

# Long-term Comparison of Targeted Soil Test P Values and Crop Removal-based Fertilization Strategies in Corn


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**Long-term comparison of targeted soil test values and crop removal as a phosphorus fertilization strategy in corn**


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**Abstract**

Finding effective phosphorus (P) recommendation strategies to optimize corn (*Zea mays* L.) yield under varying yield levels and environmental conditions is continuously sought after. A 16-year study was conducted in Concord, NE, on Nora silt loam soil initially measuring 16 ± 3 mg kg$^{-1}$ Bray-1 P. The study evaluated the impact of different P fertilization strategies on corn yield across various growing conditions (dry, normal, and wet years). Treatments included no P or N (NPNN), no P (NP),

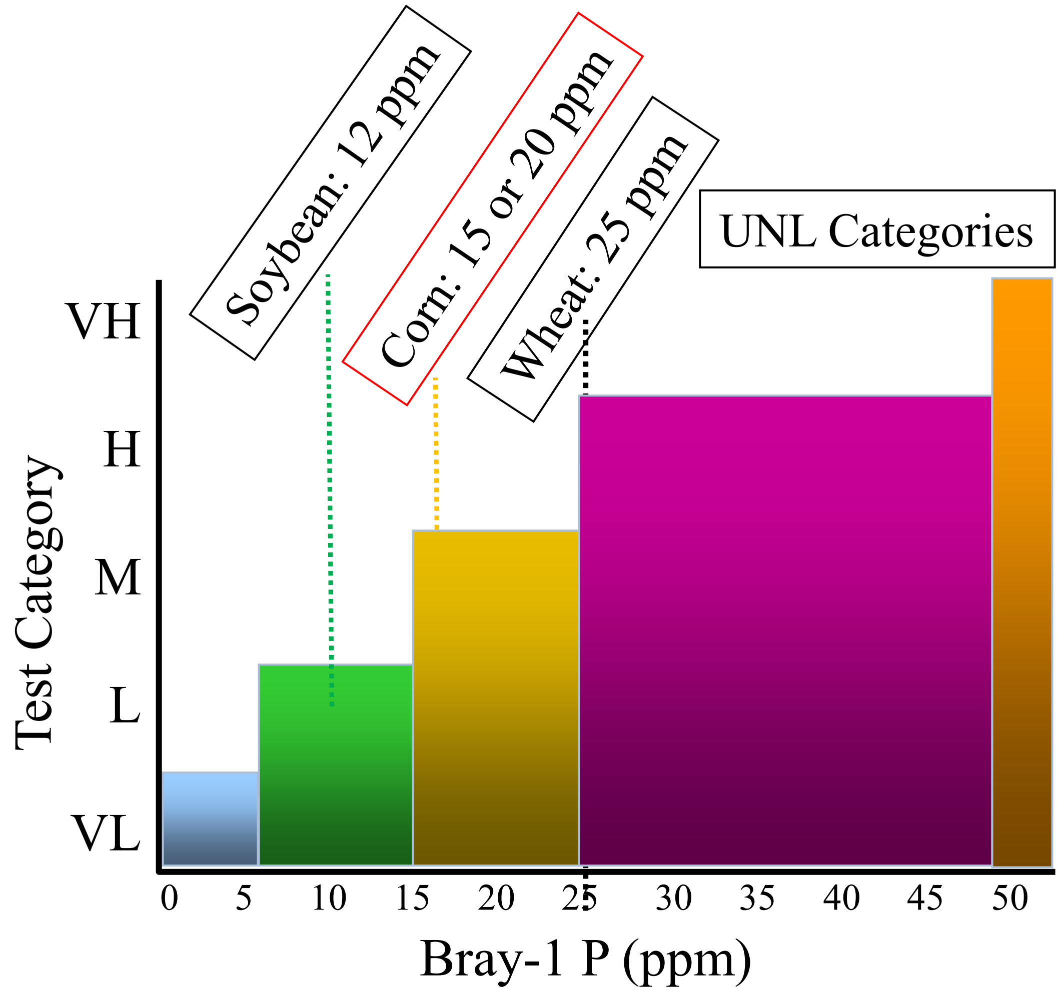
# Fertilizer Application Strategies

- **Deficiency Correction/Sufficiency Concept** - Intended to optimize profit. The risk is that in some years, or some locations within fields, nutrient supply *may limit yield.*
- **Crop Removal** – Add what you remove, depending on soil may need more or less.
- **Maintenance and Build** - Intended to minimize potential for nutrient limitations to yield. The risk is that, in most years, no yield increase will occur with P application or with increased rate of P, thus *reducing profit*.

