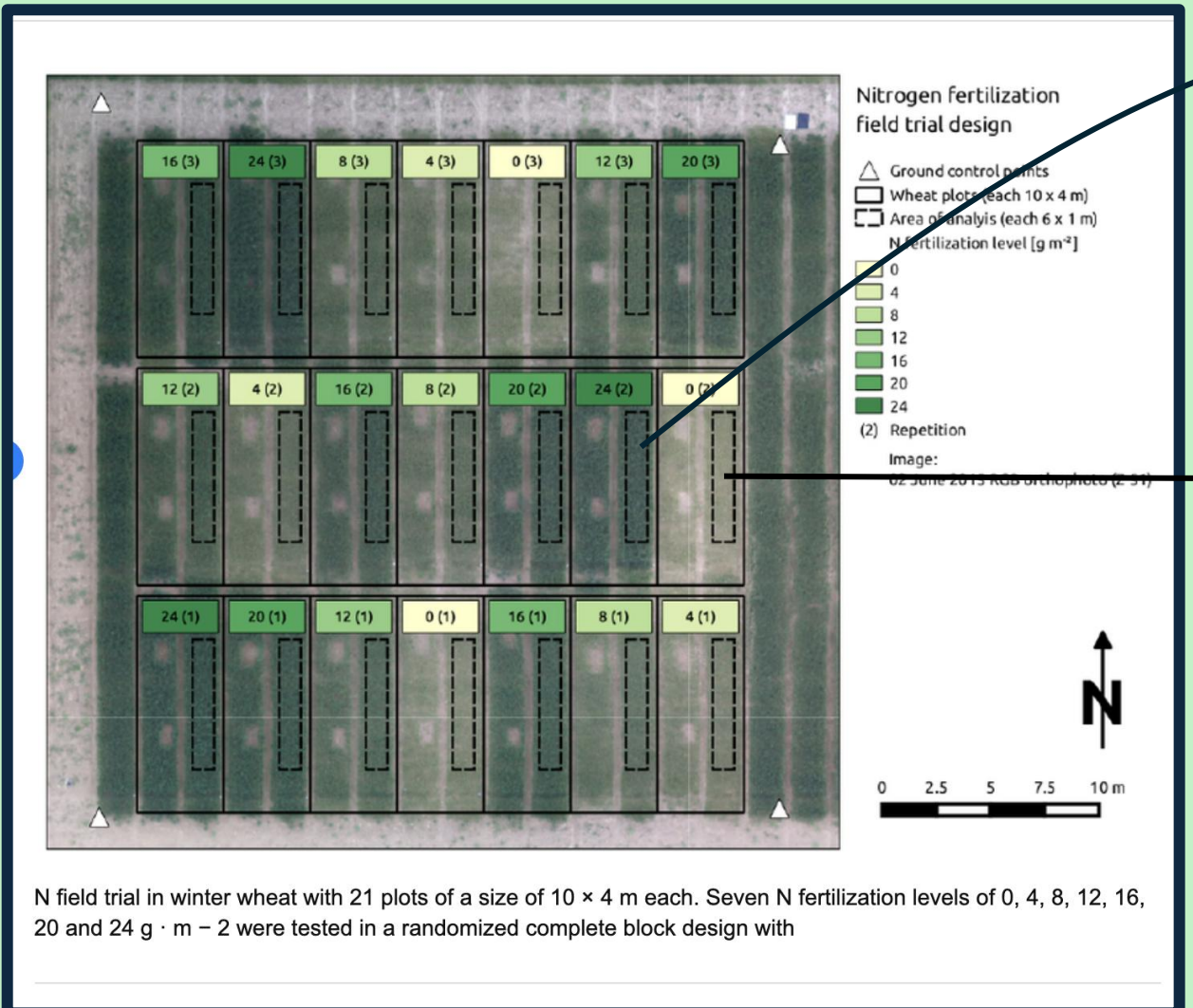

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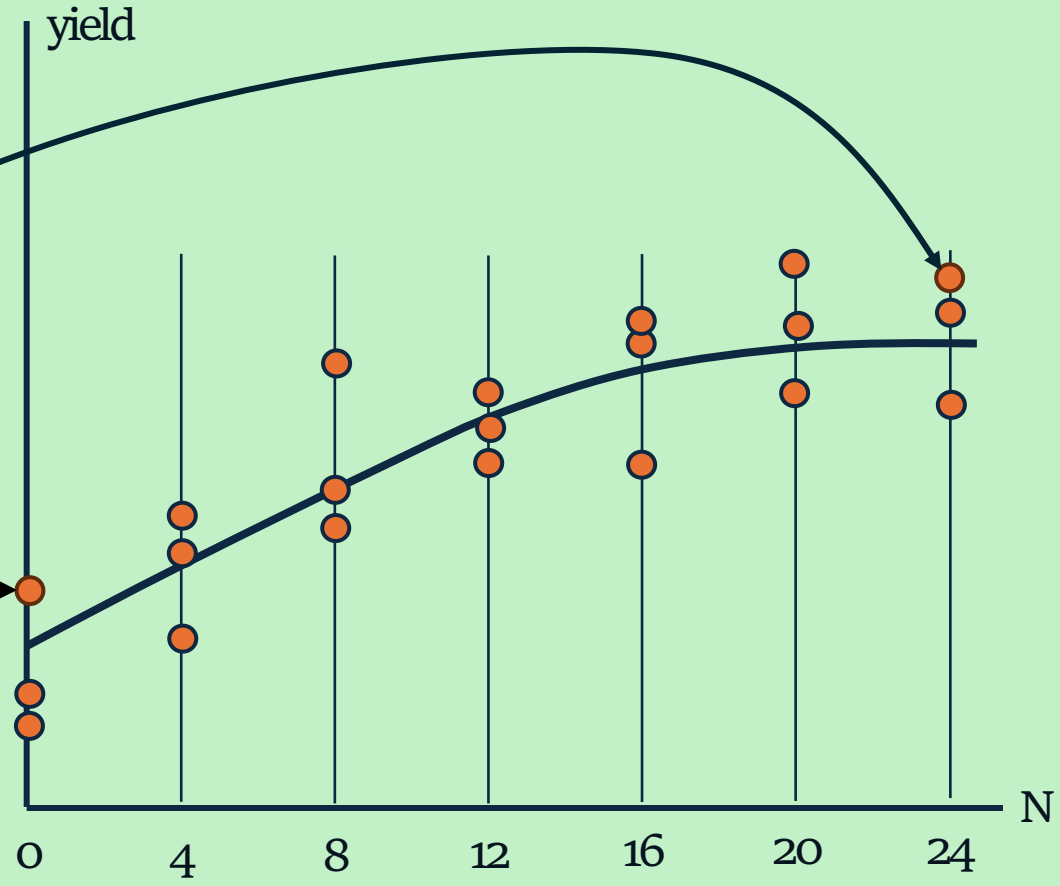
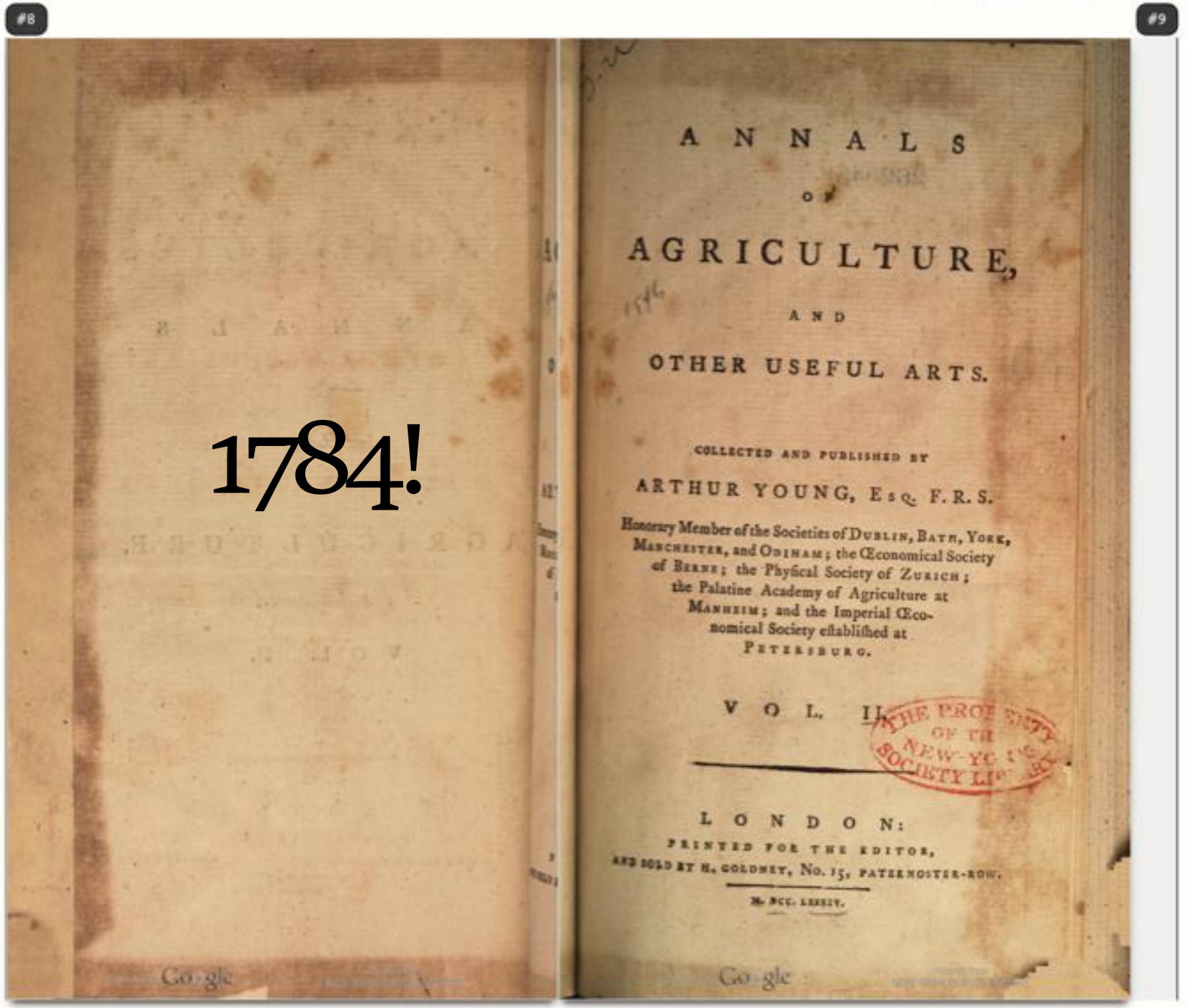


Farmers have been conducting small-plot field trials to learn about yield response for centuries:



Agronomists get a huge part of their data from small-plot field trials. Thousands of small-plot trials are run by public- and private-sector researchers every year.

