Phosphorus Source, Timing, and Rate Effects on Corn Yield in Southeastern Coastal Plain Soils

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COOPERATIVE EXTENSION

College of Agriculture, Forestry and Life Sciences

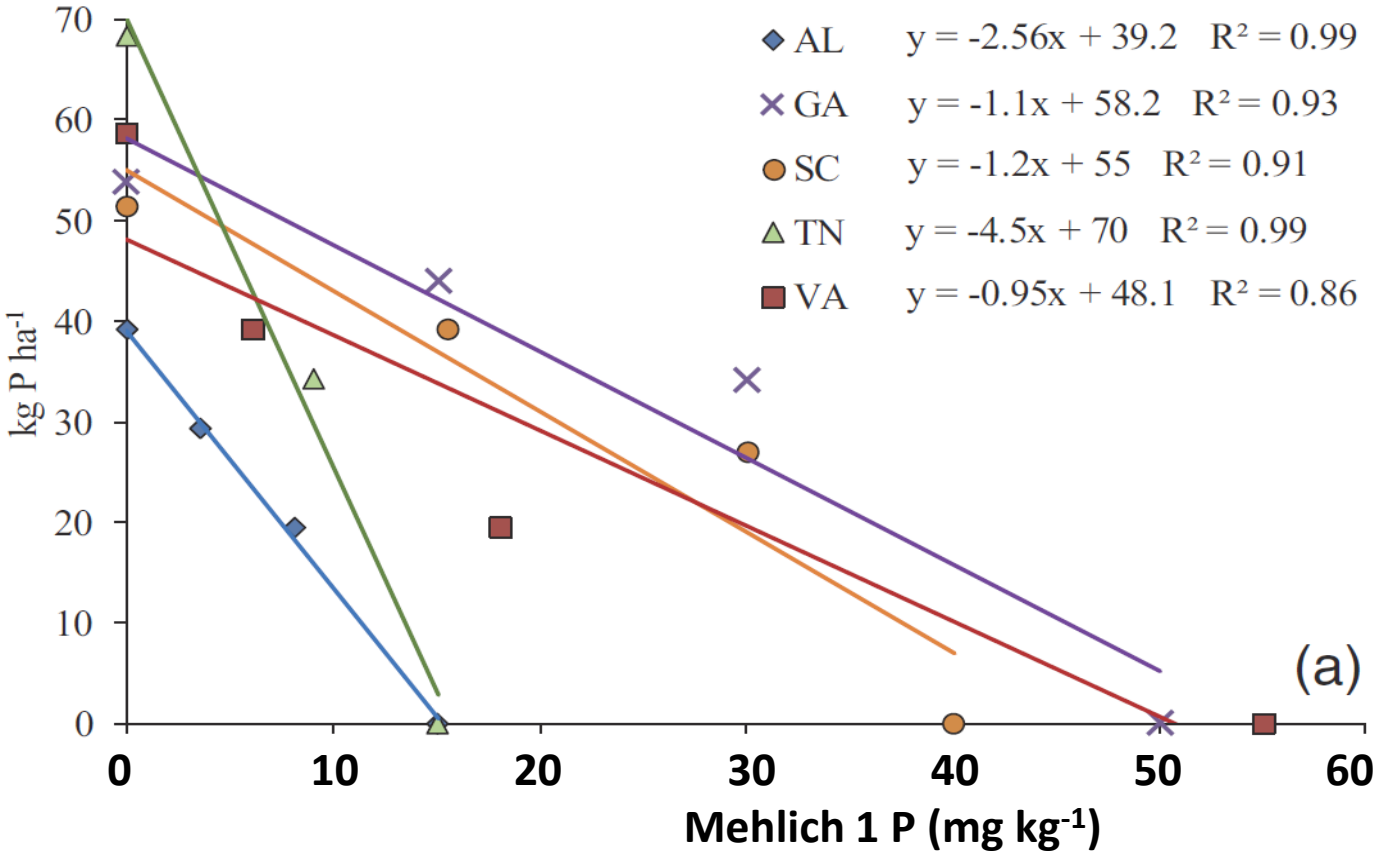
South Carolina P Management Scenario

- **Southeast Coastal Plain Soils**: Predominantly sandy texture and low native fertility
- **Historical P Applications**: Many fields have received decades of P applications
- **Current Status**:
  - A majority of SC agricultural soils test high or very high in P
  - Environmental concerns regarding P runoff to surface waters
  - Need for refined P management to balance agronomic and environmental goals

