Variability in Soil Test Values Across Plot, Replication, and Field-Level Sampling

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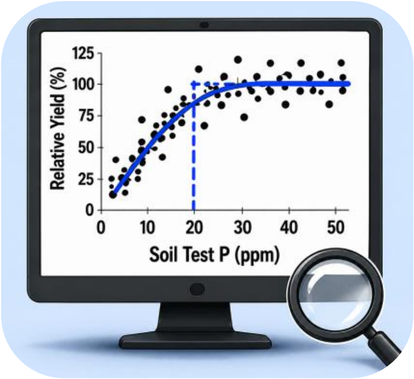
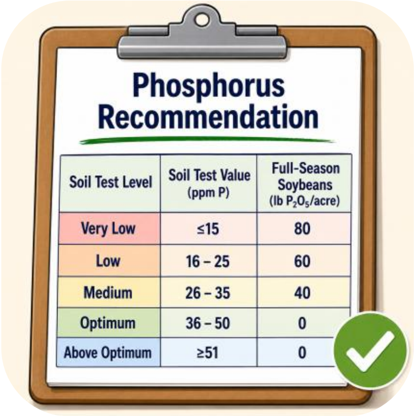
SOIL
FERTILITY

Soil sampling is the foundation for soil test correlation and calibration (STCC) research

Multi-Rate
Field Trials

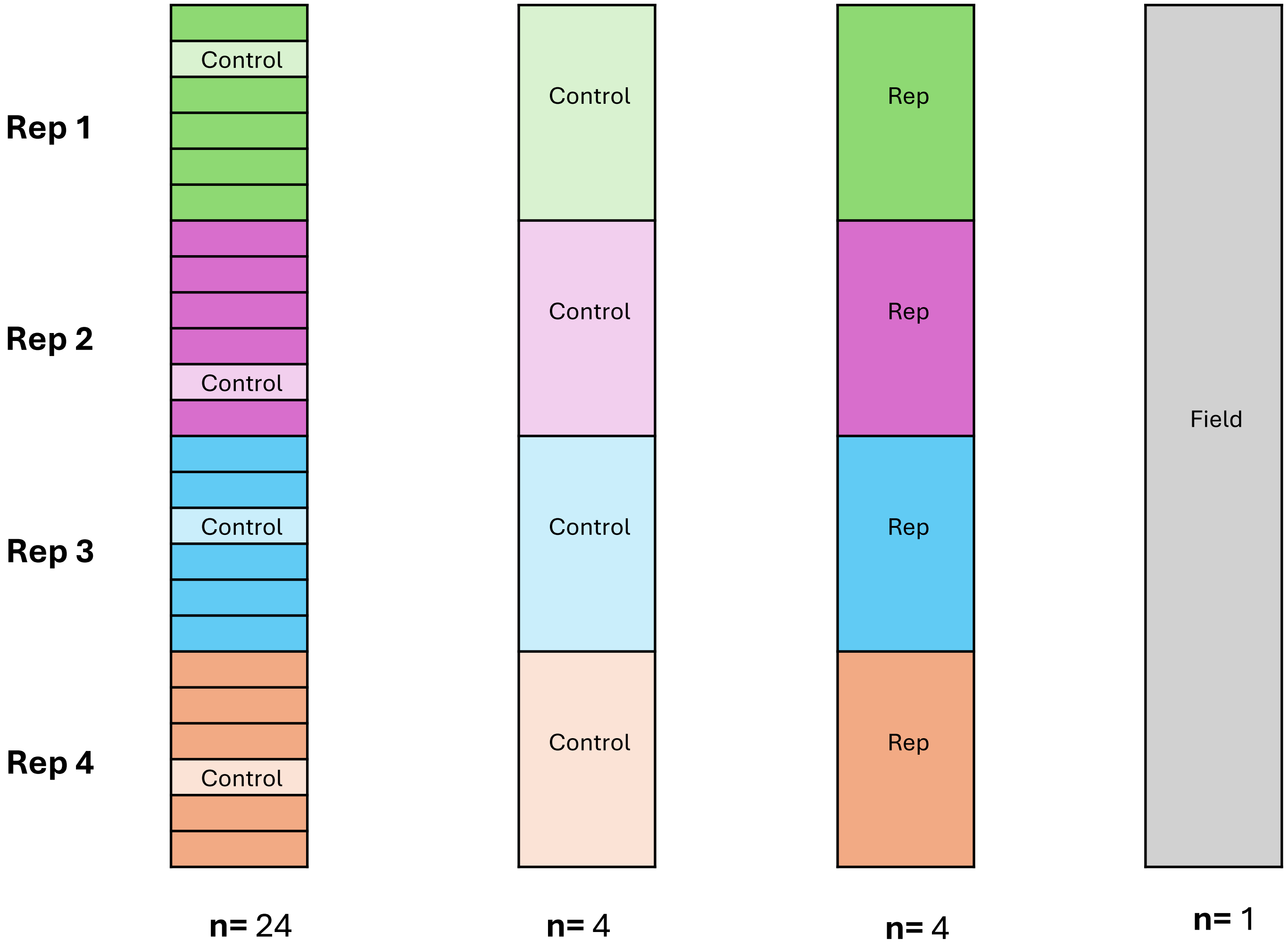


Statistical Correlation
& Modeling



Fertilizer Guidelines

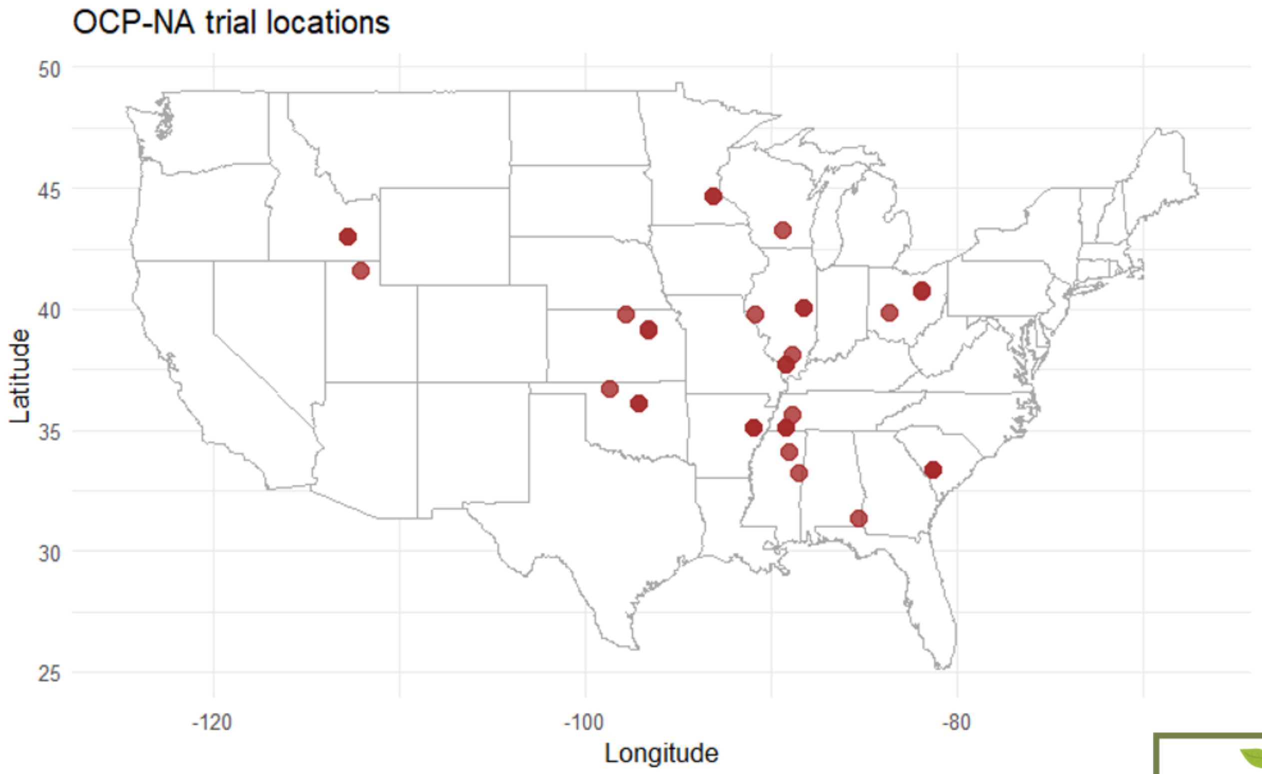
At what level should STCC trials be soil sampled?



