CAN MULTI-YEAR FERTILIZER APPLICATIONS IMPROVE PRODUCTIVITY IN A MAIZE AND SOYBEAN ROTATION?

Crop Physiology

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OBJECTIVE: ***Quantify yield responses of maize and soybean with different allocations of multi-year fertilizer applications.***

INTRODUCTION

A common fertilization practice in the Midwest is to apply two-crop amounts of phosphorus (P), potassium (K), and sulfur (S) fertilizers to maize (*Zea mays* L.) crops that are rotated with soybean [*Glycine max* (L.) Merr.]

Maize yields are often greater when fertilizer is applied in the same year, while soybean yields are usually equivalent or higher when fertilizer was applied in a previous year (Boring et al., 2018, *Agronomy*; 8, 1-12).

Increasing fertilizer prices pose a problem to farmers' ability to make a profitable return on their investment, making it important to purchase and apply fertilizer when prices are low.

RESEARCH APPROACH

Trial Design:

Experimental units were static plots four rows wide and 11 m in length with 0.76 m row spacing. Maize was planted on 7 April 2021, and soybean was planted on 10 May 2022 at Champaign, IL. Treatments were arranged in a randomized complete block experimental design with six replications.

Treatments (Table 1):

1. Untreated control (UTC)
2. Annual application to either crop
3. Biennial maize-only application
4. Biennial two-crop amount
5. Single four-crop amount

Table 1. Single crop nutrient rates of fertilizer applied to maize and soybean.

Crop	N	P_2O_5	K_2O	S	Ca	Mg
	kg ha^{-1}					
Maize	200	78	67	28	17	6
Soybean	0	34	67	17	10	3

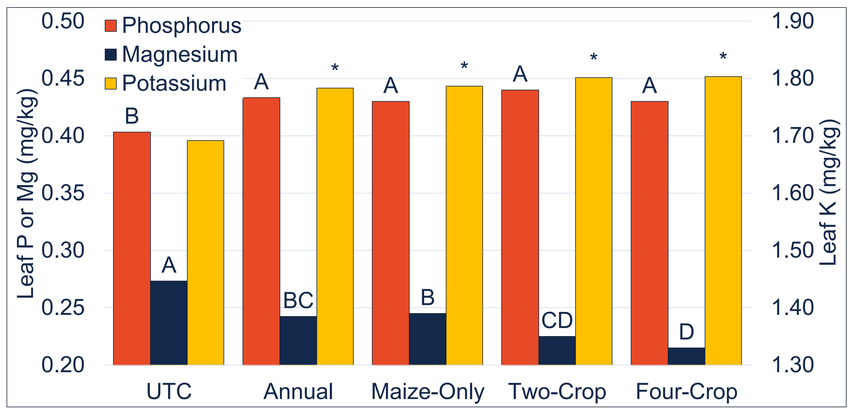
Fertilizer applied as urea (0-0-46), monoammonium phosphate (11-52-0), muriate of potash (0-0-60), and polyhalite (POLY4, 0-0-14-19S-11.4Ca-3.6Mg).

RESULTS

2021 Maize: All fertilizer treatments increased the concentrations of P and K in R2 leaf tissue and post-harvest soil tests relative to the UTC, with the four-crop application exhibiting the greatest increase (Figures 1 and 2). Conversely, Mg levels in leaf tissue decreased as fertilizer rates increased. Soil test values of Mg increased from the annual, maize-only, and two-crop applications, while the four-crop application decreased soil Mg to the level of the UTC (Figure 2). Although not statistically significant, all fertilizer applications tended to increase yield over the UTC as a result of heavier individual kernel weights (Table 2).

2022 Soybean: Grain yield and yield components of the subsequent soybean crops were not significantly increased by any fertilizer treatments, although there was a tendency for the multi-year fertilizer applications to increase yield and seed number (Table 3).

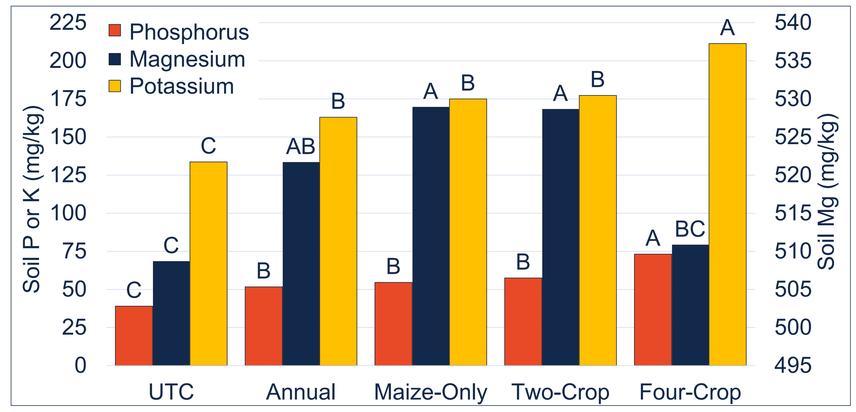
Figure 1. Effect of fertilizer treatments on the concentrations of P, K, and Mg in the leaf above the ear at the R2 growth stage of maize grown at Champaign, IL in 2021.



Bars within each parameter labeled with different uppercase letters are significantly different at $P \leq 0.10$ using Fisher's LSD separation test.

* Statistically different from the UTC at $P \leq 0.1$ using a paired t-test.

Figure 2. Effect of fertilizer treatments on soil levels of P, K, and Mg at 0-15 cm depth after maize harvest at Champaign, IL in 2021.



Bars within each parameter labeled with different uppercase letters are significantly different at $P \leq 0.10$ using Fisher's LSD separation test.

Table 2. Effect of fertilizer treatment on maize grain yield at Champaign, IL in 2021. Yield expressed at 0% moisture.

Treatment	Yield	Kernel Number	Kernel Weight
	Mg ha^{-1}	kernel m^{-2}	mg kernel^{-1}
UTC	13.7	5697	240
Annual	13.9	5644	247
Maize-Only	14.0	5605	252*
Two-Crop	14.2*	5511	257*
Four-Crop	13.9	5555	251*
p-value	0.3155	0.5716	0.0346
LSD (α = 0.10)	ns	ns	9

ns, not-significant.

* Statistically different from the UTC at $P \leq 0.1$ using a paired t-test.

Table 3. Effect of fertilizer treatment on soybean grain yield at Champaign, IL in 2022. Yield expressed at 0% moisture.

Treatment	Yield	Seed Number	Seed Weight
	Mg ha^{-1}	seeds m^{-2}	mg seed^{-1}
UTC	4.6	2581	178
Annual	4.5	2583	175*
Maize-Only	4.8	2709	178
Two-Crop	4.9	2744	177
Four-Crop	4.7	2638	178
p-value	0.2344	0.3588	0.1140
LSD (α = 0.10)	ns	ns	ns

ns, not-significant.

* Statistically different from the UTC at $P \leq 0.1$ using a paired t-test.

Conclusions

- Yield responses of maize and soybean varied with different allocations of multi-year fertilizer applications.
- Using two-crop fertilization led to the highest yields in both maize and soybean crops, suggesting farmers could apply nutrients biennially before maize with sufficient nutrients for both crops.
- The highest rate of applied K may have induced Mg to be leached from the rooting zone, while all applications of K decreased Mg levels in maize leaf tissue likely due to cation competition.