Soil test rating used in SC based on the M-1 P test levels (lbs/ac)

Soil Test Rating	STP concentration (mg kg^{-1})	Phosphorus levels (lbs/ac)
Low	<15.5	<31
Medium	15.5-30	31-60
Sufficient	30.5-40	61-80
High	40.5-60	81-120
Excessive	>60	>120

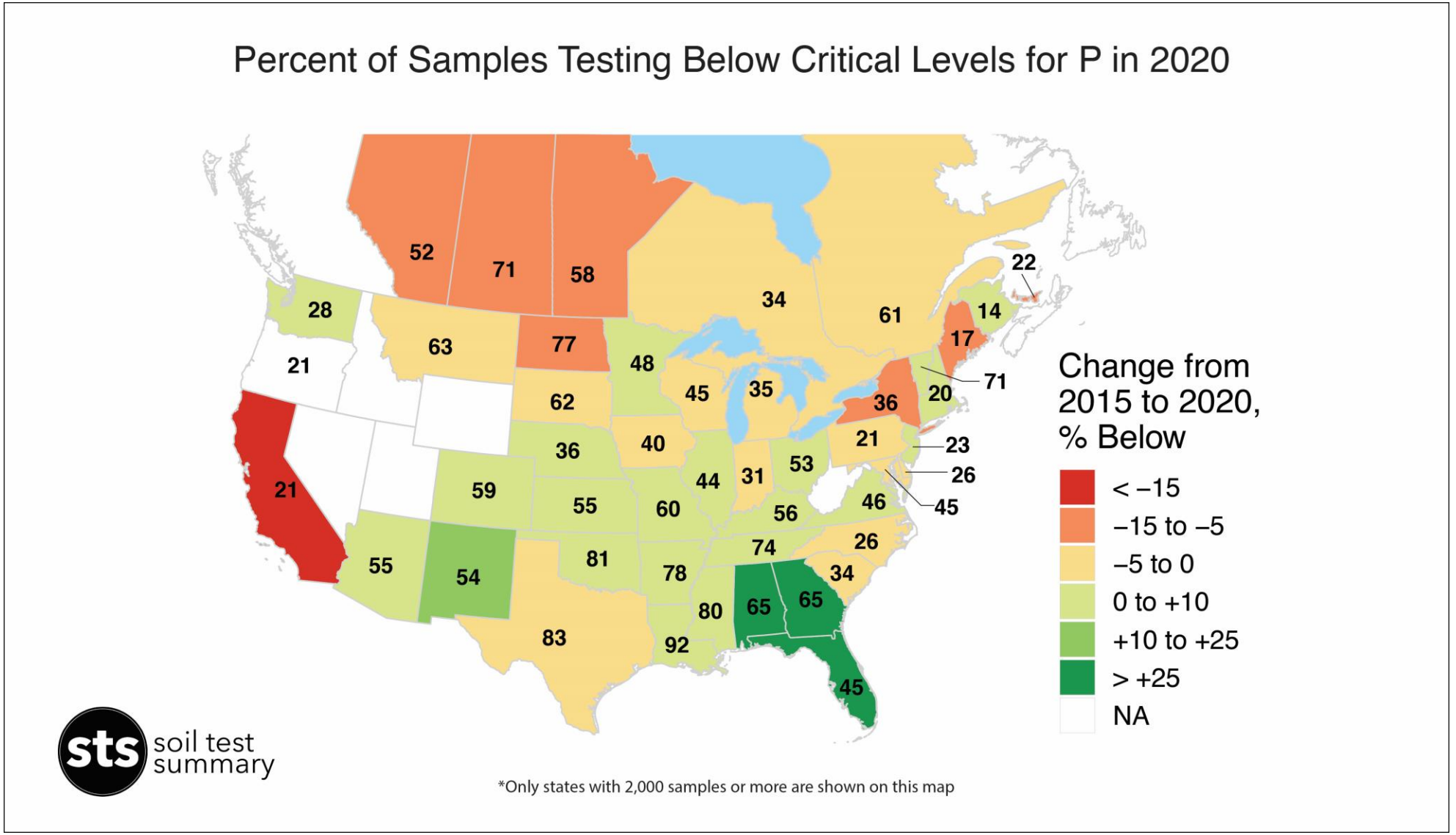
Fertilizer P rate recommendations based on M-1 for corn at a yield goal of 10.1 Mg ha^{-1}