Soil sampling inference space

Ideal world vs real world constraints

OCP-NA soil test data (2023-2025)



Metric	n
Number of trials	47
States	15
Replications	4 to 6
Treatments	9 to 20
Plots	36 to 108
Observations	2911

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OCP North America

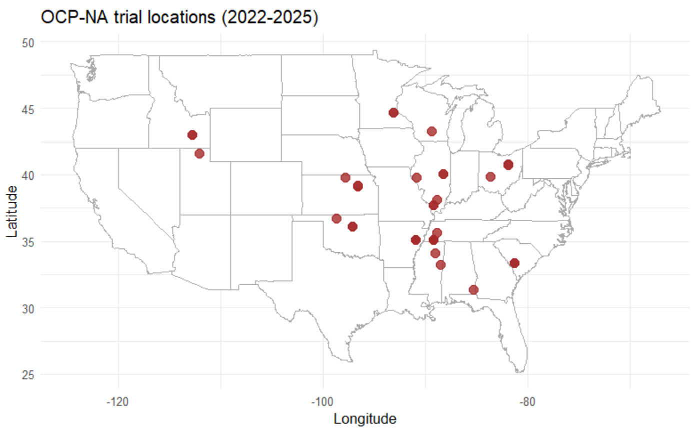
*Not all trials shown in map, only those with available coordinates data.

Objectives

1. Quantify how **soil test P (STP) values change** when summarized at different **sampling inference spaces** (plot, block/rep, individual control-plot, and field) across available site-years and identify conditions associated with greater within-trial variability.

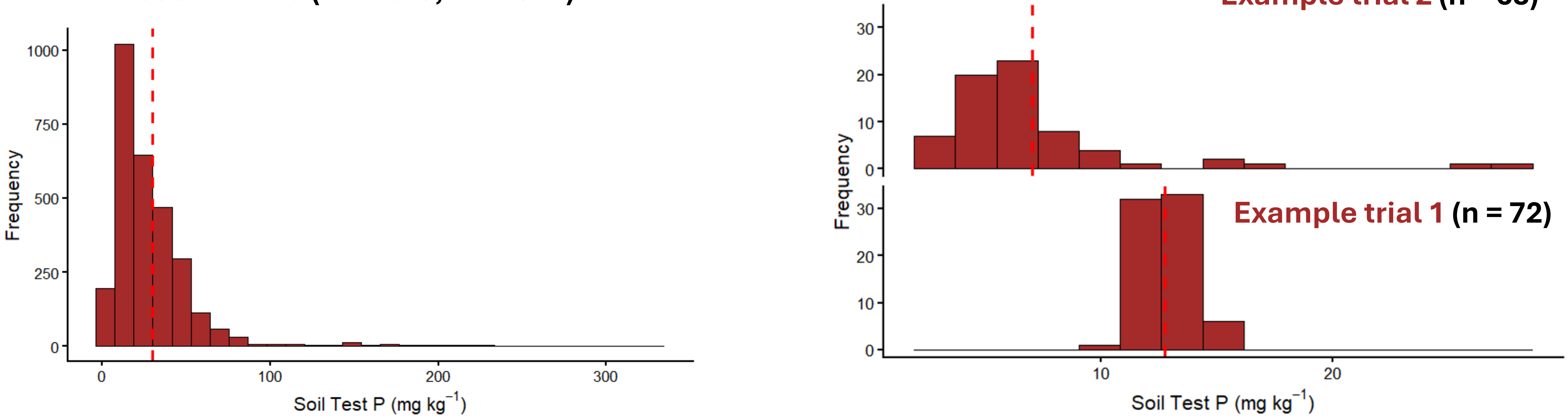
2. Determine whether **sampling inference space influences** soil test **correlation and calibration outcomes**, including estimated critical soil test values, and whether impacts are greater in site-years exhibiting higher STP variability.

Methodology



All observations (47 trials; n = 2911)

Example trial 2 (n = 68)



Methodology

1 Plot level variability | The "Noise" Indicators

- **Standard Deviation (SD):** How spread out are the soil test values around the average within the field?
- **Coefficient of Variation (CV):** How variable is this field relative to its average soil test level?
- **Range:** What is the maximum difference between the lowest and highest soil test values in the field?

2 Aggregation effects | The "Compromise" Indicators

- **Mean Absolute Difference (**average of all **| ST agg –ST plot |):** How much do aggregated soil test values differ from plot-level values on average?

3 Factors driving variability | The "Root Cause" Indicators

- **Coefficient of Determination (R^2):** How much of the field-to-field unevenness (CV) is driven by an individual site factor (site properties, management decisions, and trial design and layout)?

Results - 1 Plot level variability

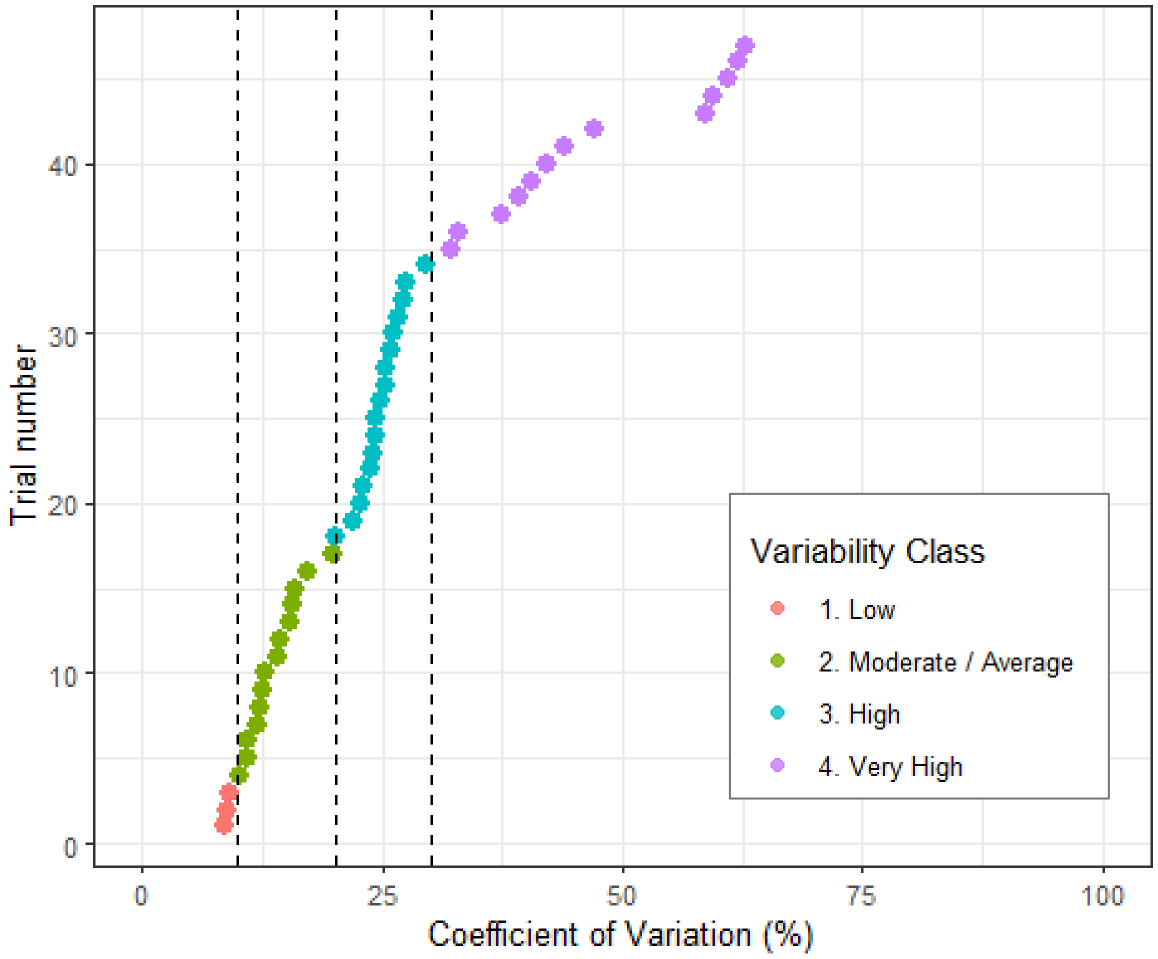
Table 1. Overall metrics (SD, CV, and range) of STP values across 47 trials.