# Basis for an application decision?

- Deficiency Correction

"Critical Level"- is the soil test value above which fertilizer is not recommended because there is not a <u>significant</u> likelihood of yield increase.



# Questions

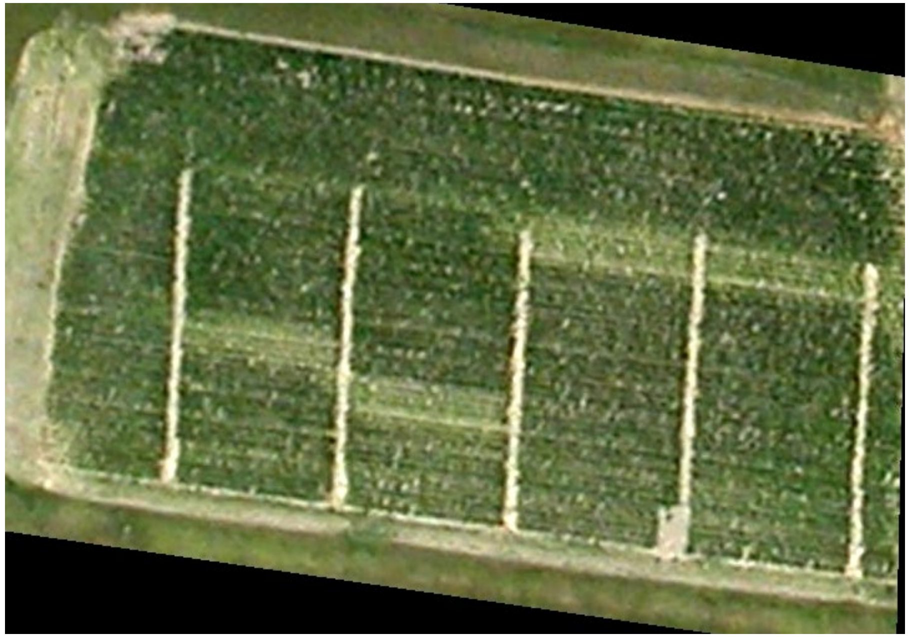
1. Is the UNL critical level of 15 or 20 ppm Bray 1P appropriate for optimizing crop yields?
2. Does maintaining soil test phosphorus (STP) levels above the current critical levels (15 or 20 ppm) lead to greater increases in crop yields and profitability?
3. How does a crop removal-based phosphorus fertilization strategy compare to a critical level (CL)-based approach?
4. Do higher STP levels result in better corn yields and economic returns compared to the crop removal approach?
5. How do annual weather patterns influence phosphorus application strategies?

# Several studies to address P questions at Northeast NE

# 16-Years Long-Term P Study

## Methods

- Haskell Agricultural Laboratory near Concord, NE.
- Soil type: Nora silt loam
- Study years (2000 – 2015).
- Continuous corn under rainfed condition.
- Randomized complete block design with six treatments.
- Plot size: six rows (0.76 m) wide and 60 ft (18.25 m) long.

