Identifying Which Management Factors Have the Greatest Impact on Soybean Yields

Tryston A. Beyrer and Frederick E. Below

Crop Physiology Laboratory, Department of Crop Sciences, University of Illinois at Urbana-Champaign

Question: ***Which agronomic management factors have the greatest impact on soybean grain yield?***

Objective: ***Identify independent and/or synergistic contributions of agronomic management factors to soybean yields.***

Introduction:

- Growers make critical decisions every year regarding the inputs needed to maximize the productivity of their farm based on the potential yield gain of a given input factor; therefore, it is critical to understand the interactions of these factors under varying levels of management.
- Standard fertilizer sources and application practices may not be adequate for modern cultivars and management systems.
- Management practices that result in greater plant growth increase light interception capable of supplying greater quantities of photoassimilates to sinks.
- Understanding the contribution of individual management practices to yield, or whether synergies exist among inputs that can result in greater returns to the grower when combined under varying levels of management

Research Approach:

Sites: 3 Illinois locations (DeKalb, Champaign, & Harrisburg), comprising: 11 soybean [*Glycine max (L.) Merr.*] evaluations (4 in 2014 & 7 in 2015). Plots were 4-rows x 11m, in which the center 2 rows were harvested at maturity for yield. All grown with 6 replications.

Evaluation of five categories of management factors using omission-addition design alterations to Standard and High Input management systems (Table 1):

•Fertilizer

•Natural soil fertility, where the average P and K soil test values (Mehlich III, ICP) were 20 and 132 ppm respectively.

•Phosphorus (P): MAP-based P fertilizer (MicroEssentials® SZ™ 12-40-0-10S-1Zn), banded 15 cm deep directly prior to planting at a yield goal-based rate of 84 kg P_2O_5 ha^{-1}.

•Potassium (K): MOP-based K fertilizer (Aspire®, 0-0-58-0.5B), broadcast directly prior to planting at a yield goal-based rate of 84 kg K_2O ha^{-1}.

•P plus K fertilizer applied as above.

•Foliar Protection

•Fungicide and insecticide mixes were prophylactically applied at the R3 growth stage using Syngenta or BASF products, depending on the seed genetics and compared to no foliar protection.

•Seed Treatment

•None or basic fungicide seed treatment was compared to a full seed treatment consisting of a combination of fungicide, insecticide & nematicide seed treatments depending on the seed genetic supplier.

•Row Spacing

•Two row spacings of 51 and 76 cm planted at a targeted final stand of 395,000 plants ha^{-1}.

•Relative Maturity (RM)

•Two cultivars selected as either a Standard or full RM for the area grown differed by 0.3 RM units on average.

Results and Discussion:

- **Early season growth enhancements from seed treatment and additional fertility were observed at all sites (Figure 1).**
- **Full season RM cultivars increased yield by 70 kg ha^{-1} (1.2 bushels $acre^{-1}$) (Figure 2).**
- **High Input management increased yield by 593 and 392 kg ha^{-1} (10.1 and 6.7 bushels $acre^{-1}$), or 14 & 10% for 51 and 76 cm row spacings, respectively (Figure 3).**
- **Averaged across all site-years, banded P applications affected yield by ~277 kg ha^{-1} (4.7 bushels $acre^{-1}$) or ~7% when added to the Standard or when omitted from the High Input management (Table 2).**
- **Despite soil test levels being relatively low, potassium had little effect on yield, where yield tended to be greater without K (Table 2).**
- **Combinations of P and K fertilizer resulted in near additive effects in both management systems (Table 2).**
- **Foliar protection increased yield 4% (3.0 bushels $acre^{-1}$) in Standard management, with a similar yield loss when not applied to the High Input management (Table 2).**

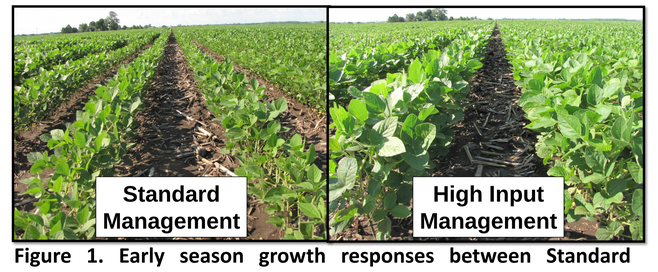

Figure 1. Early season growth responses between Standard management (left) and High Input management systems (right).

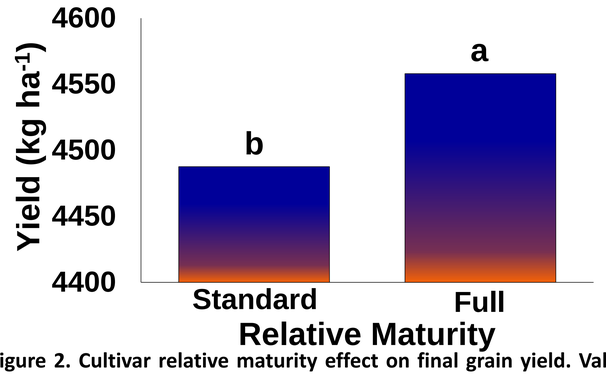

Figure 2. Cultivar relative maturity effect on final grain yield. Values are the average of 11 site-years across Illinois and yields with different letters differ (*P ≤ 0.0001*).