Metric	Mean	Median	Min	Max
SD (ppm)				
Range (ppm)				
CV (%)				

Results - 1 Plot level variability

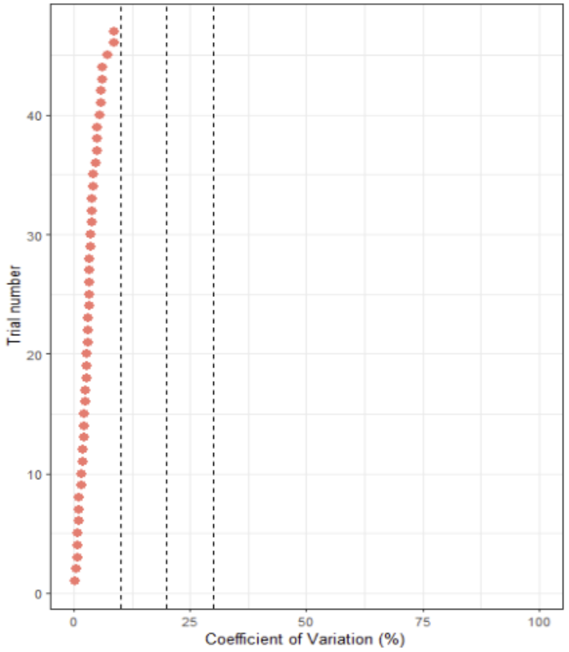
Table 2 and Figure 1. Distribution of trials across different variability classes based on CV of **STP values.**

Variability Class	CV Range	Number of Trials
Low	<10%	3
Moderate	10–20%	14
High	20–30%	17
Very High	>30%	13

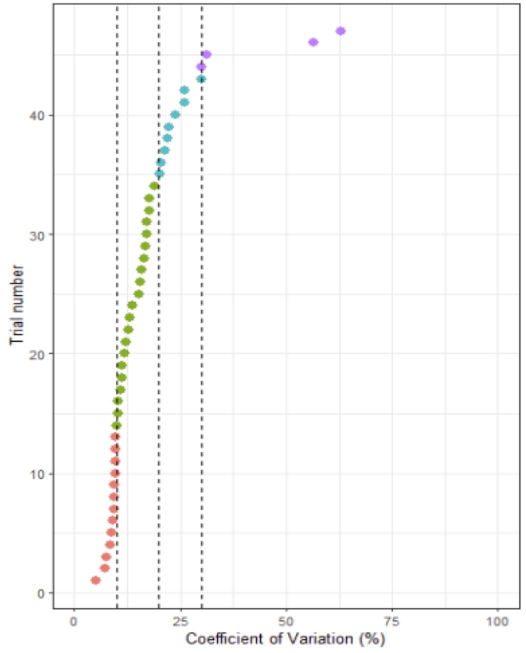


Results - 1 Plot level variability

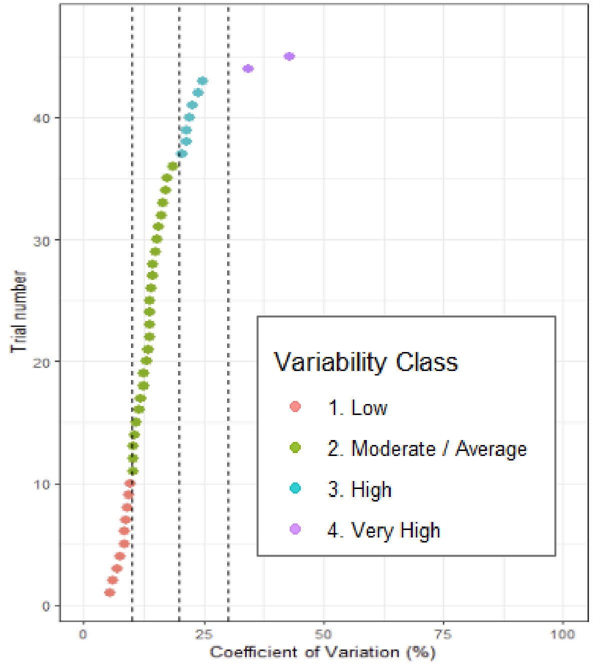
Soil pH



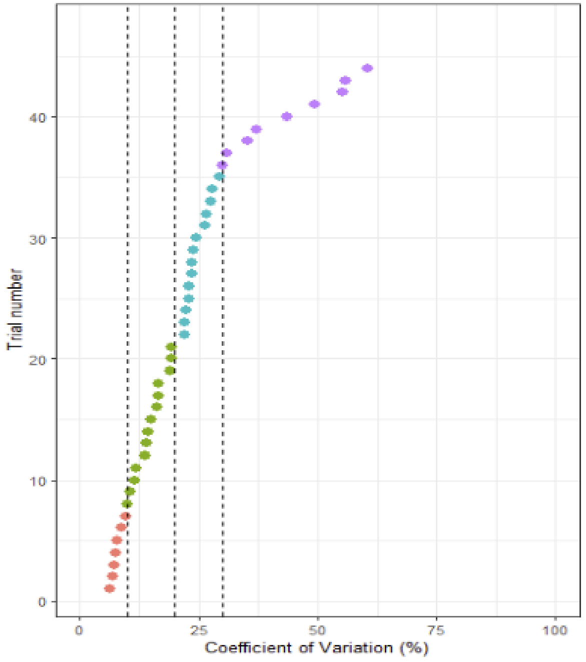
Potassium (K)



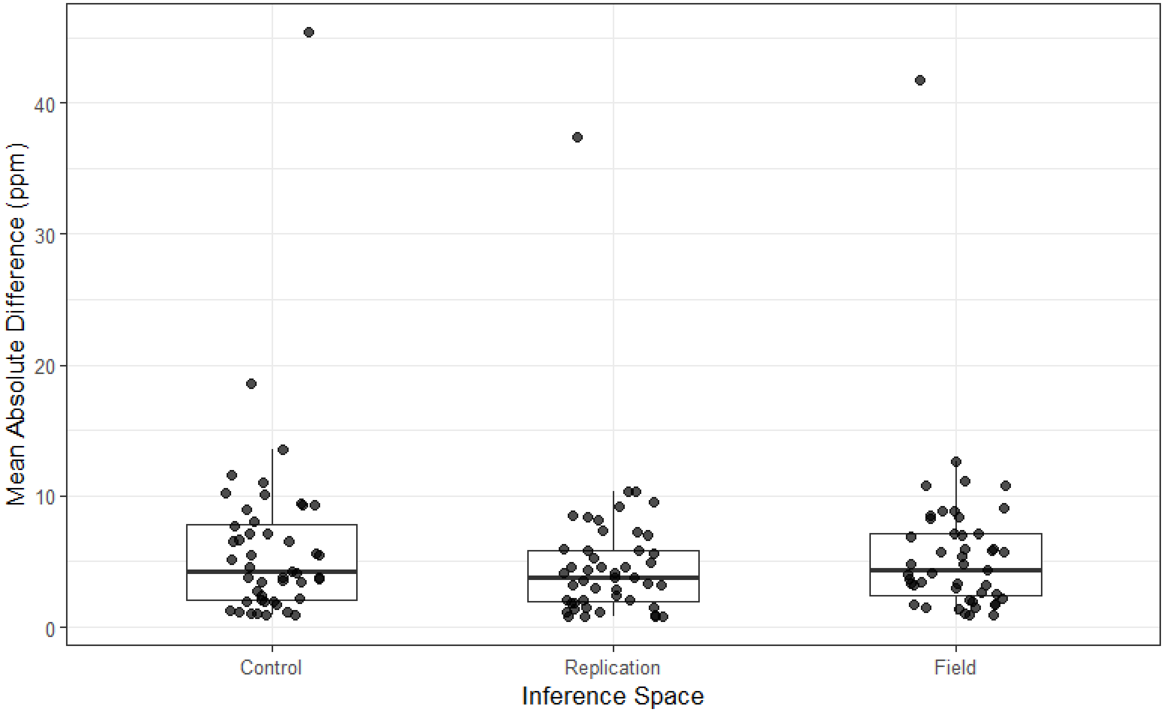
Sulfur (S)



