Management Practices to close Yield Gaps in Maize-Soybean Systems: Experiences in United States, Brazil and Argentina

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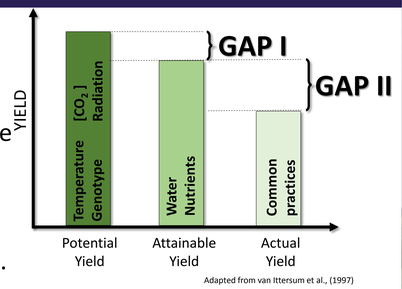
Introduction

Selecting the best genotype and management practices (e.g., seeding rate, row spacing, planting date, and fertilizer 4Rs), in consideration with the complex interaction with the environment (soil plus weather), will directly impact maximum yield potential and consequently, yield gaps.



Objective

Determine if selected management practices can close yield GAP II (herein yield GAP) in a global (United States, Brazil and Argentina) maize-soybean rotation.

Materials and Methods

Sites (6 total): Kansas (2), United States (US); Parana and Mato Grosso, Brazil (BRZ); Santa Fe (2), Argentina (ARG).
Seasons: 2014 (BRZ-ARG) 2015 (US-BRZ-ARG) and 2016 (US).
Experiment setup: Maize (*Zea mays* L.)- Soybean (*Glycine max* L.) rotation.
Treatments description:

Table 1. Overall treatment description for maize and soybean rotation for all three sites United States, Brazil and Argentina, 2014-2015.

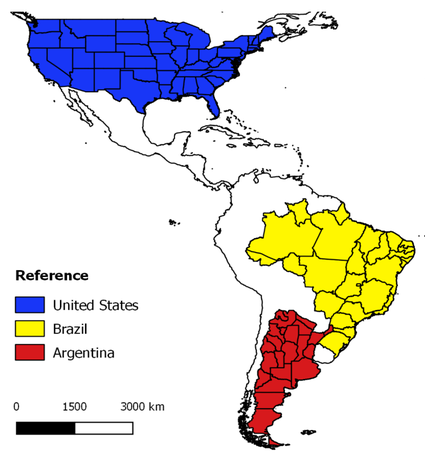
Management Practice	Maize		Soybean	
	CP	EI	CP	EI
Seeding rate (pl ha^{-1})	Farmer Practice[1] 70.000	Increased (+15K) 85.000	Farmer Practice[1] 70.000	Increased (+60K) 130.000
Row spacing (m)	Wide 0.52-0.76	Narrow (US) 0.38	Wide 0.52-0.76	Narrow 0.26-0.38
Fertilization	Only N applied	Balanced N-P-K-S	No Fertilizer was applied	Balanced P-K-S
Micronutrients	No	Single rate[2]	No	Single rate
Fungicide	No	Single rate	No	Single rate
Insecticide	No	Single rate	No	Single rate

CP=Common Practices, EI= Ecological Intensification. Pl: plants. [1]For each site where the experiment was conducted. Foliar B and Zn were applied. CP and EI at the US location were tested in both rainfed and under irrigated scenarios. In ARG early (EI) and late (CP) planting date was evaluated too.

Experimental design: complete randomized block design with 5 (US), and 3 (BRZ, ARG) replications.
Measured parameters:
- Dry biomass and total nitrogen (N) content (by plant fraction) was calculated for maize and soybean at multiple growth stages.
- Canopy coverage (Syscob®) determined via imagery analysis (US).
- Grain yield for maize (adjusted to 15% moisture) and seed yield for soybeans (adjusted to 13% moisture).
- 5-yr (2010-14 period) country-yield average (CTY) was retrieved from FAOSTAT©.
- Nutrient input efficiency: ratio of yield to total nutrient applied.

Results

How large is the yield GAP?