- **To convert M1P ppm to lbs/ac, multiply by 2, and the P rate from kg/ha to lb/ac, multiply by 0.89**
- Across states, the predicted maximum recommended fertilizer P rate using M1 ranged from 39 to 70 kg P ha^{-1} (80 to 140 lbs. P_2O_5 acre^{-1}) for corn and 39 to 63 kg P ha^{-1} (80 to 120 lbs. P_2O_5 acre^{-1}) for warm-season grasses

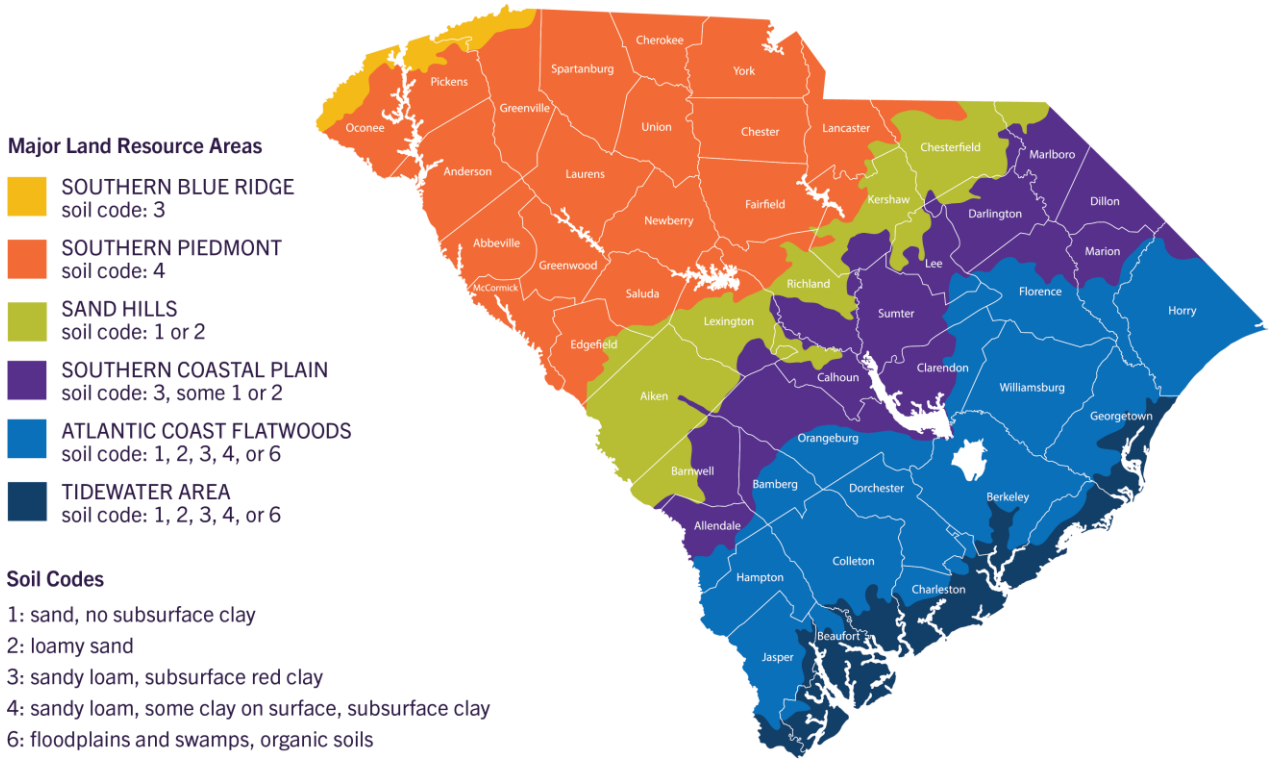
Zhang, H, Antonangelo, J, Grove, J, Osmond, D, Slaton, N A, Alford, S, Florence, R, Huluka, G, Hardy, D H, Lessl, J, Maguire, R, Mylavarapu, R, Oldham, J L, Pena-Yewtukhiw, E M, Provin, T, Sonon, L, Sotomayor, D, Wang, J. Variation in soil-test-based phosphorus and potassium rate recommendations across the southern USA. Soil Sci Soc Am J. 2021; 85: 975– 988. https://doi.org/10.1002/saj2.20280