Zinc (Zn)



Results - 2 Aggregation effects



Absolute difference (AD) = | Aggregated STP value – plot value |

Example:
AD = | Plot 1 (Rep value) – Plot 1 (Actual plot value) |
MAD = average of all plots AD

Figure 2. Mean absolute difference in STP values across sampling inference spaces

Table 3. Mean absolute difference in STP values across sampling spaces.

Inference Space	Mean absolute difference (MAD)				% of Trials with MAD > 10 ppm
	Mean	Median	Min	Max	
Control	6.2	**4.3**	0.9	45.4	14.9% (n=7)
Replication	5.0	**3.8**	0.8	37.4	6.4% (n=3)
Field	5.8	**4.3**	0.9	41.7	10.6% (n=5)

Results - 2 Aggregation effects

Figure 3. Mean absolute difference in STP values across sampling inference spaces

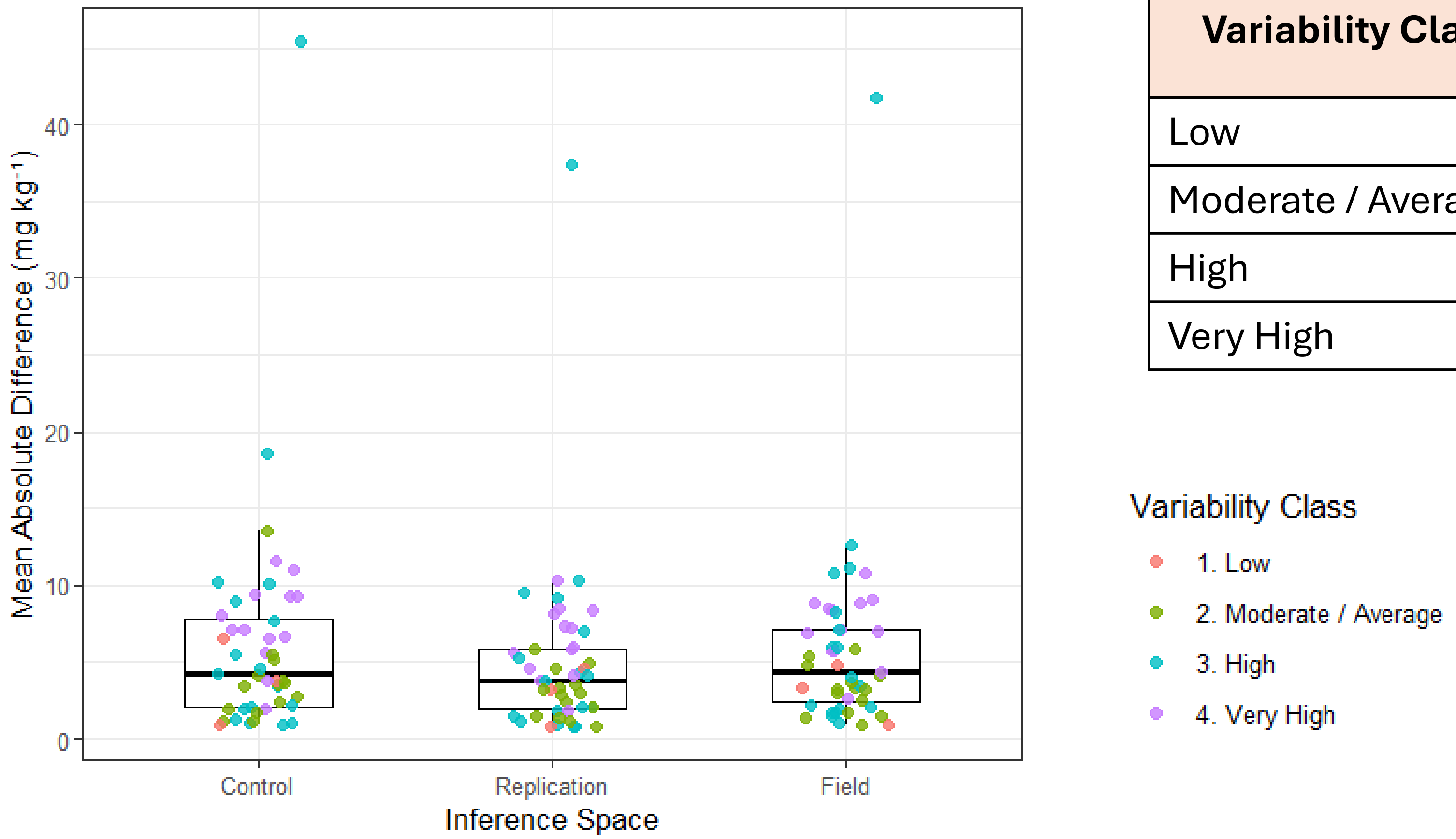
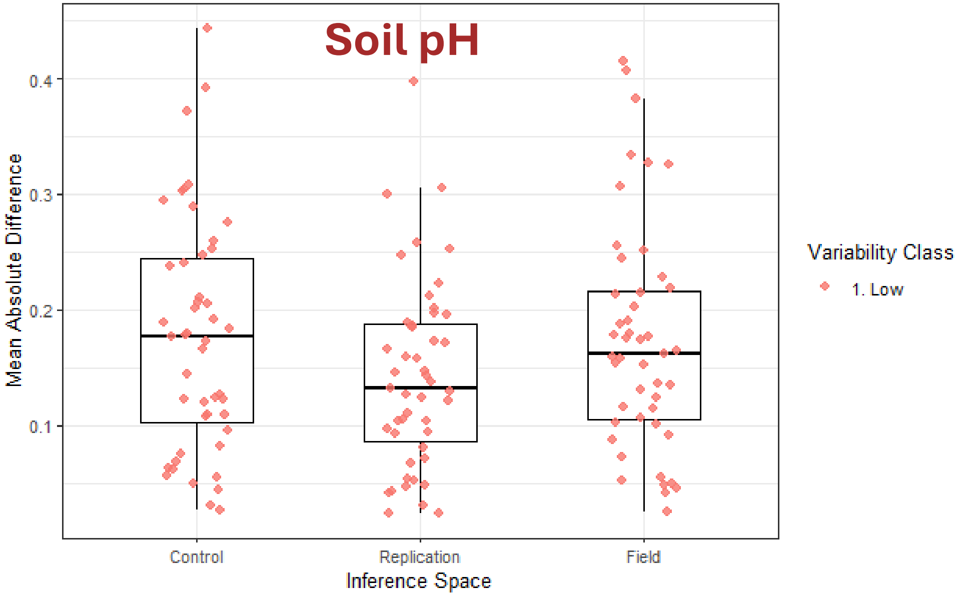
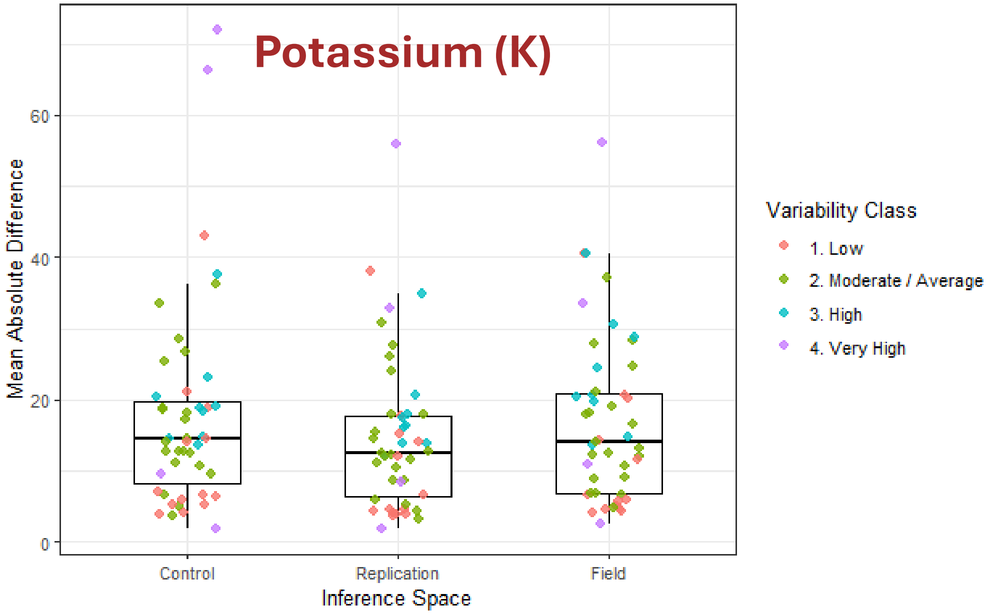
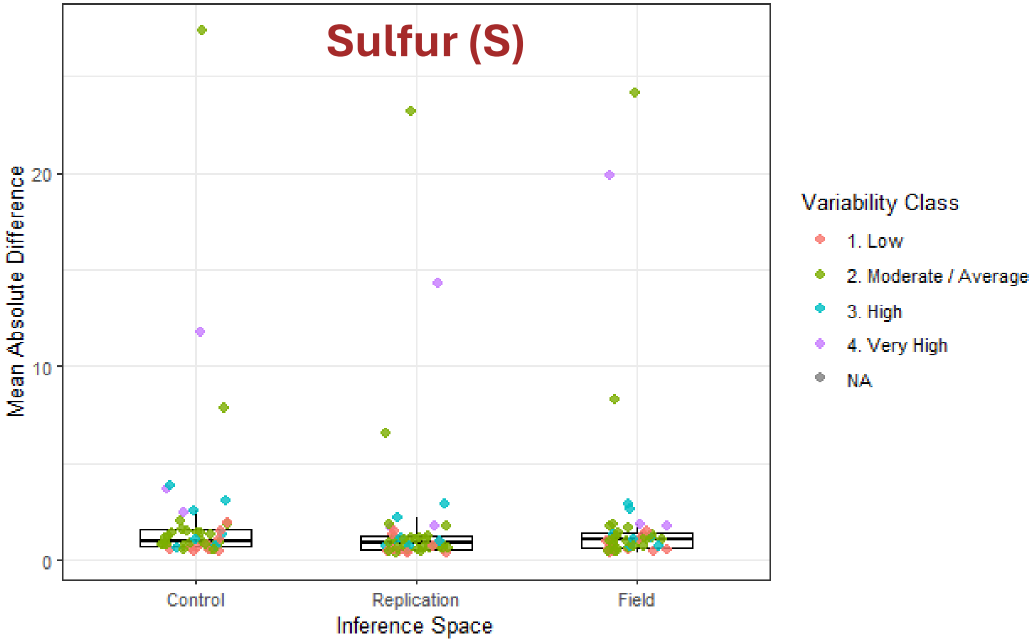