# 16-Years Long-Term P Study

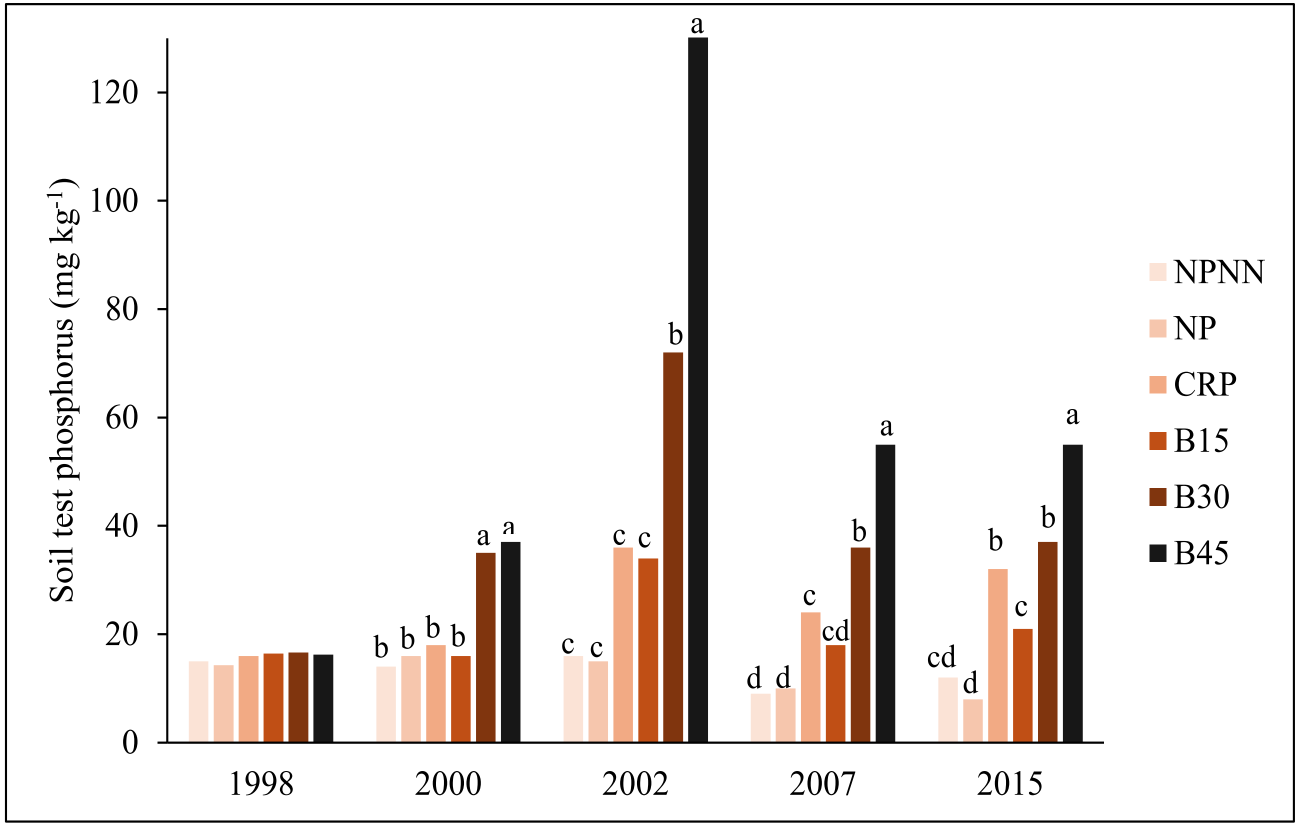
- Soils were at ~16 mg $kg^{-1}$ at the beginning.
- Except the NPNN, all other treatments received a 168 kg $ha^{-1}$ of N as preplant.

## Treatments

| | |
|---|---|
| **NPNN** | No P or fertilizer N or applied |
| **NP** | Fertilizer N applied, no P |
| **CRP** | Crop removal P applied |
| **Bray15** | Soil tests maintained at 15 mg $kg^{-1}$ |
| **Bray30** | Soil tests maintained at 30 mg $kg^{-1}$ |
| **Bray45** | Soil tests maintained at 45 mg $kg^{-1}$ |