Phosphorus Sample Distribution



Slide Credit: Soil Test Summary (https://soiltest.tfi.org/about/about_soil_test_summary)

Phosphorus Sample Distribution



The percentage of samples falling in the combined "Sufficient," "High," and "Excessive" categories for each region:

- Coastal Plains: 76%
- Lower Coastal Plains: 59%
- Piedmont: 72%
- Sandhill: 66%

Region	2024 Annual Soil Test Report for Corn fields- Clemson's Ag Service Lab					
	Total	Low	Medium	Sufficient	High	Excessive
COSTAL PLAINS	2359	128	431	356	606	838
LOWER COSTAL PLAINS	1047	157	269	182	223	216
PIEDMONT	377	61	43	28	45	200
SANDHILL	681	94	137	81	123	246

Experimental Design

- **Location**: Edisto Research & Education Center (EREC), Blackville, SC
- **Design**: Randomized complete block design with 4 replications
- **Treatments**:
  - 2 P sources: DAP and TSP
  - 2 Application timings: Fall and Spring
  - 4 P rates: 20, 40, 60, and 80 lb P_2O_5/acre
  - 1 No-P control
- **Measurements**: Baseline soil samples (0-6"), Corn grain yield
- N was non-limiting 200 lbs N/ac
- OM (LOI): 2%
- Soil pH: ~7

Treatment Structure

Treatment	P source	P Timing	P2O5 rate (lb/acre)
1	No-P check	Check	0
2	TSP	Fall	20
3	TSP	Fall	40
4	TSP	Fall	60
5	TSP	Fall	80
6	DAP	Fall	20
7	DAP	Fall	40
8	DAP	Fall	60
9	DAP	Fall	80
10	TSP	Spring	20
11	TSP	Spring	40
12	TSP	Spring	60
13	TSP	Spring	80
14	DAP	Spring	20
15	DAP	Spring	40
16	DAP	Spring	60
17	DAP	Spring	80