They lay out small plots using tape measures and orange flags:

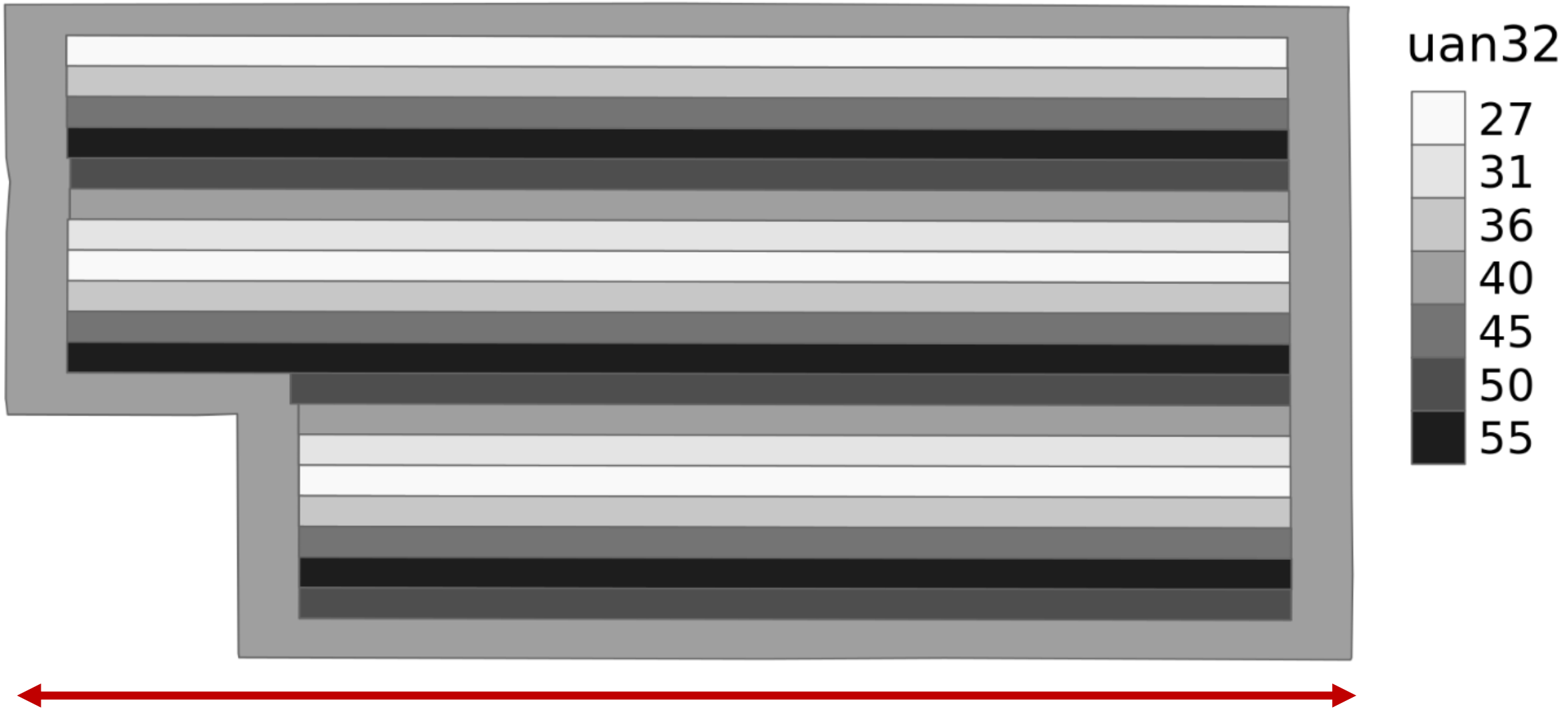
Student or technician labor:

Applying inputs by hand or with special equipment:

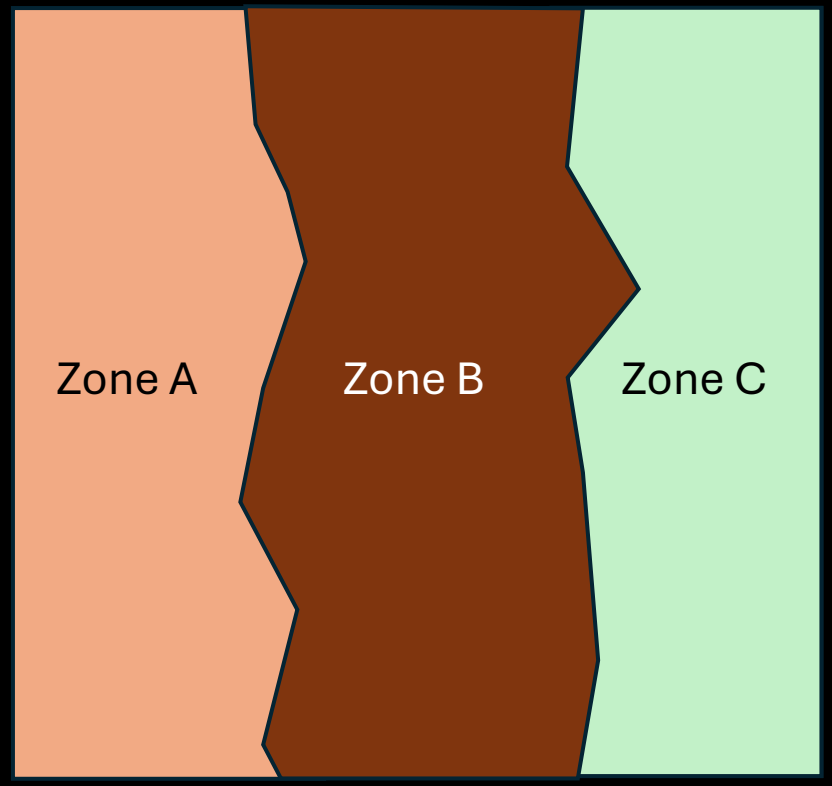
Small-plot trials are small because they are labor-intensive and therefore *expensive*.

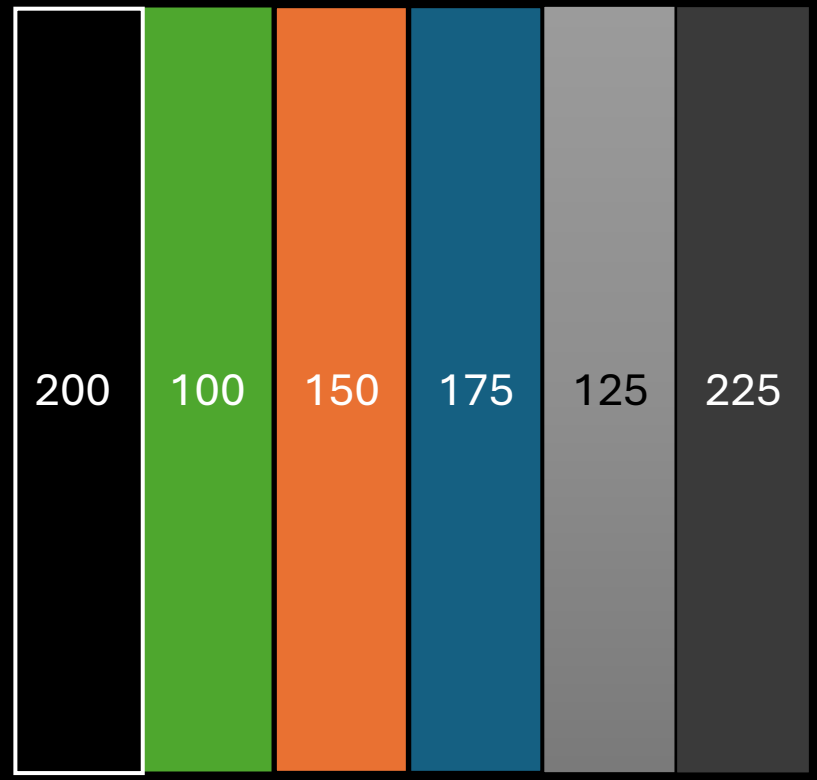
And because they are small, small-plot trials have limited *inference spaces*. (What do the results on this little piece of land mean for management of a different field?)

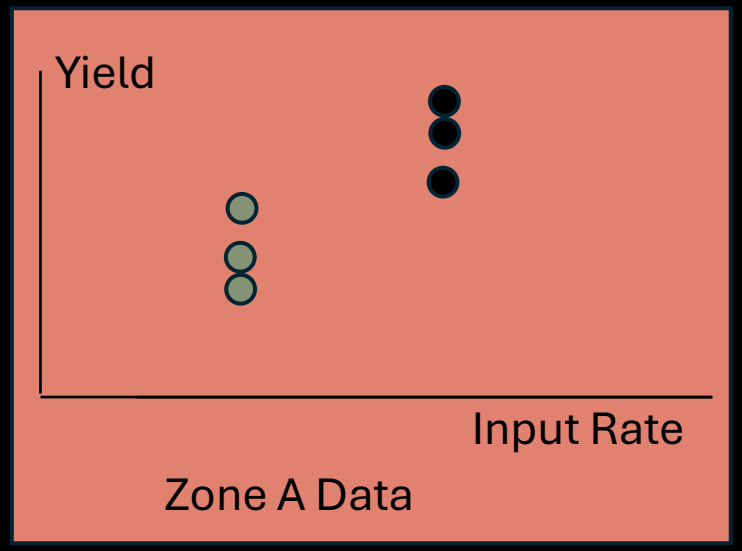
Strip trials are an often-used alternative to small-plot trials:

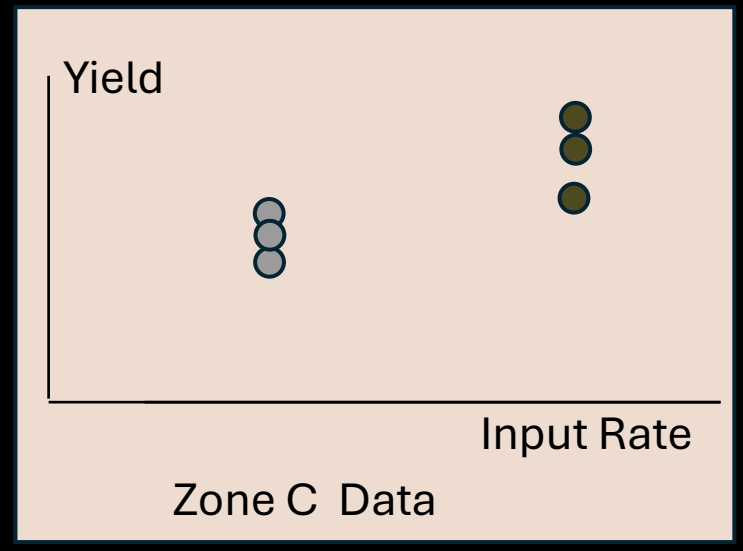


The problem with strip trials is that while they are big, they sometimes provide only limited spatial variance of the trial input rates, and so they may not be real helpful to inform site-specific management.