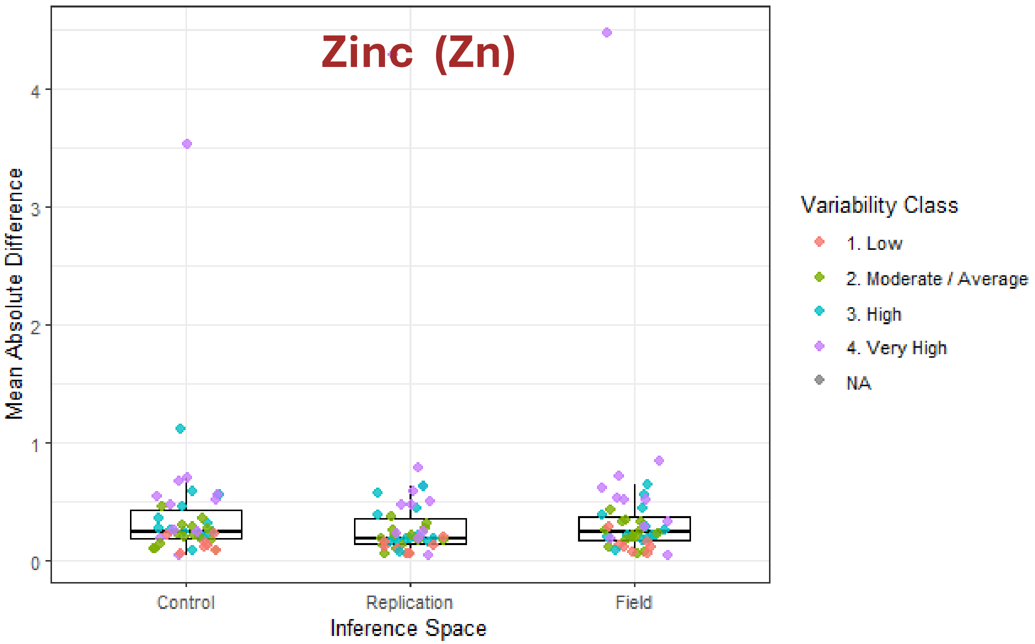
Table 4. Mean MAD in STP across sampling inference spaces and variability classes

Variability Class	Trials	Median MAD		
		Control	Rep	Field
Low	3	3.8	3.2	3.3
Moderate / Average	14	3.5	2.9	3.2
High	17	4.3	3.8	4.0
Very High	13	7.2	6.0	7.2


Soil pH
Mean Absolute Difference
0.4
0.3
0.2
0.1
Control
Replication
Field
Inference Space
Variability Class
1. Low