Field Conditions

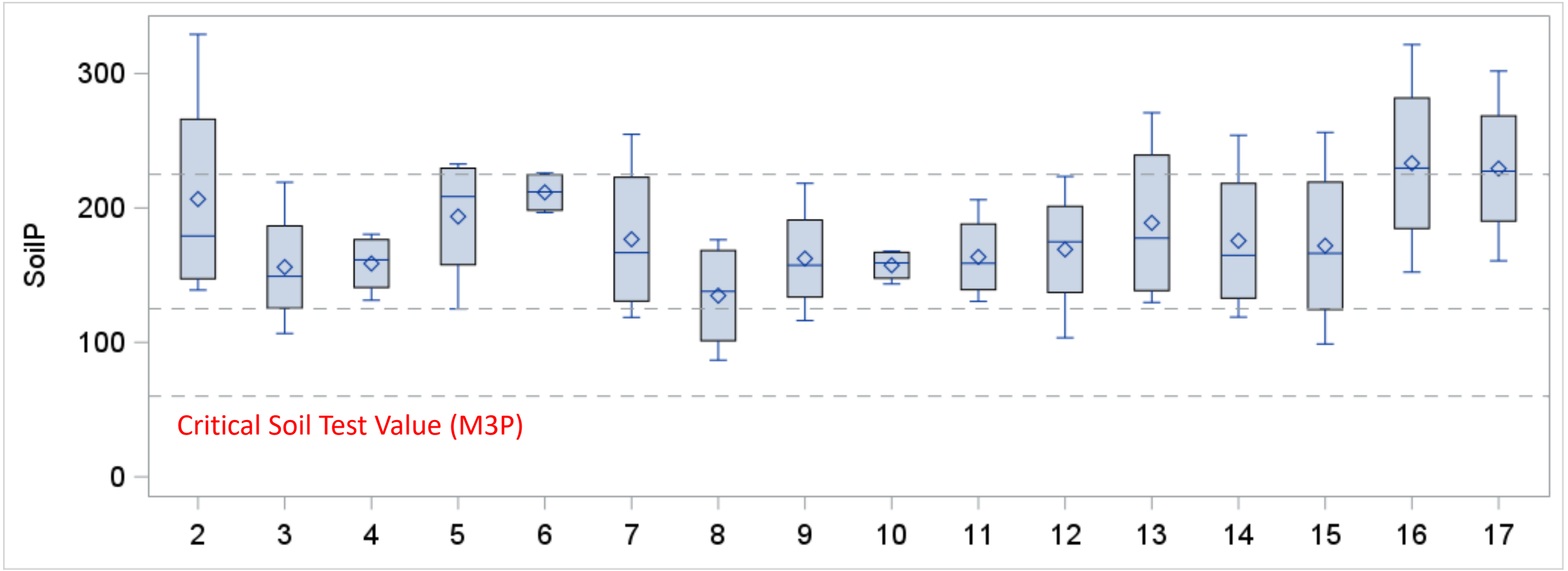
- **Soil Type**: Barnwell loamy sand
- **Initial Soil P Levels**: Range of 100-300 ppm M3P (1-3-1.8x M1P ~60-180 ppm M1P equivalent). All values are still within the "high" to "very high" category in SC recommendations.
- **Previous Crop**: Peanuts
- **Planting Date**: April 29, 2024
- **Tillage**: Disking and strip tillage
- **Fertilizer Application Dates**:
  - Fall: December 8, 2023
  - Spring: May 6, 2024
- **Harvesting Date**: September 9, 2024

Statistical Approach

- **Mixed model analysis** to account for fixed and random effects:
  - Fixed effects: P source, timing, and their interactions
  - ANCOVA analysis with soil P as a factor
  - P rate and Total P (Soil P + Applied P) were considered continuous variables
  - Random effect: Block