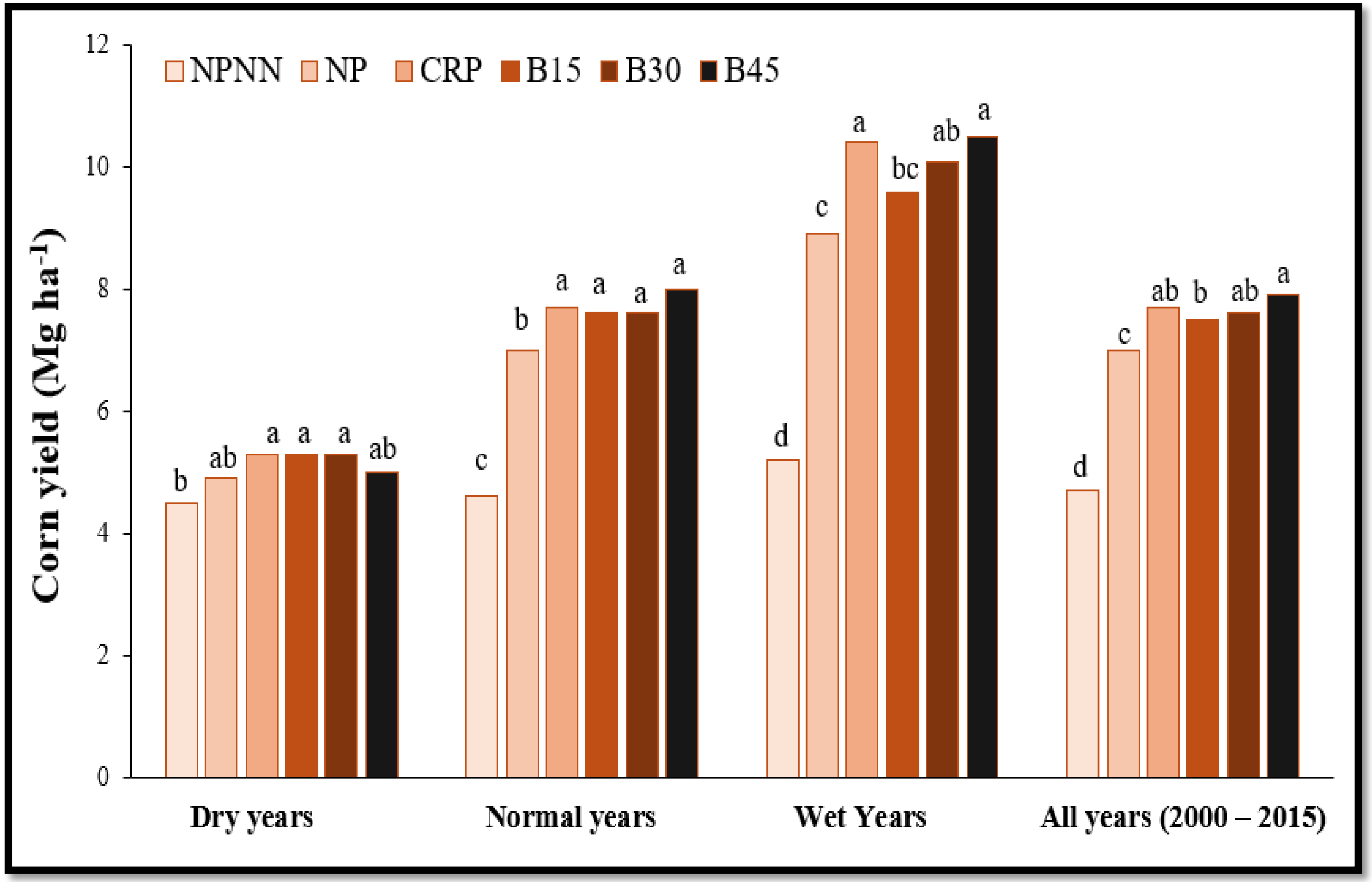
# Impact of phosphorus application strategies on soil test phosphorus levels