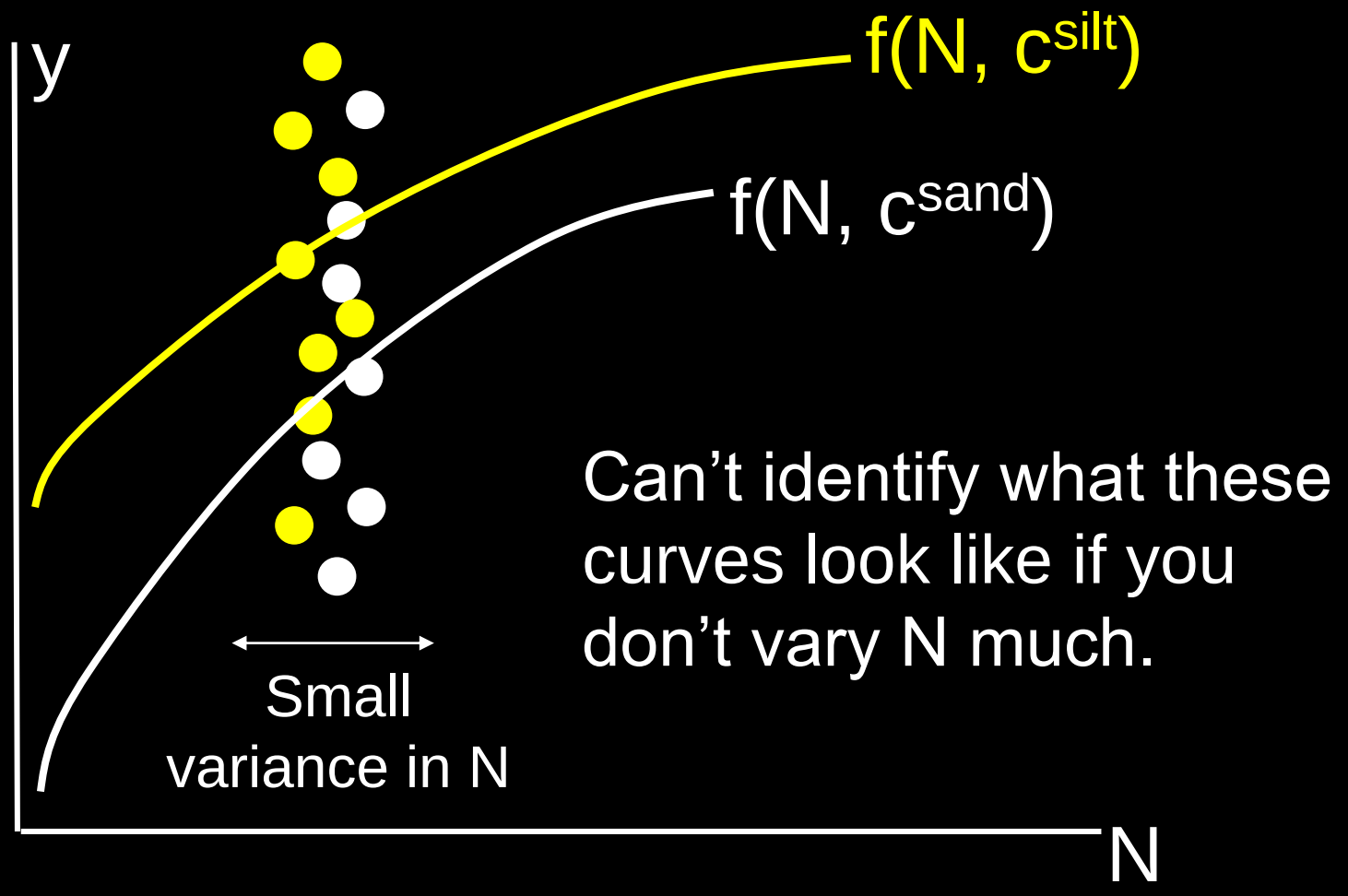
Switch gears:
Precision Agricultural Technology

Back in the 90s, a lot of smart people saw the potential of GPS, and engineered variable-rate input application machinery, and yield monitors to create a technology to allow farms to farm “precisely.” Saw a lot of pictures like this:

“We can farm by the meter!”

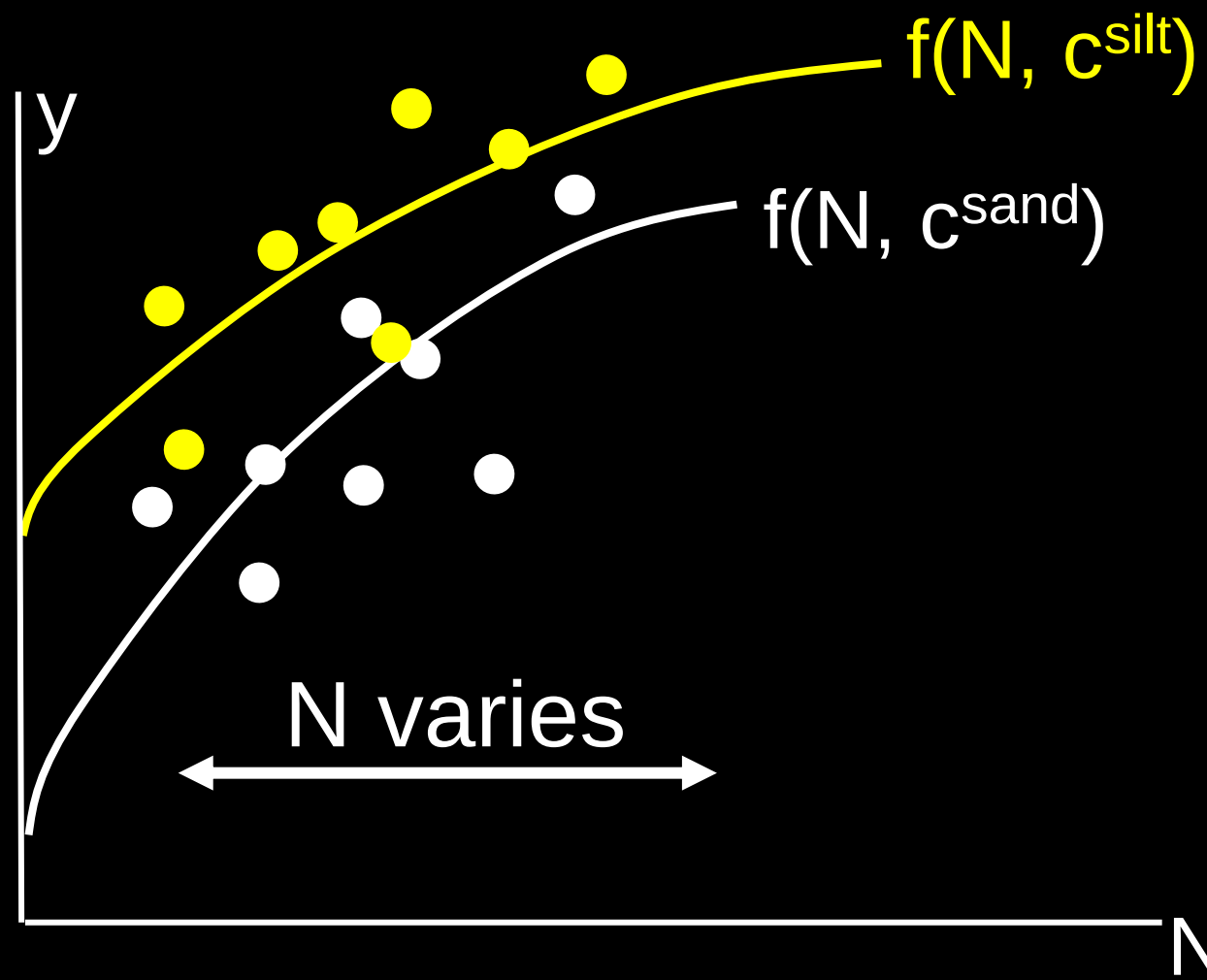
And for the past decade the idea of using drones and robots to get data to use for precision crop management has been all the rage:

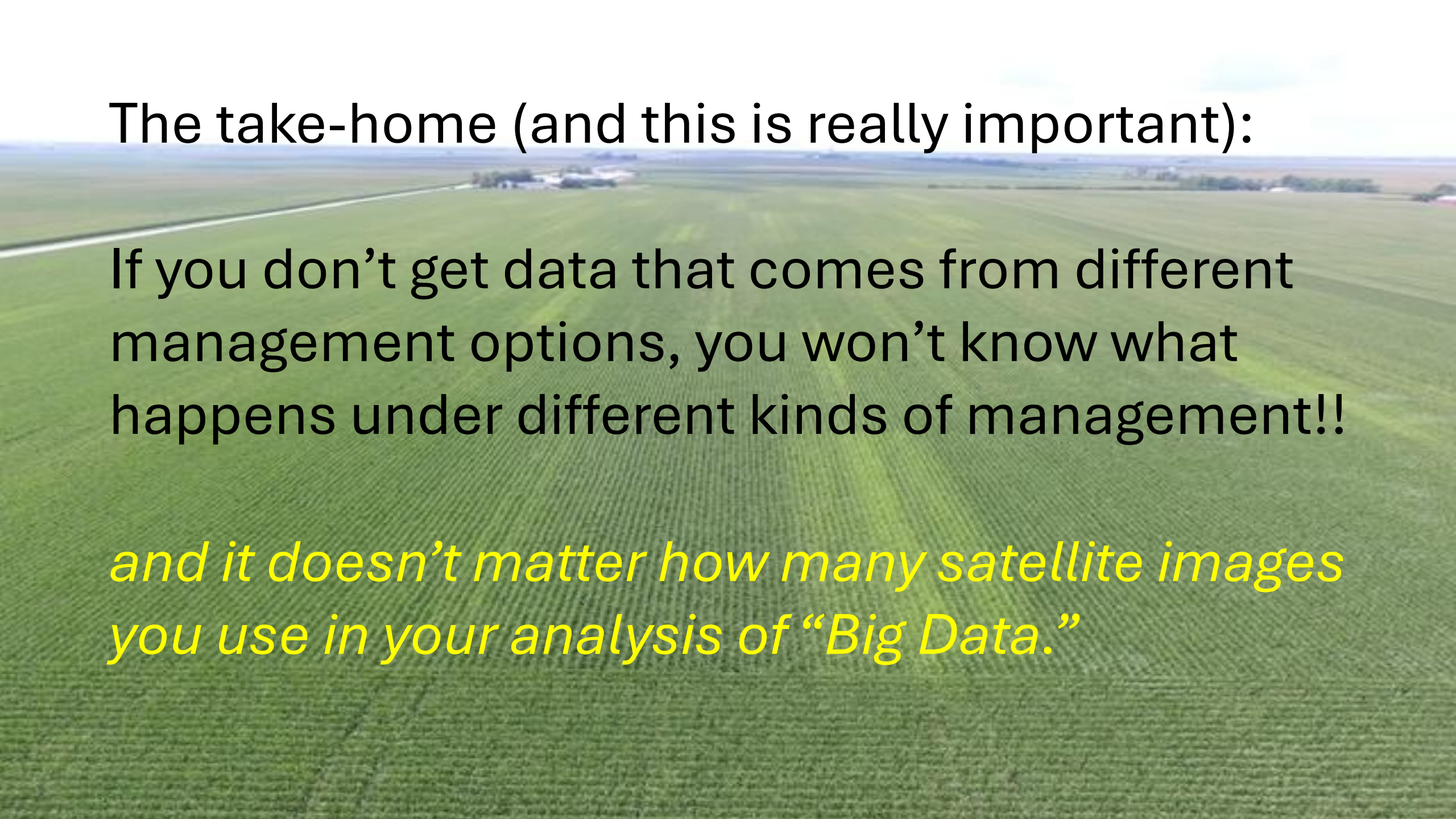
This fact is often lost in the discussion: *no matter how many drones we fly, if our data doesn't feature sufficiently varied input rates, it's usually not possible to determine the picture*. (Can't fit curves through columns of data.)