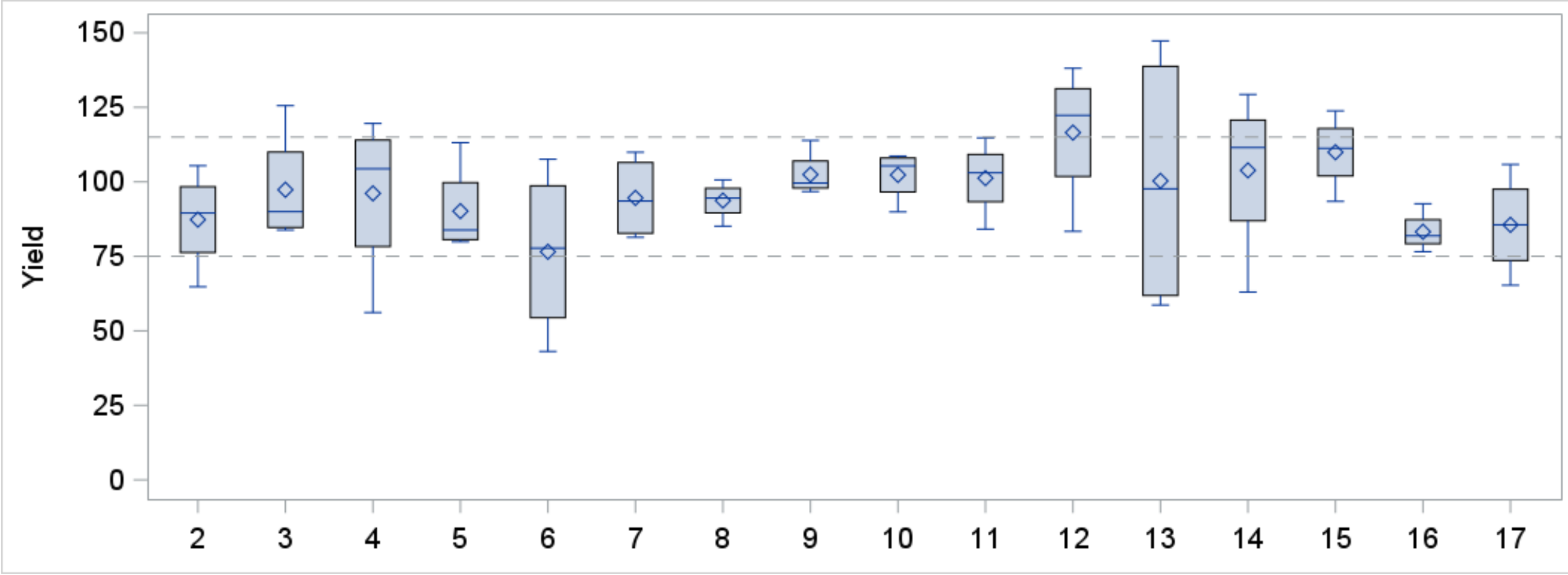
Soil P Distribution By Treatment

- High variability in M3P levels across the field, mostly between 125-225 ppm.
- Due to high variability in baseline M3P, it was accounted for in the model (ANCOVA analysis)



Yield Distribution By Treatment

- Notably, high variability in treatments 4, 6, 13, and 14.



Findings From ANOVA Analysis

Standard Anova with P rate (quadratic), timing, source, and their interactions shows all effect non-significant.

Effect	FValue	ProbF
Timing	1.22	0.2741
P_source	0.09	0.7617
P_source*Timing	0.43	0.5165
P2O5_rate	1.17	0.2843
P2O5_rate^2	1.16	0.2871
P2O5_rate*Timing	0.20	0.6527
P2O5_rate^2*Timing	0.02	0.8770
P2O5_rate*P_source	0.22	0.6393
P2O5_rate^2*P_source	0.19	0.6635
P2O5_rate*P_source*Timing	0.18	0.6767
P2O5_rate^2*P_source*Timing	0.01	0.9094