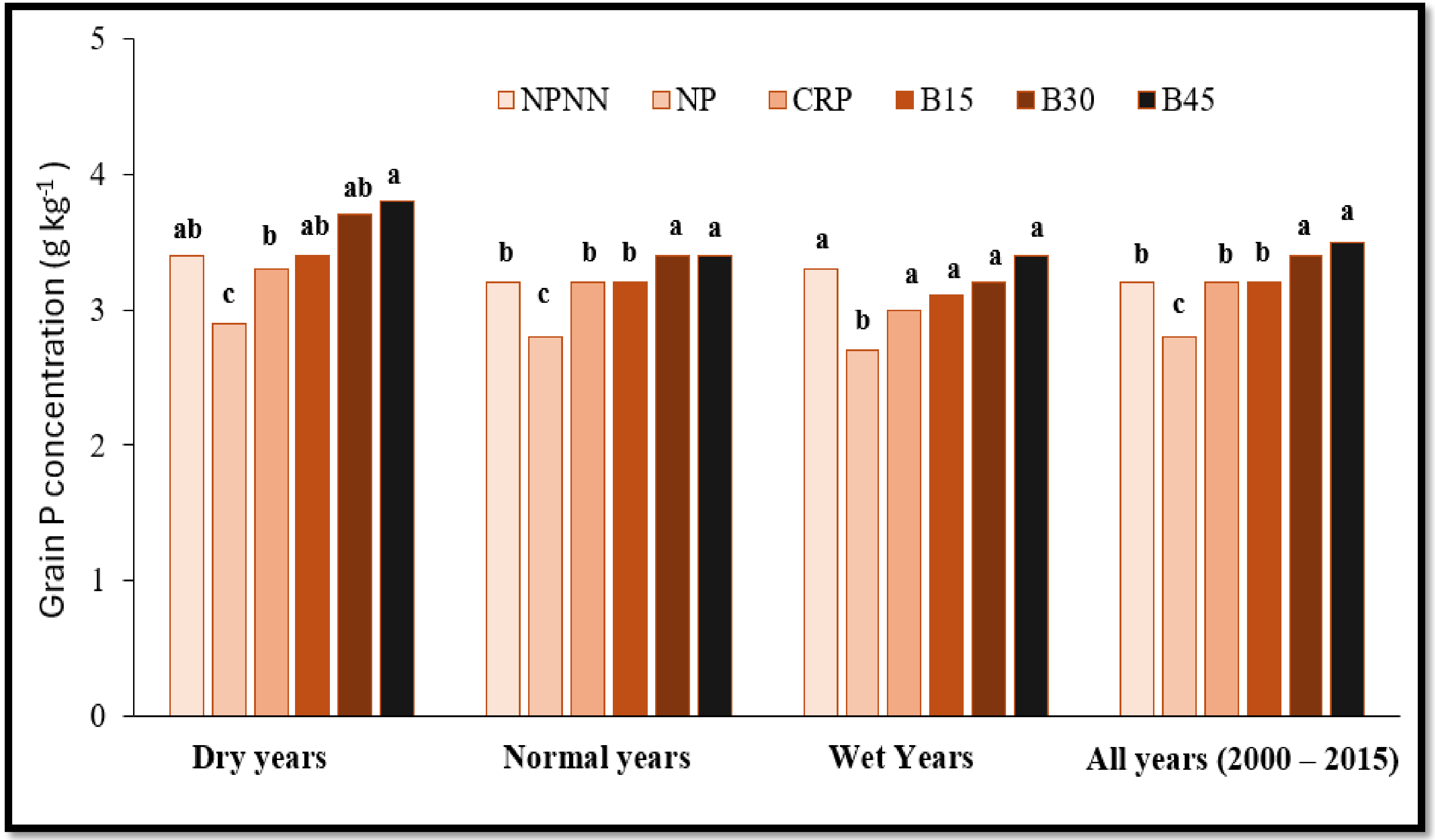

- The initial application of $P_2O_5$ increased STP levels more than anticipated; however, these levels gradually decreased to approach the target levels in subsequent years.
- CRP method required a higher total P application compared to the Bray-15 approach.

