# Do Soil Tests Predict Yield Response to Phosphorus in Modern Corn and Soybean Production?

Crop Physiology

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**Question:** ***Do soil tests predict yield response from a premium phosphorus fertilizer in modern corn and soybean production?***

**Objective:** ***Determine whether soil test P levels adequately predict yield responses from spring-banded MicroEssentials SZ.***

## Introduction:

- Phosphorus (P) fertilizer applications should be made according to the 4R nutrient stewardship and Best Management Practices guidelines which include applying fertilizer based upon soil test levels. [1]
- Illinois soil test fertilizer P recommendations have hardly changed since published in the 1960's, in contrast to production practices, yields, and P uptake. [2]
- Increasing environmental concerns dictate alternative methods of applying fertilizers such as banding in order to decrease nutrient loss and promote increased fertilizer efficiency even when soil test levels are high. [3]
- Fertilizer P applications closer to crop uptake reduces P fixation and decreases the likelihood for P loss. [4]
- Nutrients may be applied according to crop removal coefficients or yield goals, but we speculate whether current P soil test recommendations are adequate for modern corn and soybean production practices.

**References**

1. Bruuslema, T., Chen, F., Garcia, F., Ivanova, S., Li, S., Rao, D., Witt, C. 2008. A global framework for best management practices for fertilizer use. Concept paper 1 – March 2008: International Plant Nutrition Institute.
2. Bender, R.R., J.W. Haegele, M.L. Ruffo and F.E. Below. 2013. Modern corn hybrids' nutrient uptake patterns. Better Crops 97:7-10.
3. Bundy, L.G. 2001. Management practice effects on phosphorus losses in runoff in corn production systems. J. Environ. Qual. 30:1822.
4. Penas, E.J., and D.H. Sander. 1982. G82-601 Using phosphorus fertilizers effectively. Ext. Bull. G601. Soil Resource Management. Univ. Nebraska-Lincoln Ext., Univ. of Nebraska Lincoln, Lincoln, NE.

## Research Approach:

**Sites:** 4 Illinois sites (DeKalb, Rushville, Champaign, & Harrisburg) from 2011 to 2015, including:

• 22 corn (*Zea mays L.*) evaluations (6 in 2011, 2 in 2012, 8 in 2013, 3 in 2014 & 3 in 2015).

• 32 soybean [*Glycine max (L.) Merr.]* evaluations (10 in 2012, 9 in 2013, 6 in 2014 & 7 in 2015).

**Soil Sampling:** Each site was sampled to 15 cm before planting and measured for P using Mehlich-3 extraction.

**Plots:** 3 to 7 replications depending on site and year:

•Corn: 0.76m row spacing for targeted final stand of 79,000 plants $ha^{-1}$ over various elite commercial hybrids.

•Soybean: Average of 0.51m and 0.76m row spacing at a targeted final stand of 395,000 plants $ha^{-1}$ over a range of elite commercial varieties and maturity groups.

**P Source:** A premium MAP-based P fertilizer source (MicroEssentials® SZ™ 12-40-0-10S-1Zn from the Mosaic Company) that also supplies S and Zn.

**P Rate:** Based on yield goals of 15 and 7 Mg $ha^{-1}$ for corn and soybean, 112 kg $P_2O_5$ $ha^{-1}$ was applied to corn and 84 kg $P_2O_5$ $ha^{-1}$ to soybean at all sites and compared to unfertilized control plots.

**P Timing:** In the spring immediately prior to planting to help assure availability for crop uptake.

**P Placement:** Banded fertilizer placed 15 cm deep directly under the future crop row using RTK guidance.

## Yield Response from Premium P Fertilizer:

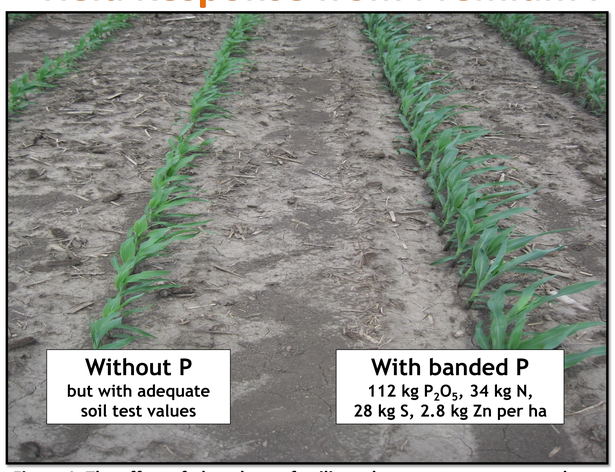


Figure 1. The effect of phosphorus fertilizer placement on corn growth.


Figure 2. The effect of phosphorus fertilizer placement on soybean growth.

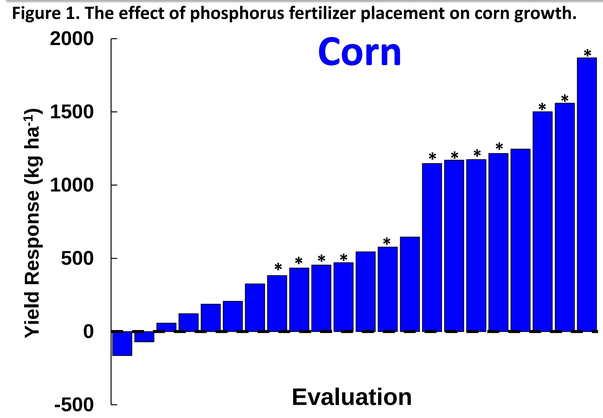


Figure 3. Corn yield change due to banded P fertilizer compared to unfertilized plots arranged by response magnitude over 22 evaluations.
* Yield response significantly different than unfertilized control ($P \leq 0.1$)