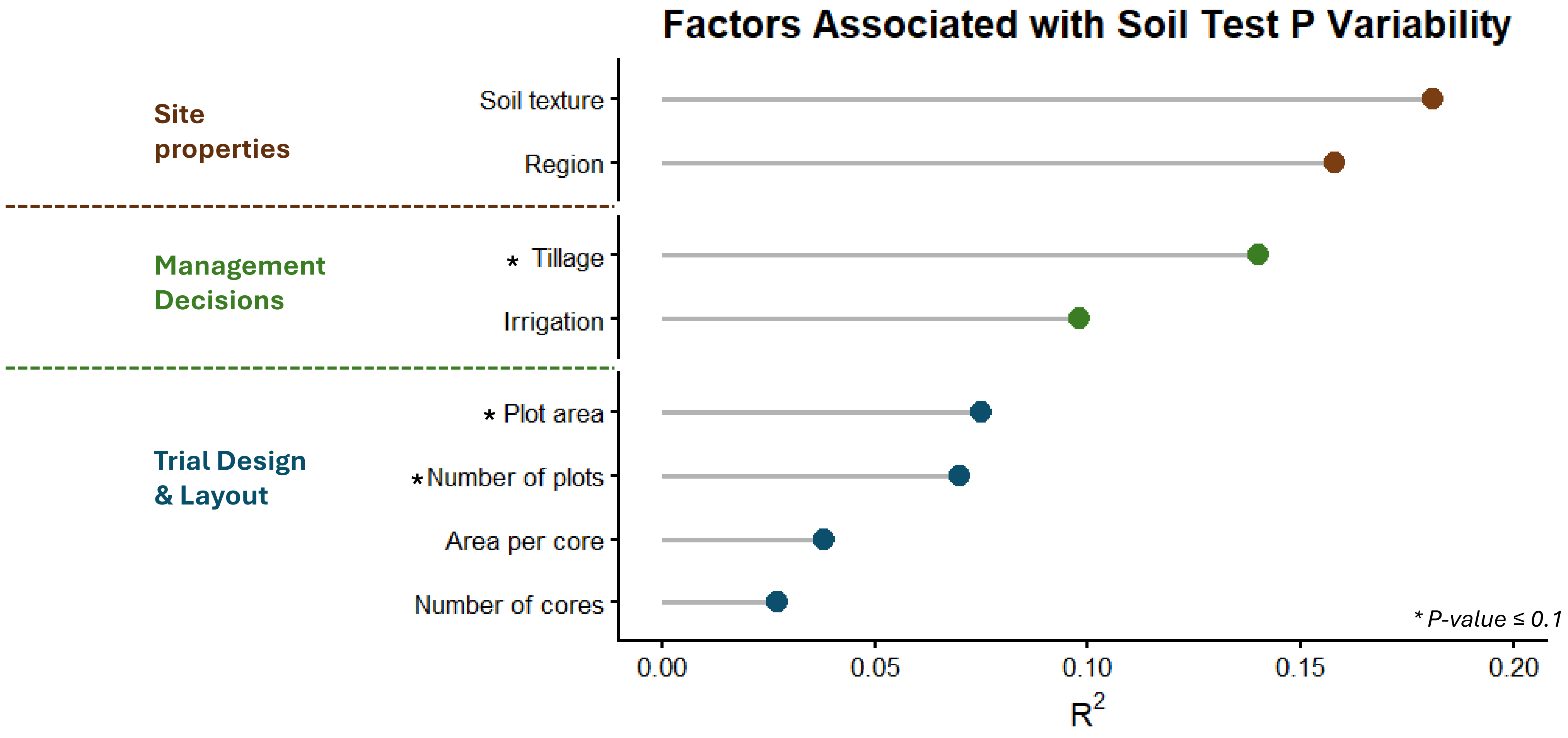

Potassium (K)
Mean Absolute Difference
60
40
20
0
Control
Replication
Field
Inference Space
Variability Class
1. Low
2. Moderate / Average
3. High
4. Very High


Sulfur (S)
Mean Absolute Difference
20
10
0
Control
Replication
Field
Inference Space
Variability Class
1. Low
2. Moderate / Average
3. High
4. Very High
NA

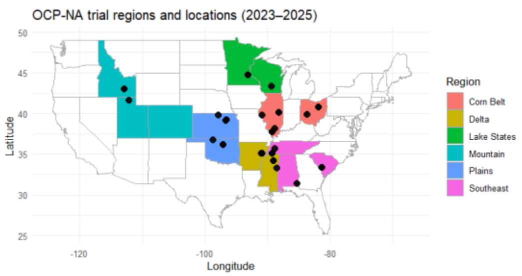

Zinc (Zn)
Mean Absolute Difference
4
3
2
1
0
Control
Replication
Field
Inference Space
Variability Class
1. Low
2. Moderate / Average
3. High
4. Very High
NA