# Impact of phosphorus application strategies on corn grain yield



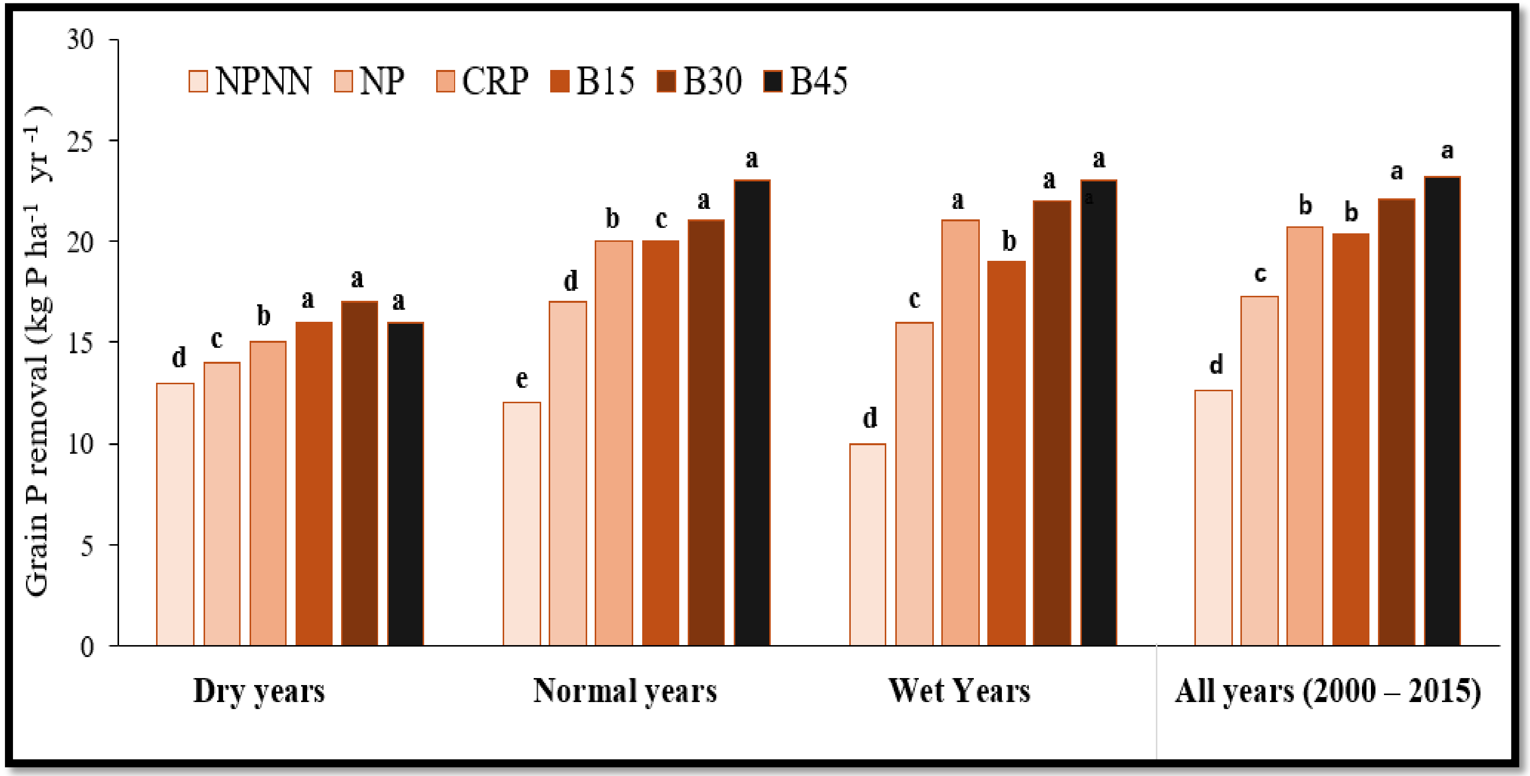

- P application increased corn yield compared to NPNN and NP.
- No differences between the CRP vs. B15, though higher yield with CRP
- A trend of increased yield with higher P, with B45 producing greater grain yields than B15.
- No differences between CRP vs. B30 and B45.
- N application influenced yield in dry years, but not P application, however, P application positively effected yield during normal and wet years.