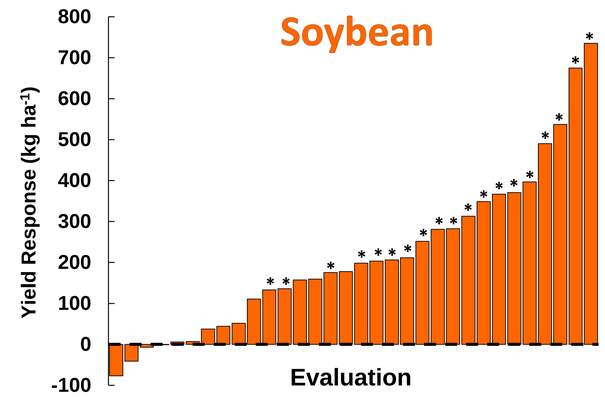


Figure 4. Soybean yield change due to banded P fertilizer compared to unfertilized plots arranged by response magnitude over 32 evaluations.
* Yield response significantly different than unfertilized control ($P \leq 0.1$)

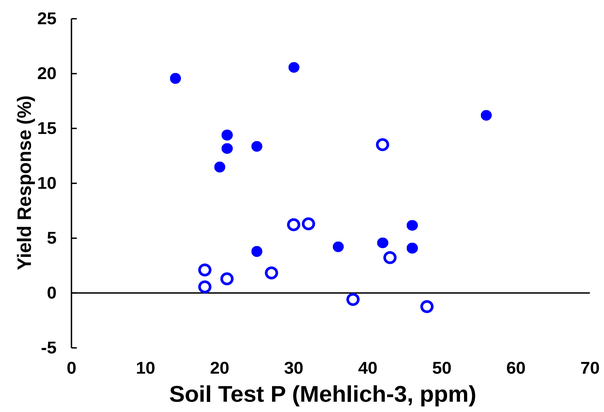


Figure 5. Magnitude of corn yield response from banded P fertilizer compared to unfertilized plots as affected by soil test P level. Filled points indicate a significant ($P \leq 0.1$) yield response over unfertilized plots in a given evaluation. Critical soil test P level for Illinois is 20 ppm.

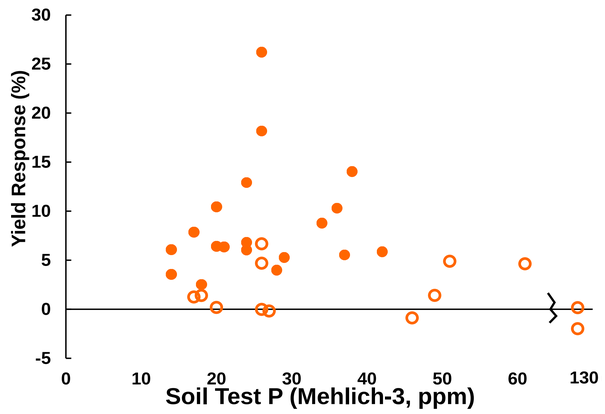


Figure 6. Magnitude of soybean yield response from banded P fertilizer compared to unfertilized plots as affected by soil test P level. Filled points indicate a significant ($P \leq 0.1$) yield response over unfertilized plots in a given evaluation. Critical soil test P level for Illinois is 20 ppm.

## Results:

- **Early season growth enhancement from banded P was observed at all sites for both crops, showing that fertility sets the potential for greater corn and soybean yields (Figures 1 & 2).**
- **Averaged across all evaluations banded P applications increased yield of corn by 555 kg $ha^{-1}$ (10.5 bushels $acre^{-1}$) or 5.2% (Figure 3), and by 212 kg $ha^{-1}$ (3.6 bushels $acre^{-1}$) or 5.4% for soybean (Figure 4).**
- **55% of the corn evaluations exhibited significant yield increases from banded P application, averaging 1010 kg $ha^{-1}$ or 11%, and these sites had an average soil P test level of 32 ppm (range 14-56 ppm) (Figures 3 and 5).**
- **Most of the corn sites (82%) tested over the critical 20 ppm soil P level (average of 35 ppm, range of 21-56 ppm), yet banded fertilizer P increased yield by an average of 5.5% at these sites (Figure 5).**
- **Corn yield responses from banded fertilizer P application was not associated with soil test values ($R^2$=0.02) (Figure 5).**
- **59% of the soybean evaluations exhibited significant yield increases from banded P application, averaging 319 kg $ha^{-1}$ or 8%, and these sites had an average soil P test level of 26 ppm (range 14-42 ppm) (Figures 4 and 6).**
- **For the 23 soybean sites that tested over the 20 ppm critical soil test P level (average of 41 ppm, range of 21-126 ppm), banded fertilizer P application increased yield an average of 5.4 % (Figure 6).**
- **Soybean yield responses from banded fertilizer P application was poorly associated with soil test values ($R^2$=0.09) (Figure 6).**

## Conclusions:

**1. Are current Illinois P soil test recommendations adequately predicting when responses to fertilizer addition P are unlikely?**

X **No, Yield responses from modern fertilizer application practices were poorly associated ($R^2$=0.06) with soil test levels when averaged over both corn and soybean, despite the majority of the evaluations exhibiting positive yield responses.**

**2. Are responses from modern fertilizer application practices possible above current soil test P critical levels?**

✓ **Yes, Yield responses from spring banded MicroEssentials SZ resulted in a 5.4% yield response from the 40 corn and soybean environments (74% of all environments) that were above the Illinois current P critical level.**

**3. Is soil testing still a valuable tool for phosphorus management?**

✓ **Yes, While many soils testing below critical P levels required P fertilizer for maximum corn or soybean yield, greater yields can also be obtained on soils testing above the critical levels using fertilizer in conjunction with the best 4R nutrient stewardship principles.**