Results

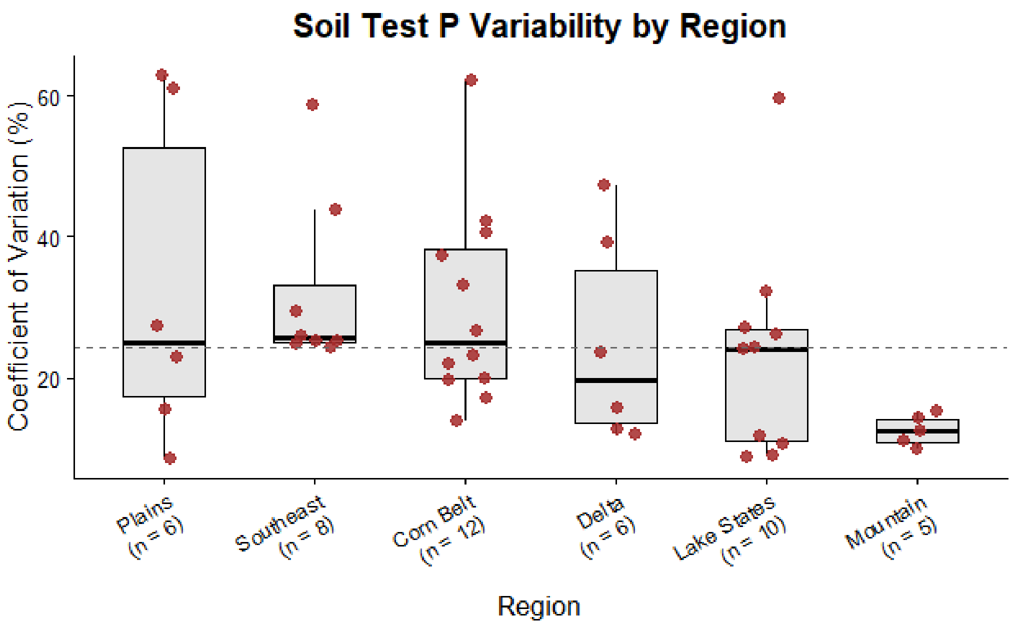
Results - 3 Factors driving variability

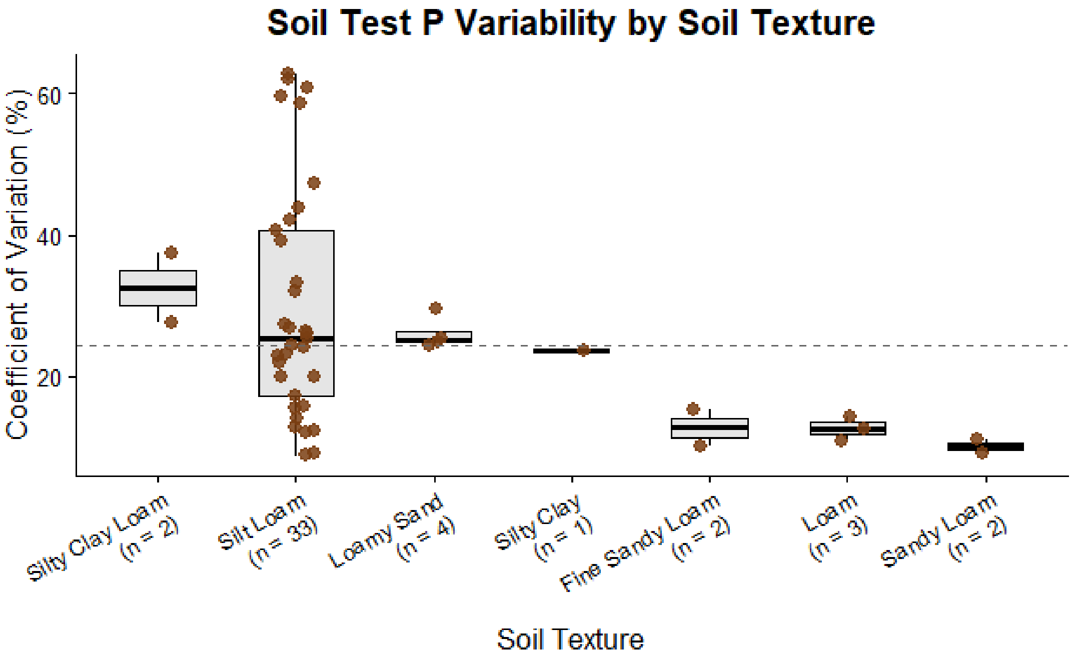


Results - 3 Factors driving variability



Site properties

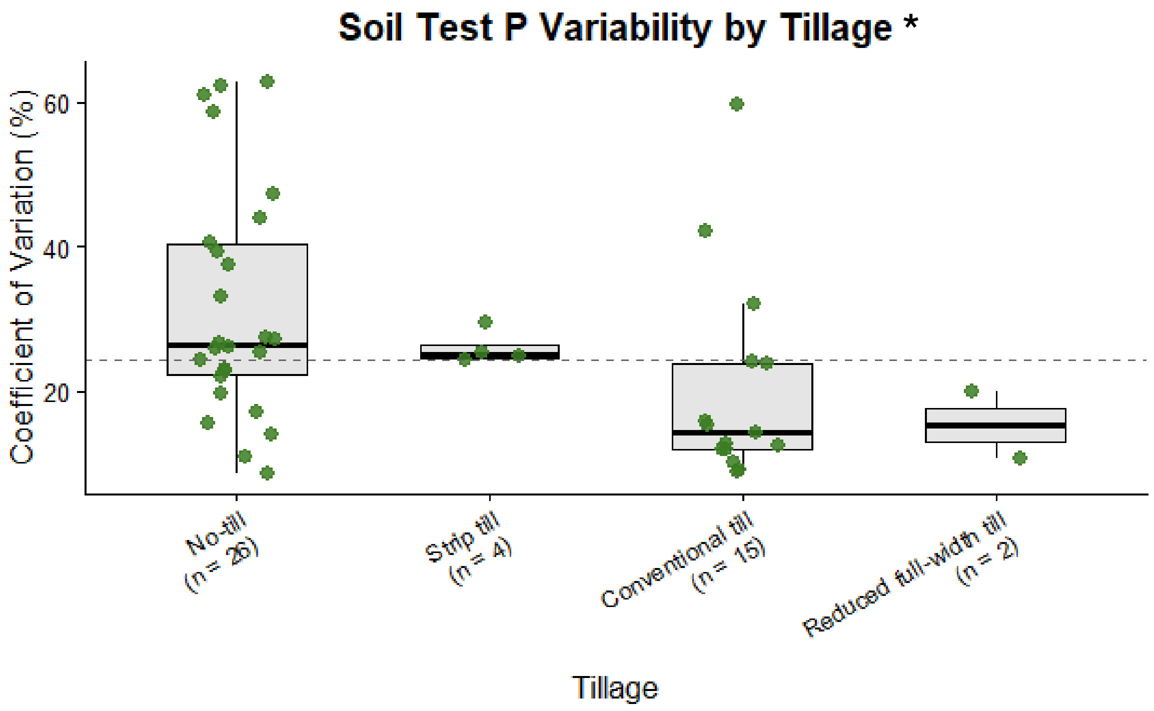


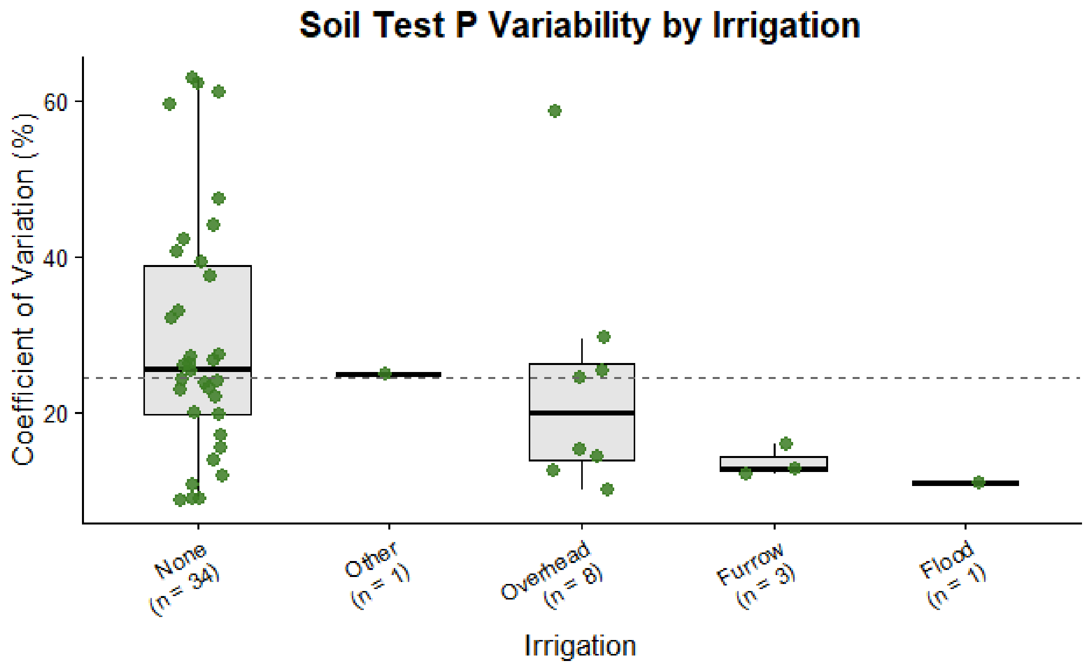


** P-value ≤ 0.1*

Results - 3 Factors driving variability

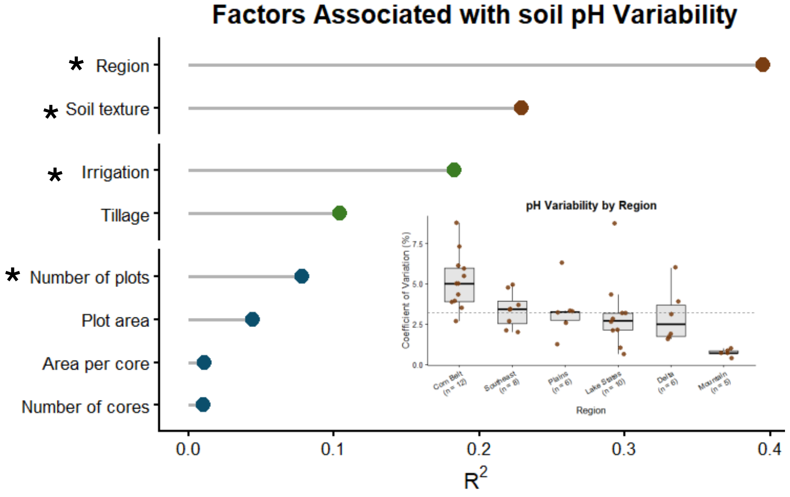
Management Decisions

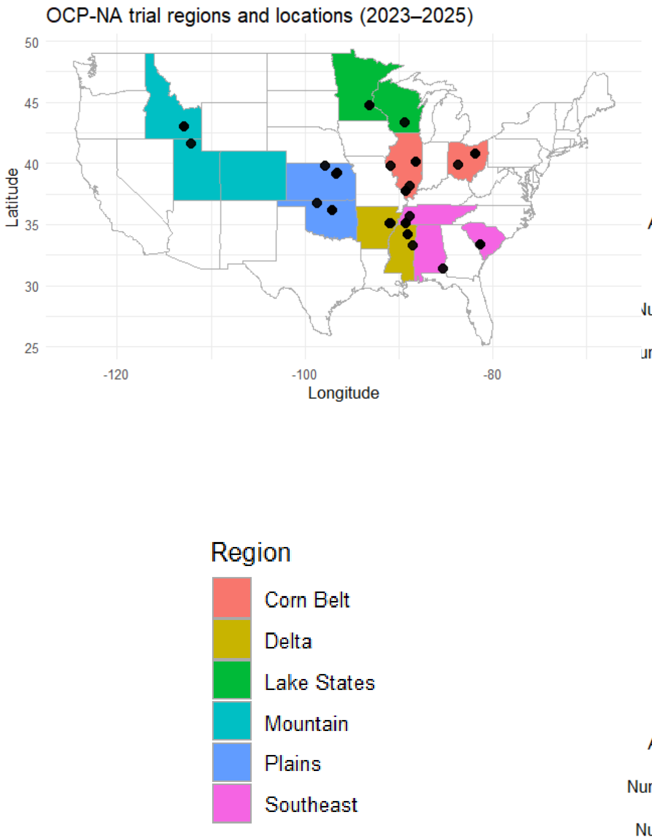


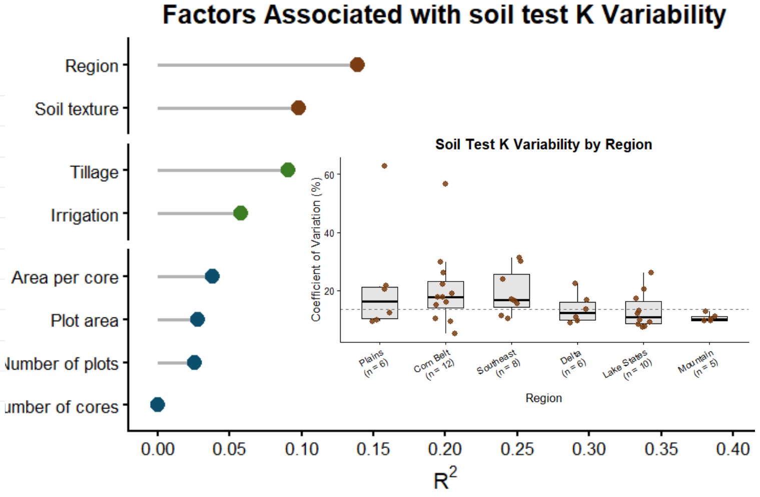


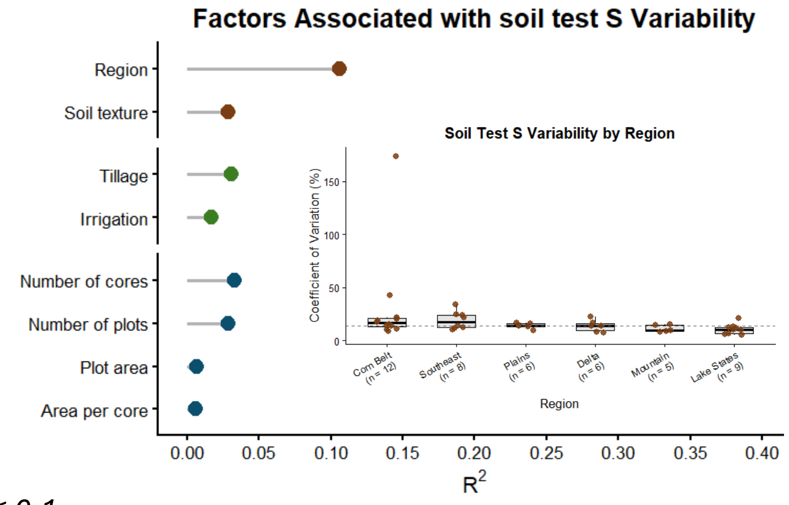
** P-value ≤ 0.1*

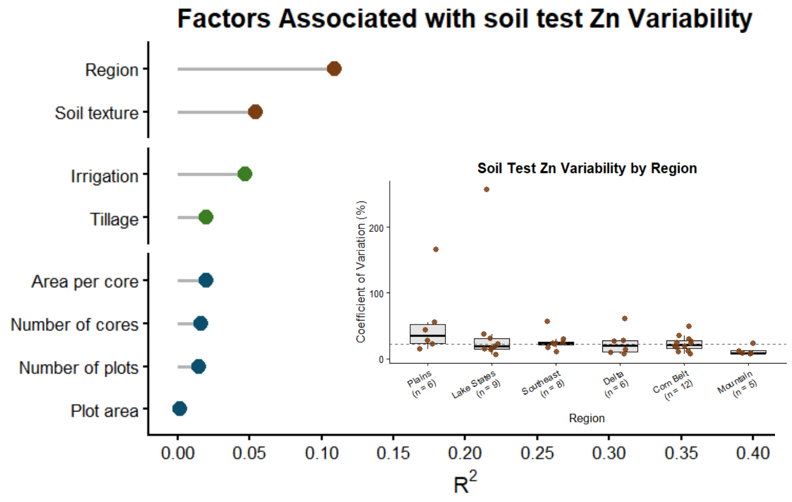
Results - 3 Factors driving variability





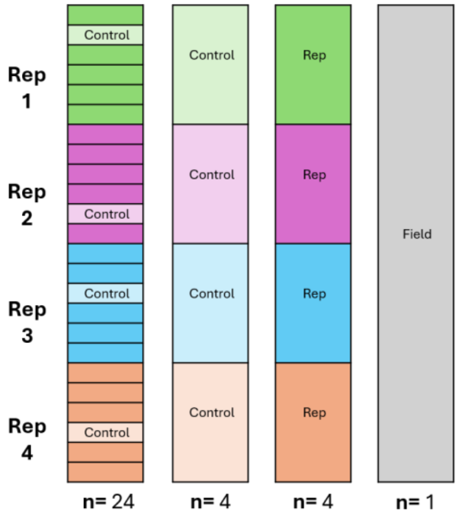


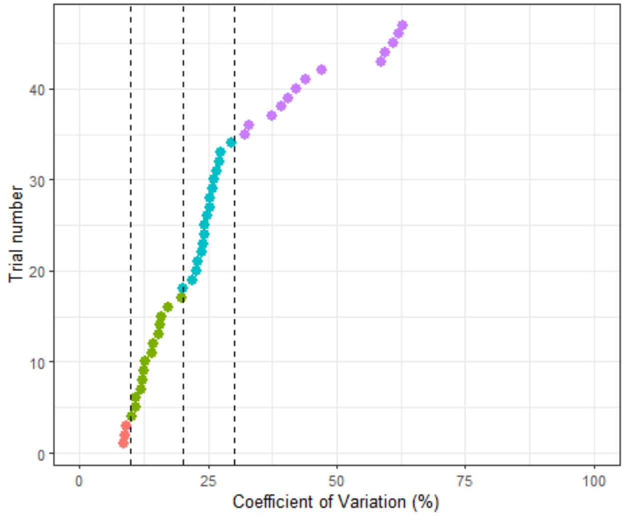


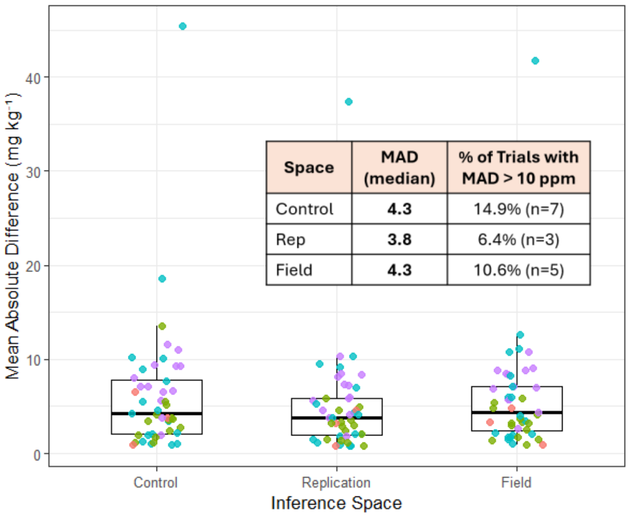


* *P-value ≤ 0.1*

Conclusions and implications







Space	MAD (median)	% of Trials with MAD > 10 ppm
Control	**4.3**	14.9% (n=7)
Rep	**3.8**	6.4% (n=3)
Field	**4.3**	10.6% (n=5)

At what level should STCC trials be soil sampled?

Uniformity in STP was low

30 out of 47 (63%) multi-state trials had high to very high STP variability (CV > 20%).

Plot-level sampling remains the most **complete approach**, but it may **not always be feasible**.

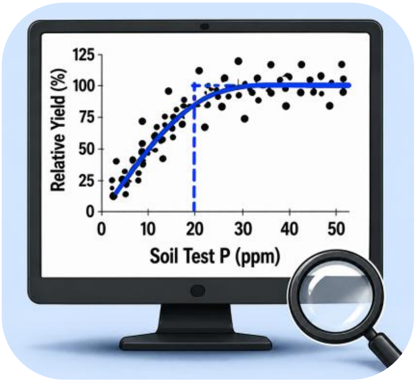
Aggregated vs plot STP values

Compositing samples introduced a median error of ~4 ppm P across sampling inference spaces.

Replication-level sampling was the best practical compromise in this dataset.

Next steps

- Control blocks evaluation.
- Determine whether sampling inference space influences soil test correlation and calibration outcomes.



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THANKS
QUESTIONS?

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Photo: Arana (2019)

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