Can't identify what these curves look like if you don't vary N much.

So agronomic field trials vary managed input rates, to see how yield responds to different rates in different environments:





The take-home (and this is really important):

If you don’t get data that comes from different management options, you won’t know what happens under different kinds of management!!

and it doesn’t matter how many satellite images you use in your analysis of “Big Data.”

An alternative idea:

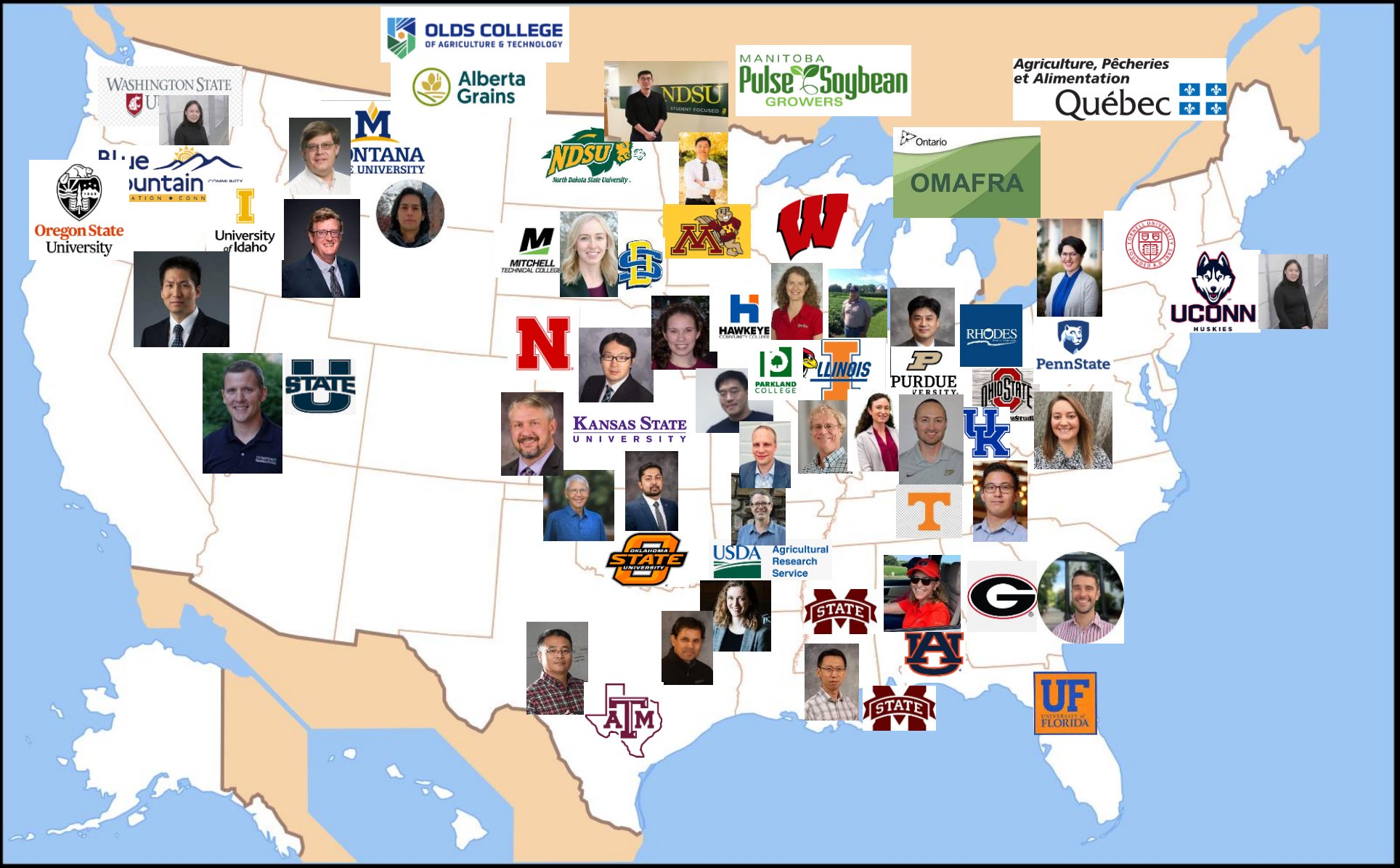
On-farm Precision Experimentation.

OFPE uses precision technology to generate the data needed to estimate site-specific yield responses.

OFPEs are way bigger,

way cheaper,

and implemented by farmers on their own fields to get information about how to manage those same fields.



South Africa

DIFM-affiliated partners around the world are working on OFPEs and an OFPE cyber-infrastructure

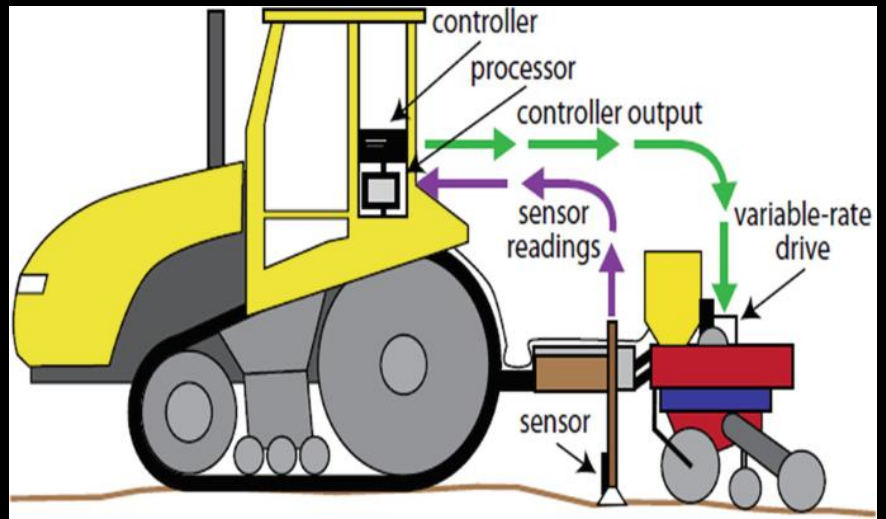
In 2025, farmers and crop consultants from twenty U.S. states and four Candian provinces will working with DIFM to design, run, and analyze the results of on-farm precision experiments.

But we don’t want to run 150 trials. We want to give the world the ability to run *tens of thousands* of trials every year. For this we have developed the difm.farm cyber-infrastructure.

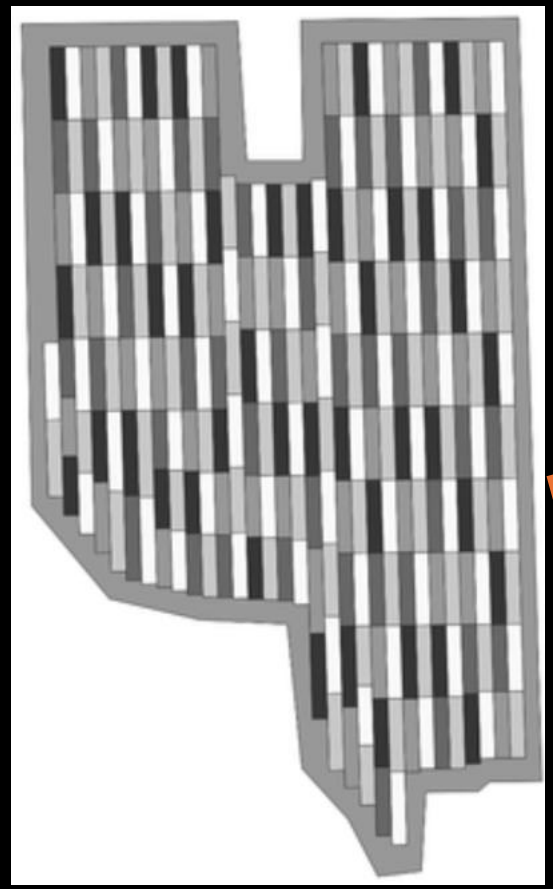
Some basics: the types of precision agriculture technologies used in on-farm precision experimentation:

Variable-rate Input Applicators

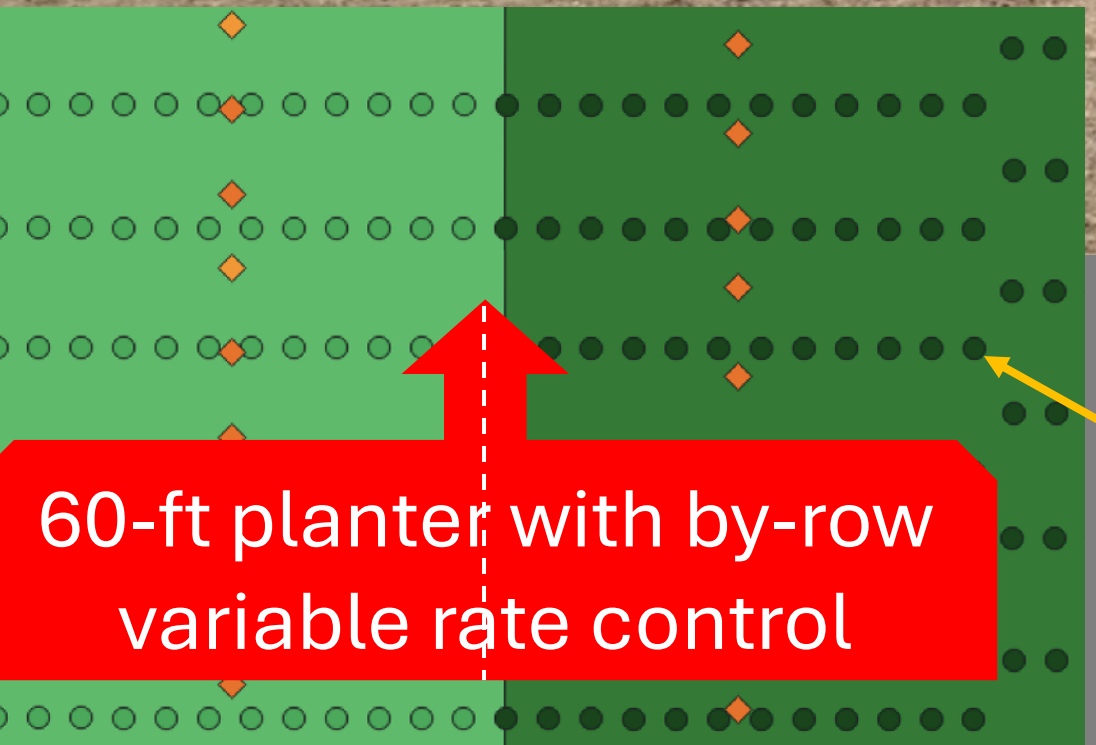
Variable-rate applicators use computer files, software and GPS to apply inputs at different in different parts of the field.

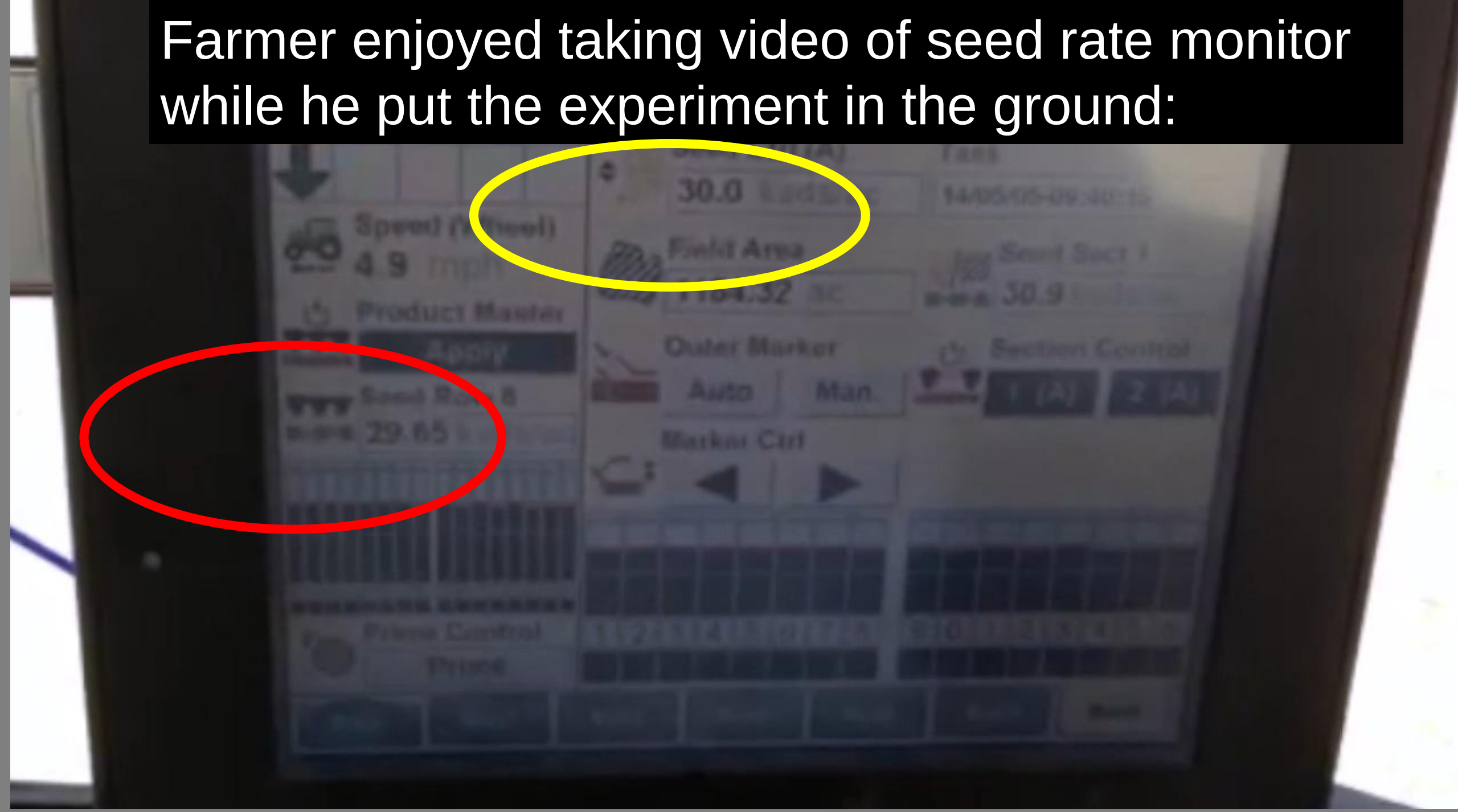


- Machine operator can upload a trial design shapefile just like any other variable rate “prescription”:

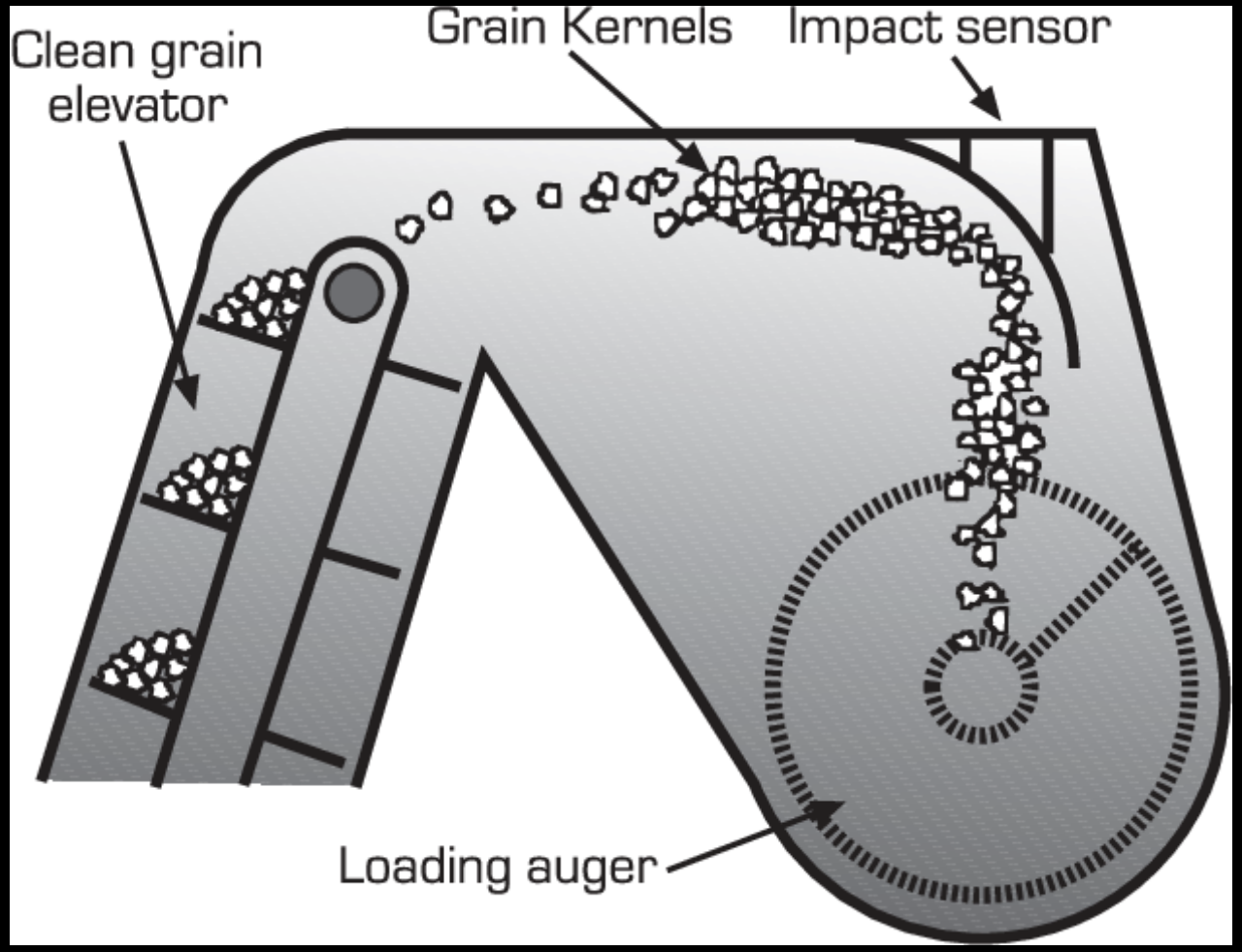


Then the variable rate planter and the GPS worked with the trial design shapefile to put the trial design “in the ground” while the farmer *just drives*.