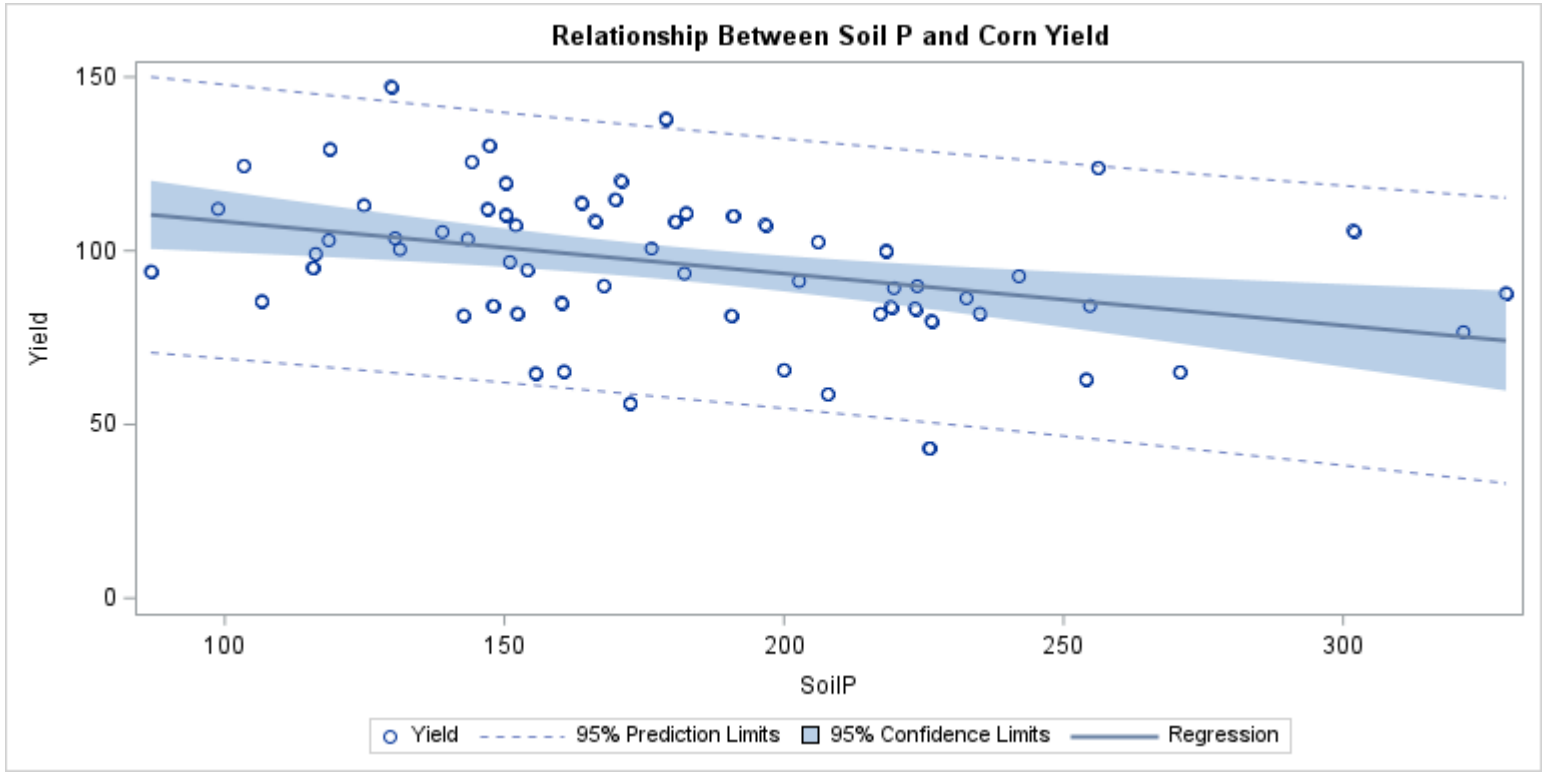
Findings From ANCOVA Analysis

ANCOVA analysis showed that only Soil P significantly affected corn yield.

Effect	FValue	ProbF
Timing	0.00	0.9930
P_source	0.08	0.7778
P2O5_rate	0.08	0.7750
P2O5_rate^2	0.05	0.8260
SoilP	**11.96**	**0.0012**
P2O5_rate*Timing	0.28	0.6007
P2O5_rate^2*Timing	0.38	0.5393
P2O5_rate*P_source	0.10	0.7495
P2O5_rate^2*P_source	0.07	0.7919

Findings From ANCOVA Analysis

For every 100-unit increase in soil phosphorus (SoilP), corn yield decreases by approximately 15 bushels per acre, indicating that excessive soil P levels may negatively impact corn yield.