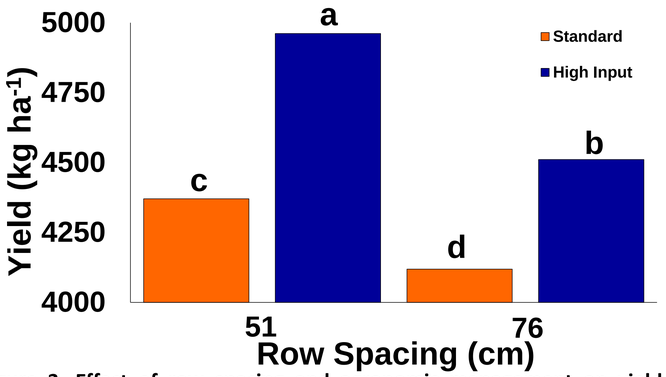

Figure 3. Effect of row spacing and agronomic management on yield. Values are the average of 11 site-years across Illinois and yields with different letters differ (*P ≤ 0.05*).

- **Full seed treatment resulted in greater yields with High Input management, where changing to the basic seed treatment resulted in a 123 kg ha^{-1} yield decrease (Table 2).**
- **Synergies of adding individual management factors were observed in High Input 51 cm vs Standard 76 cm row spacing (Table 3).**

Table 2. Effect of agronomic management on yield. Values are the average of 11 site-years across Illinois. *Yield response significantly different than Standard or High Input management (*P* ≤ 0.05).

	Standard		High Input	
Factor	Yield	Δ from adding	Yield	Δ from omitting
	kg hectare^{-1}			
None or All	4116		4962	
Phosphate	4392	+276*	4684	-278*
Potassium	4092	-24	4965	+3
P & K	4360	+244*	4698	-264*
Foliar Protection	4289	+173*	4781	-182*
Seed Treatment	4201	+84	4839	-123*

Table 3. Comparisons between the soybean yield increases of the High Input (HI) over the Standard (Std) management control treatments (shown as 95% confidence intervals; μ_{HI}-μ_{Std}) and the summation of the yield changes provided by each supplemental treatment to the Standard management control yield when significant as affected by row spacing.

	Row Spacing (cm)			
Treatment	51	76	Average	51 HI vs 76 Std‡
	kg hectare^{-1}			
μ_{HI}-μ_{Std}	593 (506-679)	392 (308-477)	493 (432-553)	846 (740-952)
$\Sigma(Y_{+ FACTOR} - Y_{Std})$†	921	449	727	703

† $\Sigma[(Y_{+ Phosphorus} - Y_{Std}) + (Y_{+ Potassium} - Y_{Std}) + (Y_{+ Foliar} - Y_{Std}) + (Y_{+ Seed\ Treatment} - Y_{Std})]$

‡ $\Sigma[(Y_{+ Phosphorus} - Y_{Std}) + (Y_{+ Potassium} - Y_{Std}) + (Y_{+ Foliar} - Y_{Std}) + (Y_{+ Seed\ Treatment} - Y_{Std}) + (Y_{+ Row\ Spacing\ of\ Std\ 51} - Y_{Std\ 76})]$

Table 1. The omission-addition design used to evaluate individual management factor treatments from Standard or High Input management systems. All treatments were evaluated using two relative maturity cultivars in 51 and 76 cm rows.

		MANAGEMENT FACTORS				
	Treatment	Phosphate	Potassium	P & K	Foliar Protection	Seed treatment
	HIGH INPUT	Yes	Yes	Yes	Yes	Full
Omit Management	-Phosphate	None	Yes	Yes	Yes	Full
	-Potassium	Yes	None	Yes	Yes	Full
	-P and K	Yes	Yes	None	Yes	Full
	-Foliar Protection	Yes	Yes	Yes	None	Full
	-Seed Treatment	Yes	Yes	Yes	Yes	Basic
	STANDARD	None	None	None	None	Basic
Add Management	+Phosphate	Yes	None	None	None	Basic
	+Potassium	None	Yes	None	None	Basic
	+P and K	None	None	Yes	None	Basic
	+Foliar Protection	None	None	None	Yes	Basic
	+Seed Treatment	None	None	None	None	Full

Conclusions:

1. Does soybean respond to intensified management?

✓ **Yes, Soybean responded to individual and combinations of inputs with mean yield increases ranging from 70 to 846 kg ha^{-1}.**

2. Which management factors have the greatest impact on soybean yields?

All management factors except potassium fertilizer (phosphorus fertilizer, foliar protection, seed treatment, row spacing, and relative maturity) were influential at increasing yield in at least one management system.

3. Do agronomic practices contribute synergistically to soybean yield?

✓ **Yes, Combining phosphorus fertilizer, foliar protection, seed treatment, and narrower row spacings resulted in a greater yield increase than any factor individually.**