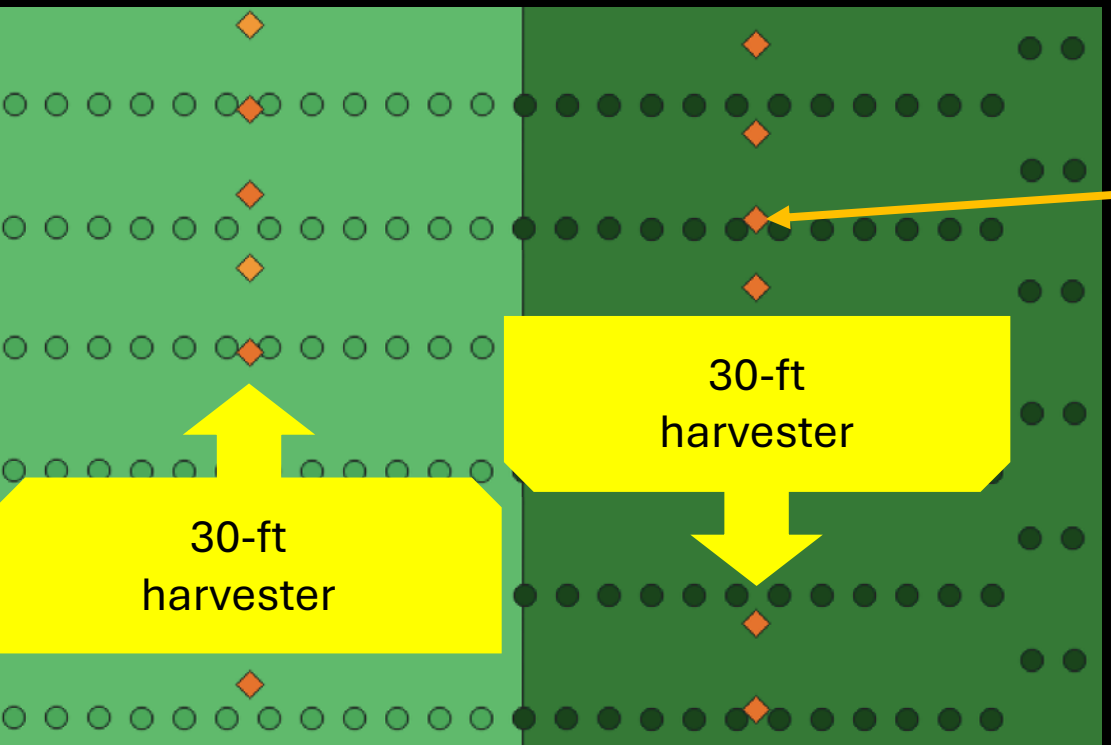



Farmer enjoyed taking video of seed rate monitor while he put the experiment in the ground:
30.0
Field Area
4.9
Product Master
Outer Marker
Auto
Man
29.65

At harvest, yield monitors record yield and provide a data point every five or six feet:

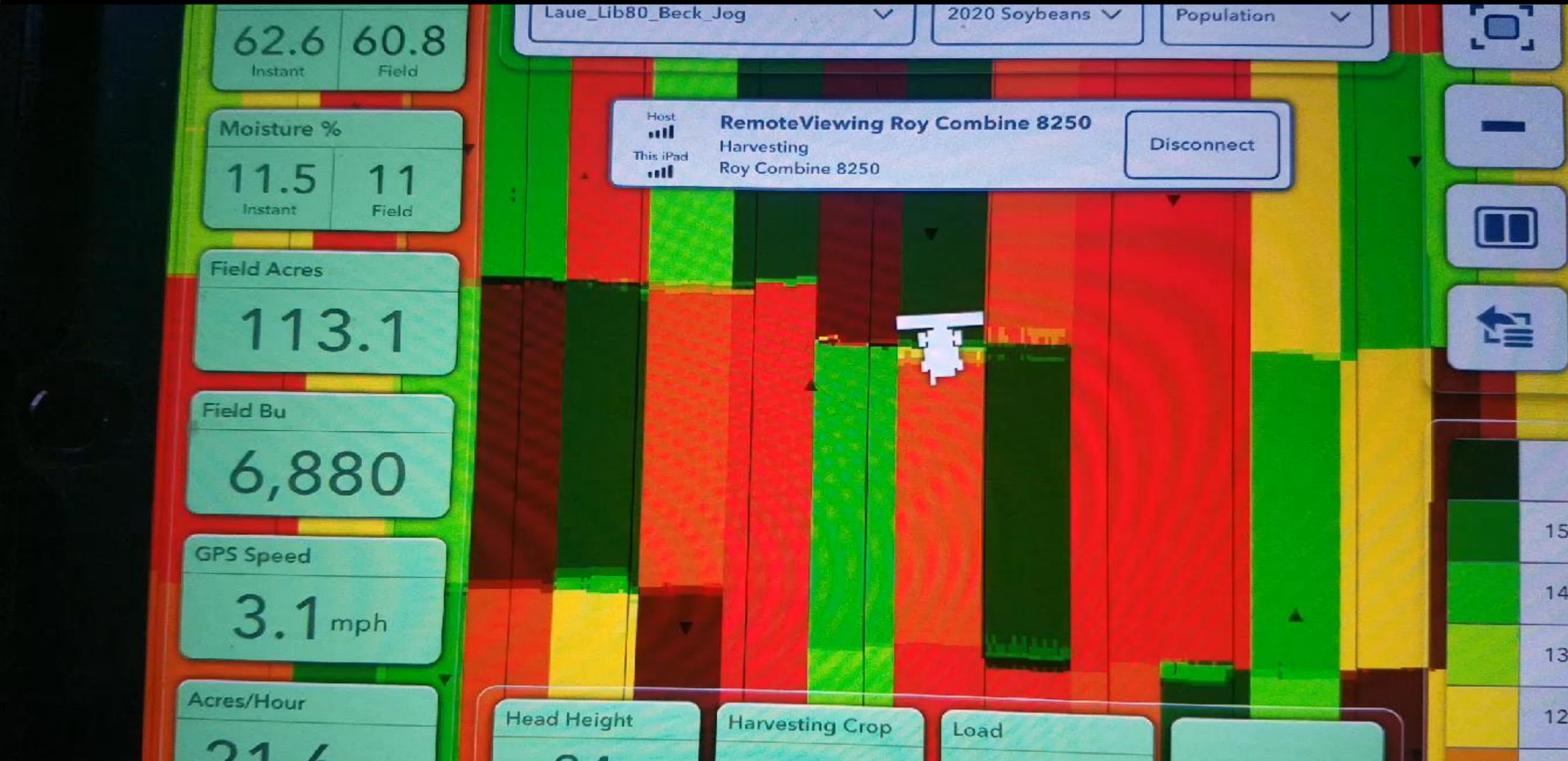


At harvest, a yield monitor is used to record yields over the entire field:

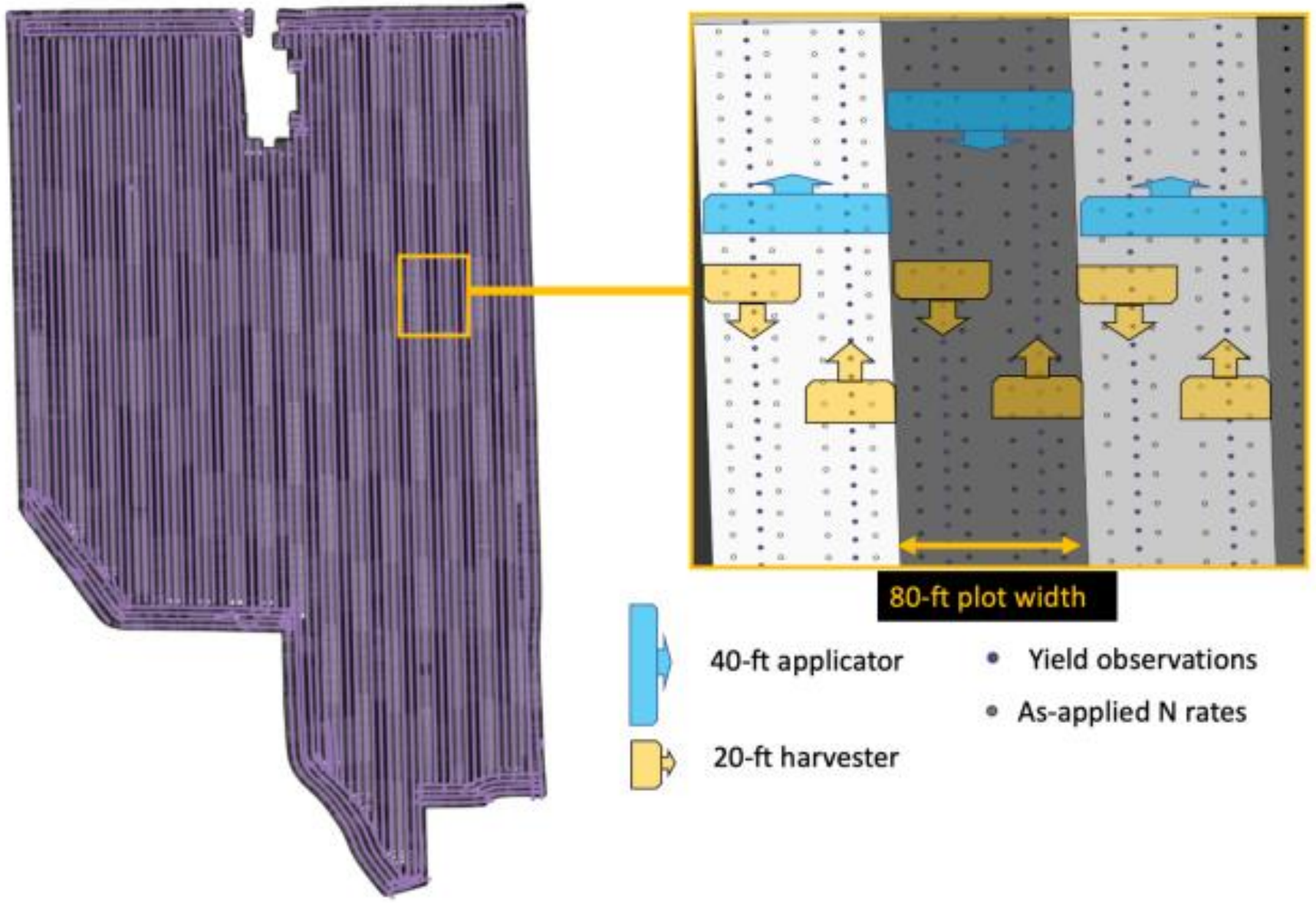


yield data

Gathering yield data at harvest:



Yield and application rate data are generated:



On-Farm Precision Experimentation on a 71-acre Ohio field:

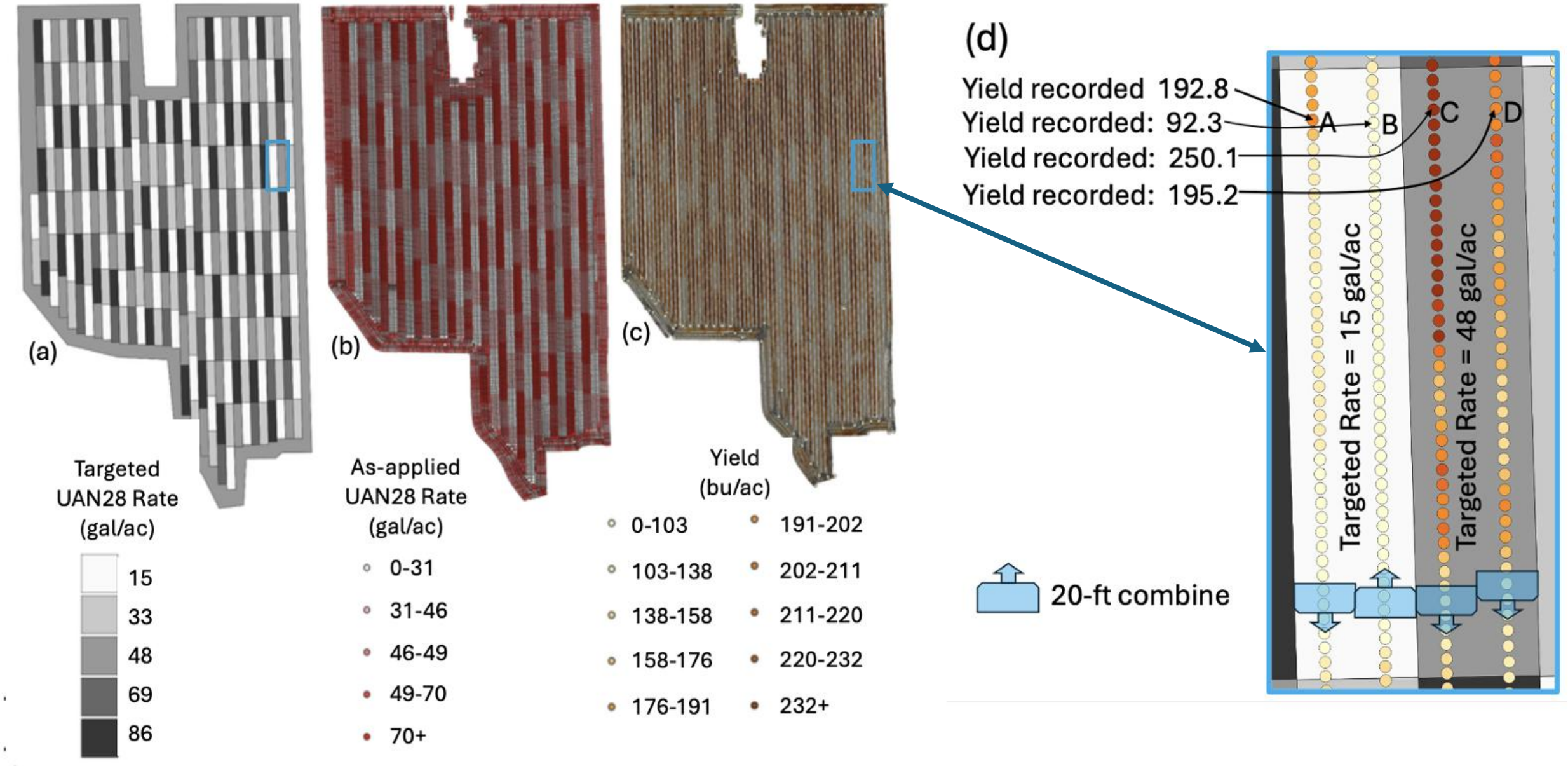


Figure 5. (a) OFPE design, (b) as-applied map, (c) yield map, (d) close-up of boxed areas shown in

But how can a regular farmer or crop consultant do this?

- Aren’t there computer programs to write?
- How would a farmer know what a trial design should look like?
- Where does the data go? How can they be managed?
- Who analyzes the data and figures out what it means for crop production management?
- Who writes down the results and interpretations?

DIFM has developed a user-friendly cyber-infrastructure that automates these tasks. https://difm.farm.

It's free! It's a public resource.

Demonstrate: With difm.farm, anyone can:

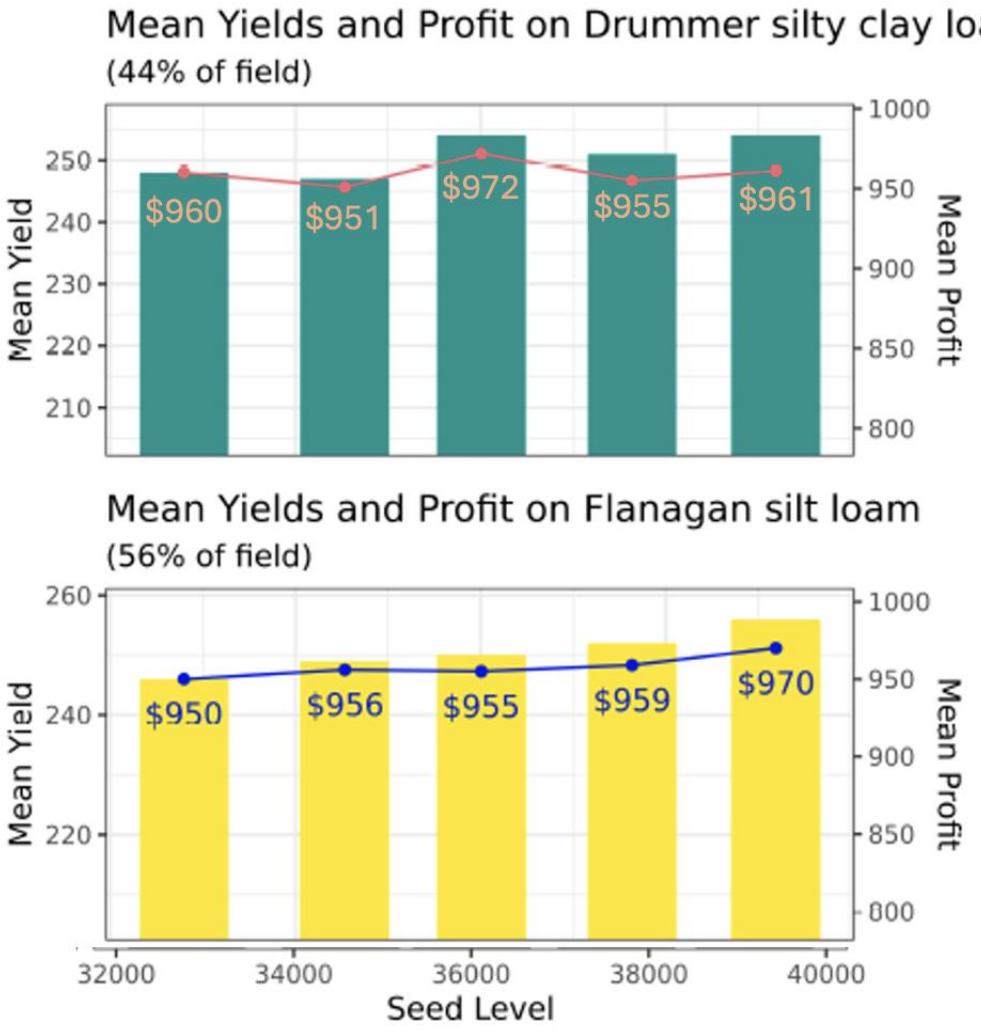
- Create field trial design “shapefiles”
- Get help putting the trial designs “in the ground”
- Upload, process, manage data
- Create reports that discuss the real-world implications of the data analysis.

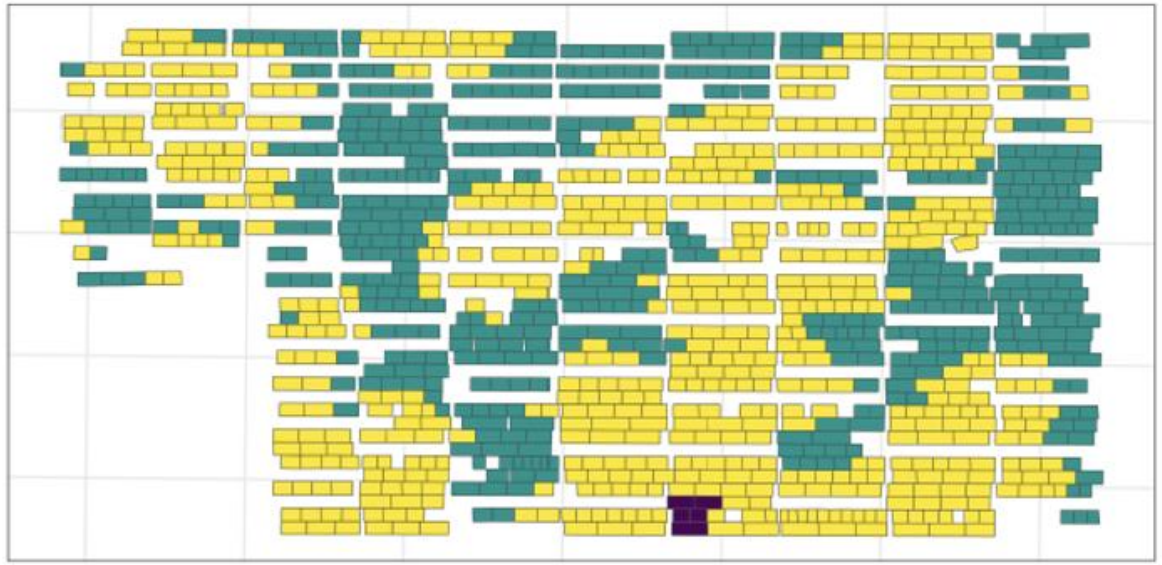
***Question to translators: This is about a 5-minute video, and the narrator is talking very rapidly. Do you want to translate the audio? It will be a lot. I am only going to play the part of the video after the 1:35 time mark.

https://www.youtube.com/watch?v=JTqs8twZ3ho

Site-specific Management Recommendations

The analytical engine looks for field characteristic that affect optimal management, and the automatic reporting system illustrates these relationships