# Impact of phosphorus application strategies on corn grain P concentration



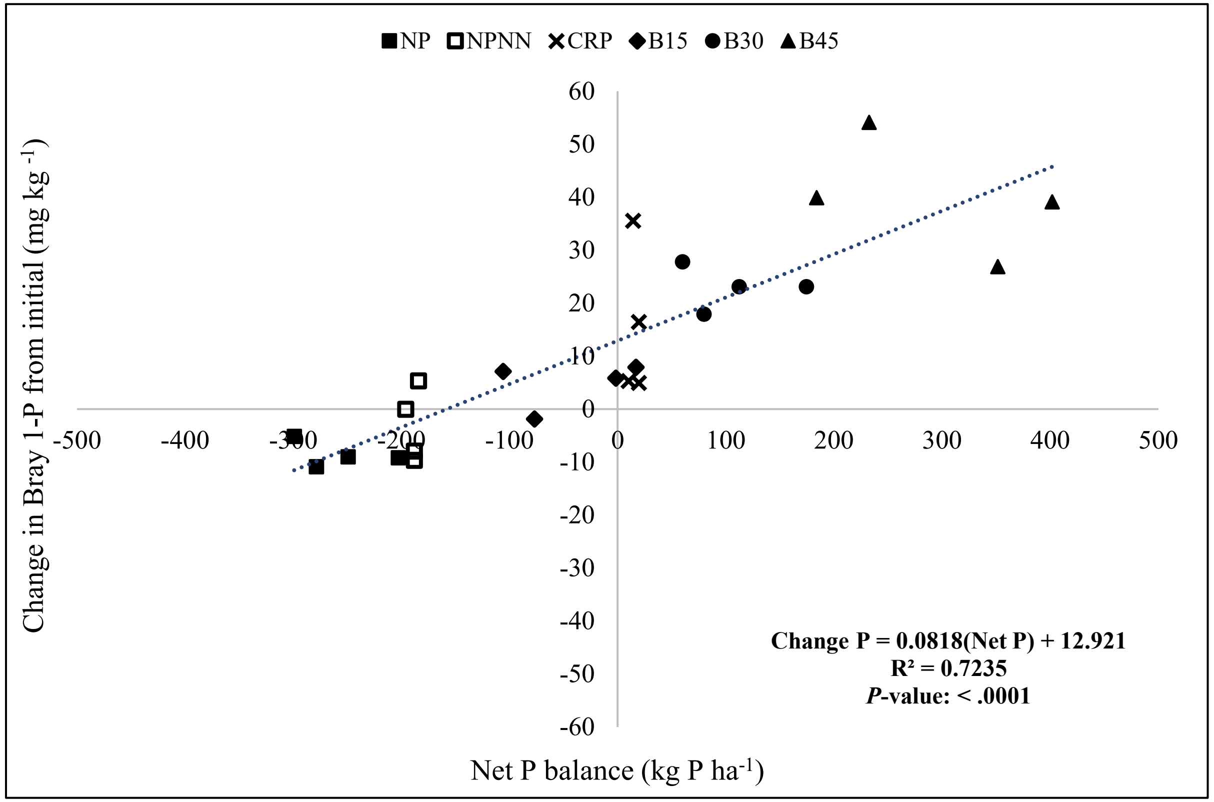

- P application increased corn grain P concentration compared to NP, irrespective of growing conditions
- No differences in grain P concentration between CRP vs. B15.
- A trend of higher grain P concentration with higher P levels, indicating luxury P consumption at higher P application rates, even during dry years.

# Impact of phosphorus application strategies on corn grain P removal




- P application increased corn grain P removal compared to NP and NPNN, regardless of growing conditions.
- No differences in grain P removal between CRP vs. B15.
- A trend of higher grain P removal with higher P application rates, indicating luxury P consumption at higher P levels, even during dry years.