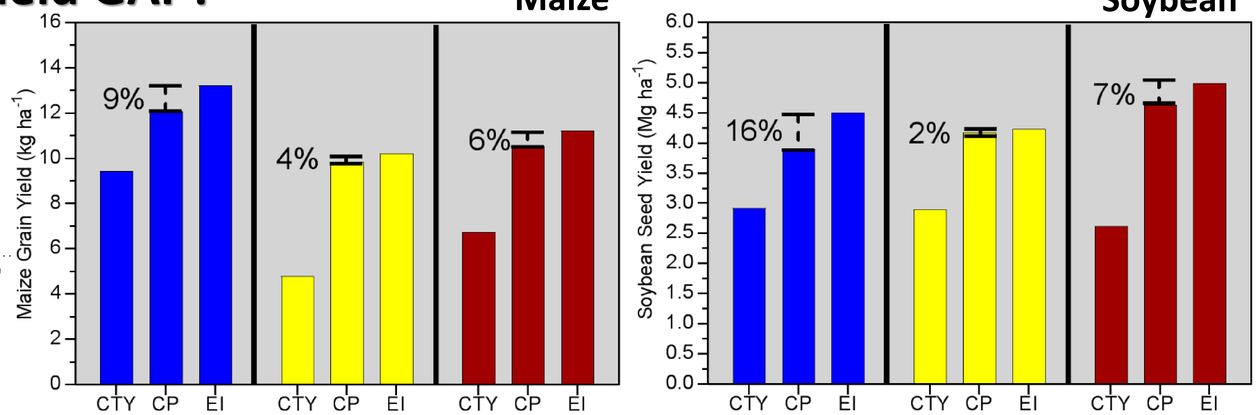


Figure 1. Final yields for the five-year country-average (CYT), common Practices (CP) and ecological Intensification (EI) treatments for both soybean and maize at each country: United States (blue), Brazil (yellow) and Argentina (red). The percentage (%) indicates the yield GAP measured, determined as the difference between the EI and CP.

Which management factors contributed to closing the yield GAP? US Site

Row spacing and Seeding rate

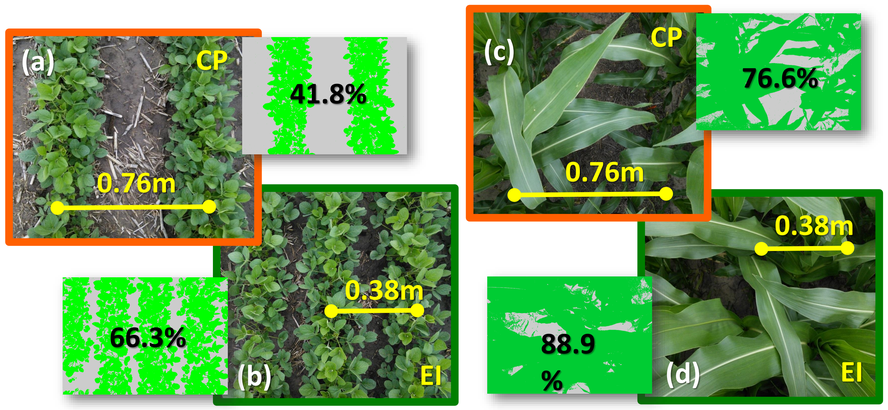


Figure 2. United States Site. Canopy coverage at vegetative stage in soybean (V4) and maize (V10): for Common Practices **CP** (a,c; 0.76m) and Ecological Intensification **EI** (b,d; 0.38m), (Season 2014). Software for imagery analysis: Siscob®.

Irrigation (Water supply)

- For soybeans, irrigation increased seed yield by 53%, averaging all treatments.
- For maize, this factor improved grain yields by 9%, averaging all treatments.

Balanced Nutrition Program

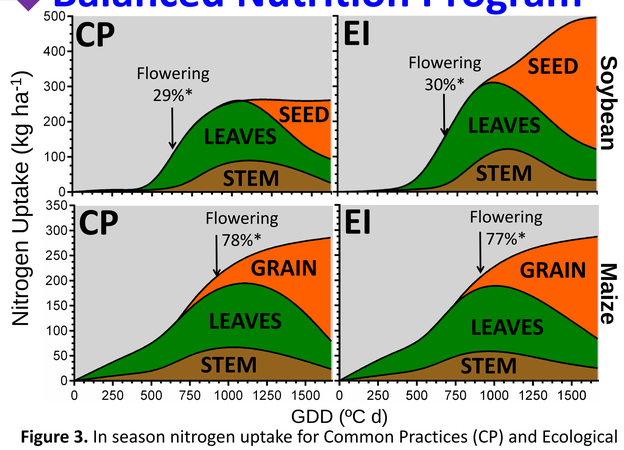


Figure 3. In season nitrogen uptake for Common Practices (CP) and Ecological Intensification (EI) in soybean and maize crops. *Relative proportion at flowering as compared with the final value attained at physiological maturity.

At comparable level of nutrient inputs, but intensifying managements practices:
- *For soybeans, nutrient input efficiency was 19% and 29% greater under irrigated and dryland conditions, respectively.*
- *For maize, balanced nutrition was the main factor in increasing yields and close yield GAP.*

Conclusions

- ✓ Yield GAP ranked US>ARG>BRZ for both crops. Larger yield GAP was observed for soybean. US reached the maximum attainable yield in maize as compared with other countries (studies); while for soybean, greater attainable yield was observed in ARG relative to US and BRZ sites.
- ✓ Greater impact of management practices to close yield GAP was recorded in the US.
- ✓ Ecological intensification treatment (EI) produced superior yields across the three sites. For the rotation, intensifying management practices combined with a balanced nutrition program allowed closing yield GAP in both crops of a maize-soybean cropping rotation.