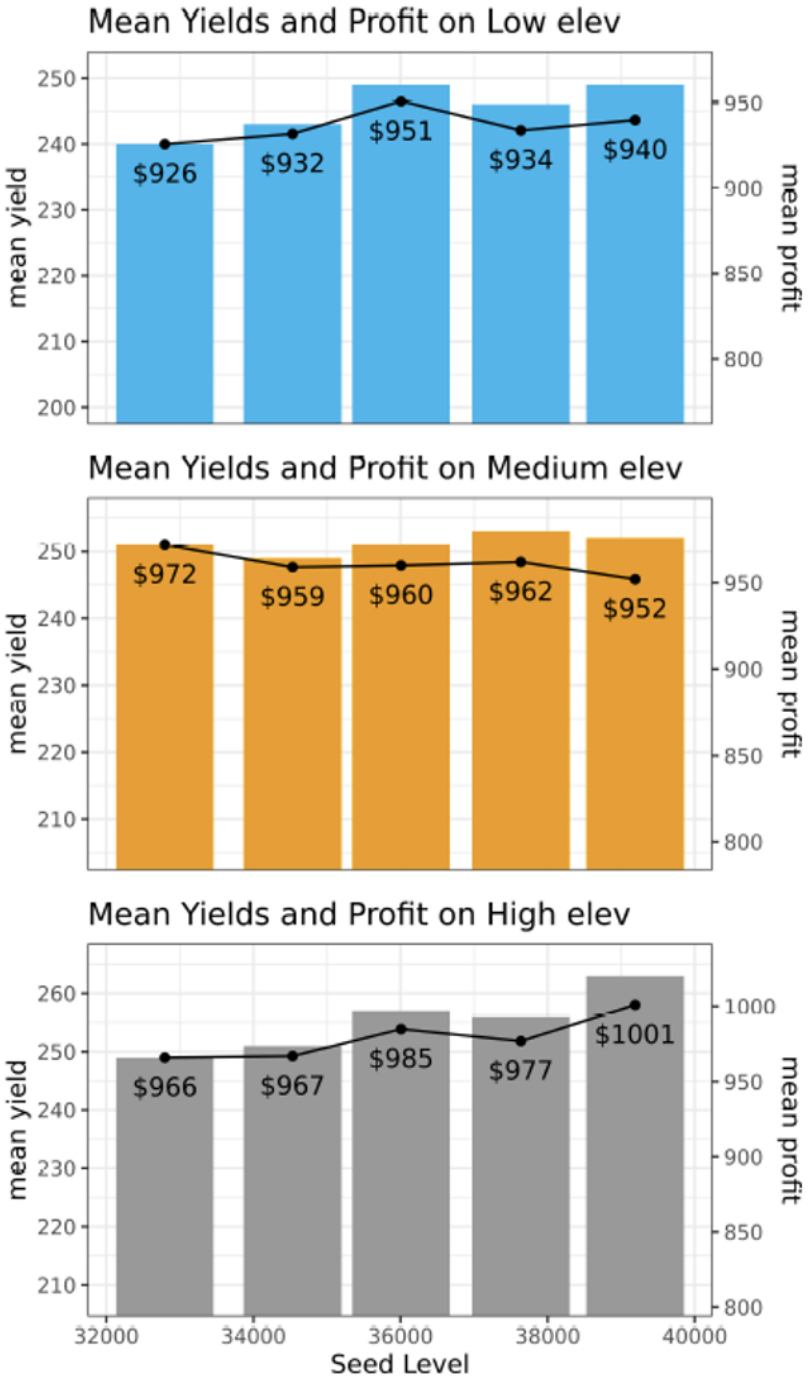




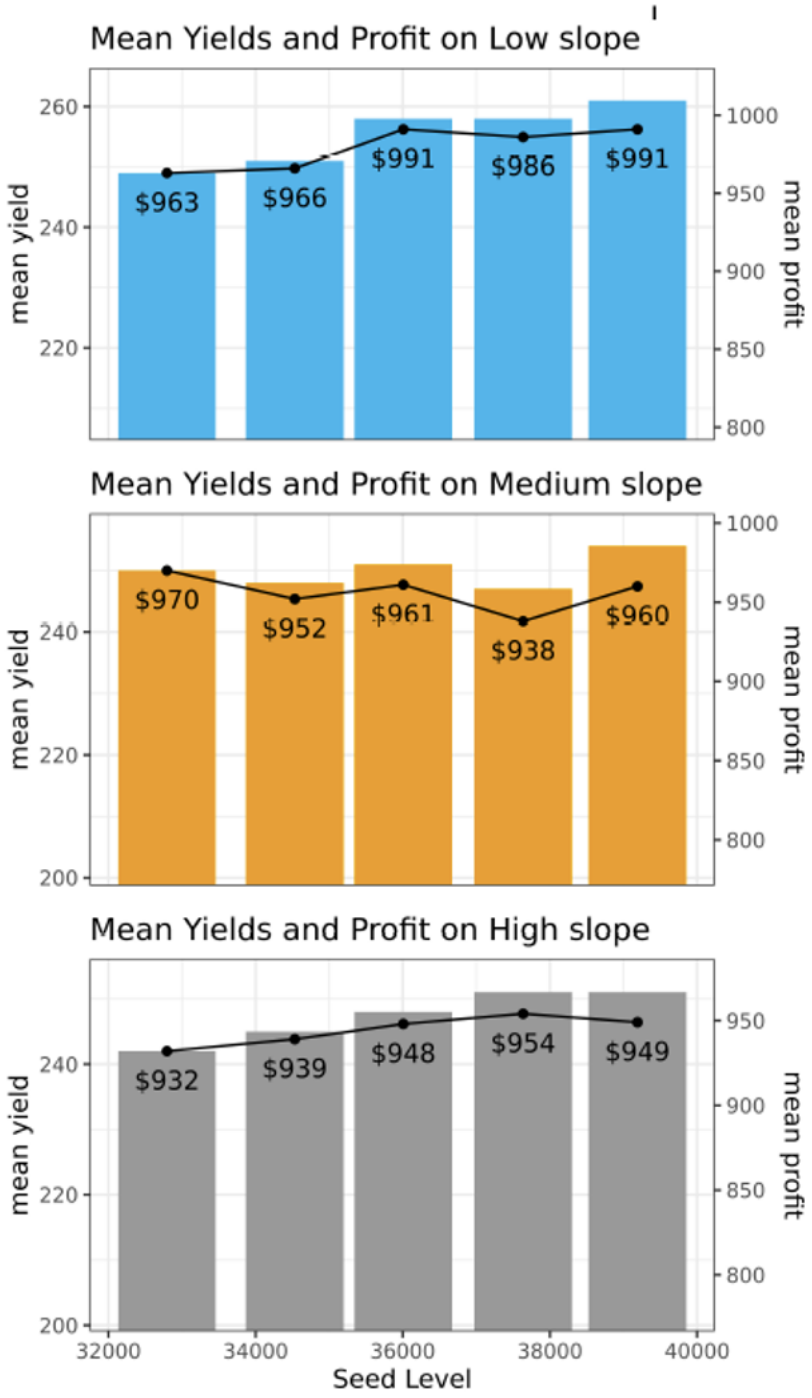
Soil Type

- Drummer silty clay loam
- Flanagan silt loam

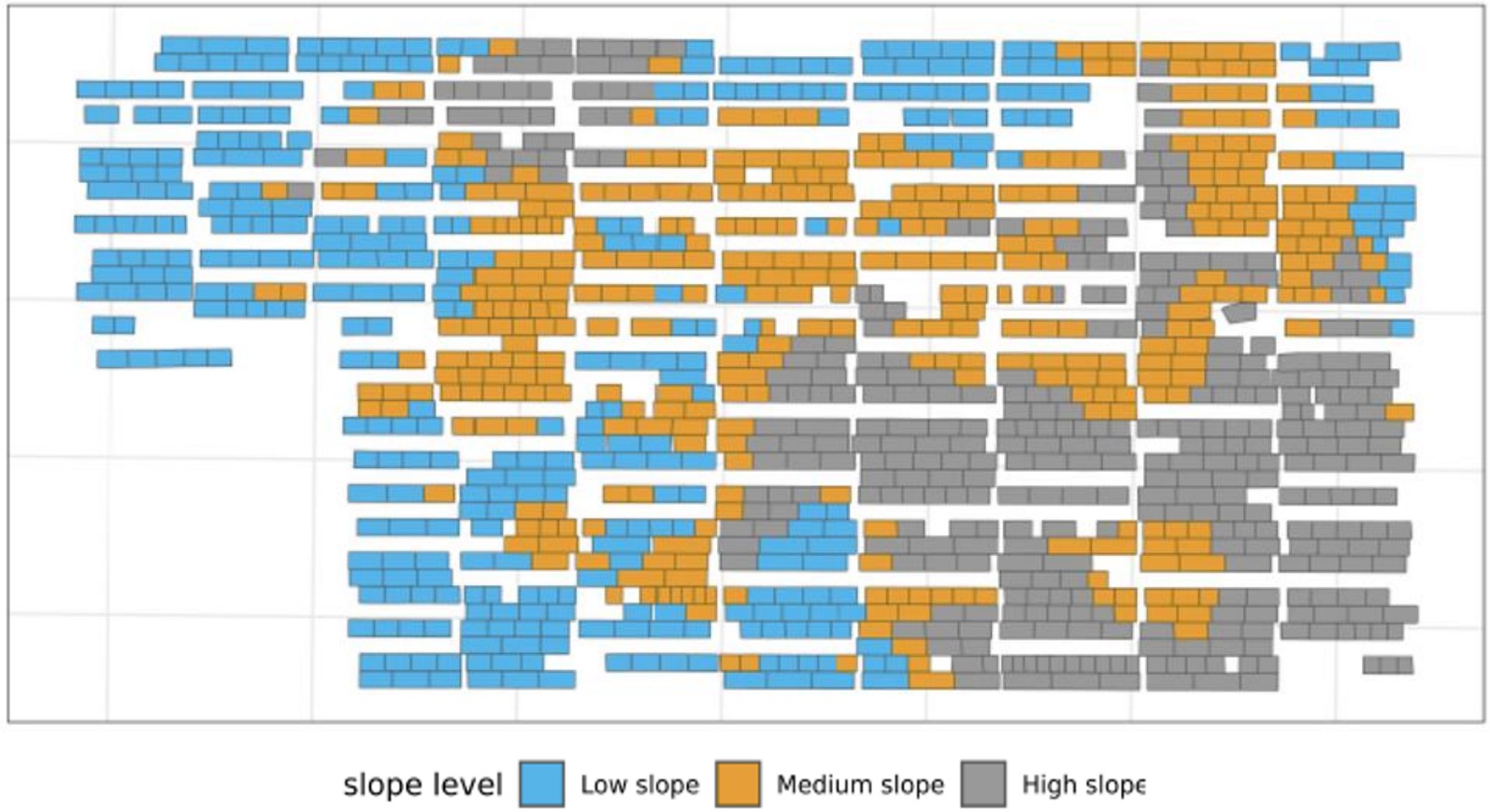
Yield and profit response to seeding strategy by elev level



Low elev Medium elev High elev



Profit and yield response to seeding strategy by slope level



Best of all, using difm.farm is free!
DIFM has won over $9 million in grants from the U.S. Department of Agriculture. DIFM's mission is to help farmers and their advisors all over the world to promote more profitable and sustainable crop production.

Data Security and Ownership

- Farms own their data. DIFM will not sell or give away your data without your permission.
- Data is secure within Oracle-based cyber-infrastructure.
- DIFM reserves the right to use your data for academic research. Your farm will remain anonymous.