# Impact of phosphorus application strategies on Net P Balance




- ΔSTP was positively correlated with net P balance.
- In the absence of P application (negative net P), STP values decreased by the end of the study period.
- B15 treatment, with either a negative or slightly positive net P balance, showed minimal or no change in final STP values.
- In contrast, B30 and B45, along with CRP treatment, had a positive net P balance and resulted in increased STP values.

# Economic Impact of phosphorus application strategies across all years

| | Average across year (2000 – 2015) | | | | | |
|---|---|---|---|---|---|---|
| | **Δ Yield** | **Net income** | **P applied** | **Cost** | **Net return** | **ROI** |
| Treatment | Mg ha$^{-1}$ | \$ ha$^{-1}$ | kg P ha$^{-1}$ yr$^{-1}$ | \$ ha$^{-1}$ | \$ ha$^{-1}$ | |
| CRP | 0.76ab | 107ab | 20c | 22c | 85 | 4.9 |
| B15 | 0.52c | 73c | 16c | 18c | 55 | 3.6 |
| B30 | 0..66bc | 93bc | 27b | 30b | 63 | 3.1 |
| B45 | 0.93a | 131a | 40a | 44a | 88 | 3 |
| SE | 0.26 | 36 | 1.9 | 2.1 | 36 | 1.3 |
| | P > F | | | | | |
| | * | * | *** | *** | NS | NS |

- CRP has greater yield increase than B15, but was similar to B45.
- Net Income was higher in B45 and CRP than B15 treatment.
- No significant differences in Net Return were observed between treatments.
- The CRP approach was the most economical, offering the lowest cost per bushel of yield increase and the highest return per pound of P applied.

# Economic Impact of phosphorus application strategies across different moisture regimes

| | Dry year | | | Normal year | | | Wet year | | |
|---|---|---|---|---|---|---|---|---|---|
| | Δ Yield | Net return | ROI | Δ Yield | Net return | ROI | Δ Yield | Net return | ROI |
| Treatment | Mg $ha^{-1}$ | \$ $ha^{-1}$ | | Mg $ha^{-1}$ | \$ $ha^{-1}$ | | Mg $ha^{-1}$ | \$ $ha^{-1}$ | |
| CRP | -1.67 | -258 | -10.5ab | 0.69b | 76b | 4.3ab | 3.4 | 458 | 21.3a |
| B15 | -1.72 | -262 | -14.5b | 0.57b | 62b | 4.8a | 2.59 | 347 | 21.3a |
| B30 | -1.68 | -268 | -7.8a | 0.63b | 60b | 3c | 3.07 | 403 | 14.7ab |
| B45 | -1.99 | -325 | -6.3a | 1.04a | 103a | 3.5bc | 3.5 | 449 | 11.7b |
| SE | 0.29 | 43 | 1.7 | 0.09 | 14 | 0.6 | 0.28 | 40 | 2.4 |
| | NS | NS | * | *** | * | * | NS | NS | * |

- P application should be avoided or minimized during dry years, as the financial risks increase with higher P application rates under these conditions.
- In wet year, no differences in ΔYield and net return among treatments receiving P application
- In normal year with adequate moisture and favorable growing conditions, maintaining soil at a very high P level (B45) maximized the yield increase and net return.

# Conclusions

- Lower corn grain yield from our current (B15-B20) recommendations than CRP and B45 across all years, especially in wet years, indicate a potential yield loss especially when conditions favor high yield potential.
- High STP levels increased grain P concentration and removal without consistent yield improvement across all moisture scenarios, indicating that P removal may not necessarily be an indicator for grain yield.
- CRP-based application seems a better strategy for maximizing the ROI compared to other P strategies. However, a higher P (B45) that provides higher absolute return, can be used in soil
  - less prone to P loss or when budget constraints are not an issue
  - high yield is expected due to the abundance of other inputs driving crop growth, necessitating additional P to meet crop demand and achieve higher yield goals.
- Overall, the findings from this study suggest that the UNL P recommendations for dryland continuous corn, based on a deficiency correction approach, could be revisited.

# THANK YOU

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