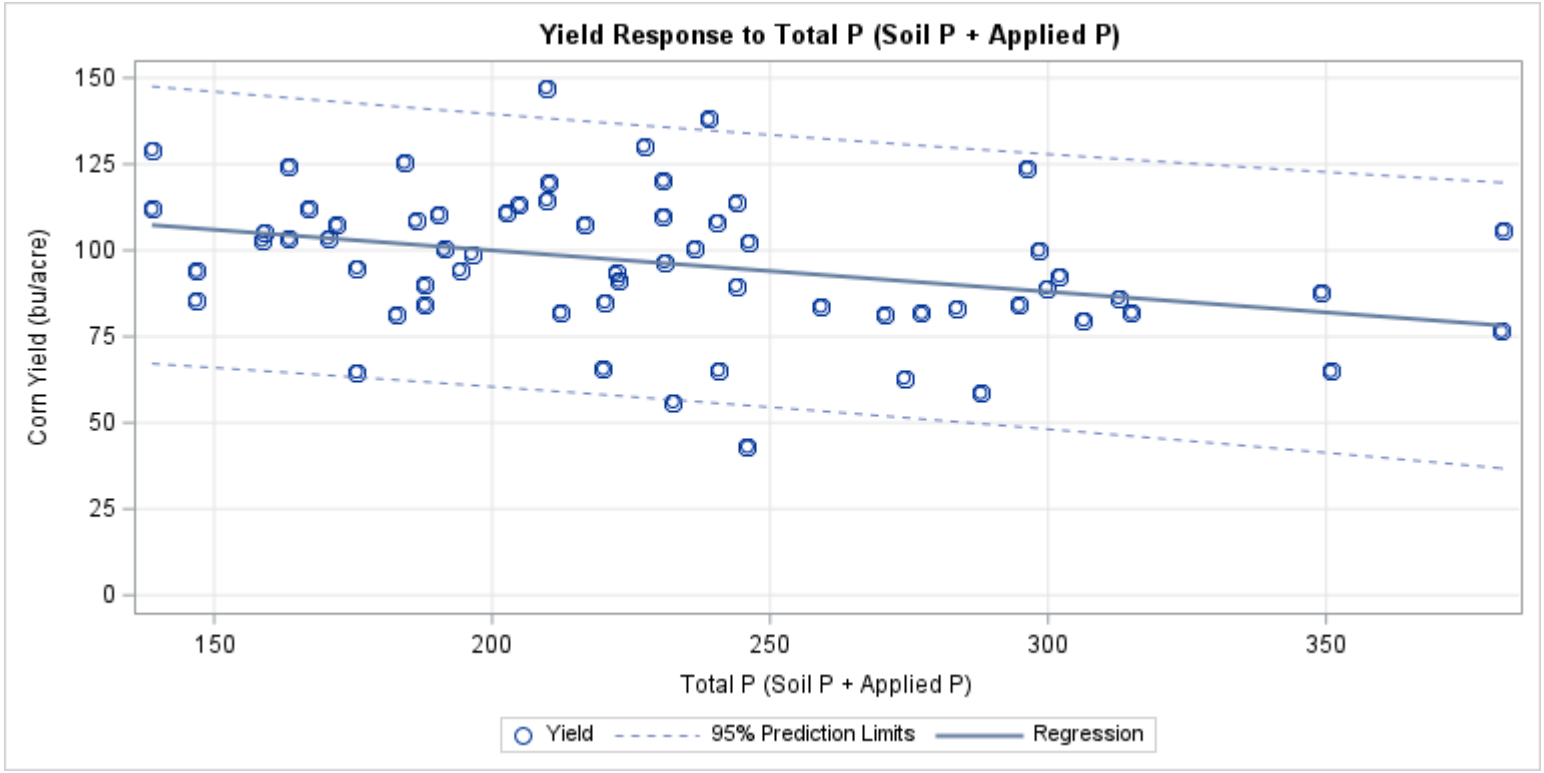
Extended ANOVA Analysis With Total P (Soil + Applied P)

Extended ANOVA analysis showed that total of soil P plus applied P (P_SoilP) is the only significant predictor of yield (p=0.0142).

Effect	**F Value**	**Pr > F**
Timing	2.02	0.1614
P_source	0.67	0.4166
P_source*Timing	0.18	0.6696
P_SoilP	**6.56**	**0.0142**
P_SoilP*Timing	1.04	0.3114
P_SoilP*P_source	0.50	0.4833
P_Soil*P_sour*Timing	0.14	0.7066

Extended ANOVA Analysis With Total P (Soil + Applied P)

- **Corn yield decreases as total phosphorus (soil P + applied P) increases, with a negative linear relationship showing approximately 30 bushels per acre decline across the observed range of 150-375 lb/acre total P.**



Key Takeaways

- **In high-testing soils (>200 ppm), phosphorus application may be unnecessary or even counterproductive.**
- **Native + applied P is more important than how or when P is applied.**
- **<u>Check soil test P levels before establishing the trial.</u>**

Thanks to OCP-NA for supporting the study and FRST group for the collaborative efforts.

Questions and Suggestions?

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FRST
FERTILIZER RECOMMENDATION SUPPORT TOOL