Modeling a Corn-Soybean Rotation with APSIM in Western US Corn Belt

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Introduction

The Agricultural Production Systems sIMulator (APSIM) can provide support to producers to select appropriate management practices for their crops.

Objective

Evaluate APSIM model prediction accuracy for a Corn-Soybean rotation in Western US Corn Belt under two contrasting crop production management strategies.

Materials and Methods

Experiments setup: a corn (*Zea mays* L.)-soybean (*Glycine max* L.) rotation was established in 2014 (dryland and irrigated conditions) at Scandia, KS (**Image 1**).

Treatments: Two treatments were simulated with APSIM (**Table 1, Image 2**).

Table 1. Treatment description for corn and soybean rotation at Scandia, KS. 2014-2015.

	Corn		Soybean	
	CP	**EI**	**CP**	**EI**
Seeding rate (pl ha^{-1})	74,000	89,000	274,000	429,000
Row spacing (m)	0.76	0.38	0.76	0.38
Fertilization (kg ha^{-1})	56N	P-K-S* 56N+112N	No	P-K-S* 56N
Micronutrients	No	1x	No	1x
Fungicide	No	1x	No	1x
Insecticide	No	1x	No	1x

CP=Common Practices, **EI**= Ecological Intensification *Following university recommendations. Pl: plants. N expressed in kg ha^{-1}.

Image 1. Plots locations for 2014 and 2015 growing seasons under irrigation. Both crops present in each season.

Measured parameters:

- Dry biomass and total nitrogen (N) content (by plant fraction) was calculated at multiple growth stages for corn (V_6, V_{13}, R_1, R_3, R_6) and soybean (V_4, R_1, R_3, R_5, R_7).
- Grain yield for corn (15.5% moisture) and seed yield for soybeans (13% moisture).

APSIM setup:

- Model setup included rotations, variety/hybrid, weather, and soil data.
- Total of six simulations were performed by combining crop rotation, water condition and treatment.
- Output variables were total plant dry biomass and by fraction, harvest index (HI), total N content (aboveground fractions, excluding roots) and yield.

Statistical analysis

RRMSE, model efficiency (EF) and R^2 were calculated to test model accuracy.

$$RMSE = \sqrt{\frac{\sum_{i=1}^{n}(Si-Oi)^2}{n}} \qquad \mathrm{EF} = 1 - \frac{\sum(Si-Oi)^2}{\sum(Oi-\bar{O})^2} \qquad RRMSE = \frac{RMSE}{\bar{O}} x100$$

Where *Si*: simulated, *Oi* observed, $\bar{O}$ average of observed, *n*: number of observations.

Results

Differences in canopy coverage and biomass production were observed between treatments at vegetative stages. Narrow row spacing, increasing seeding rates and balance nutrition showed more canopy coverage and plant biomass (**Image 2**).

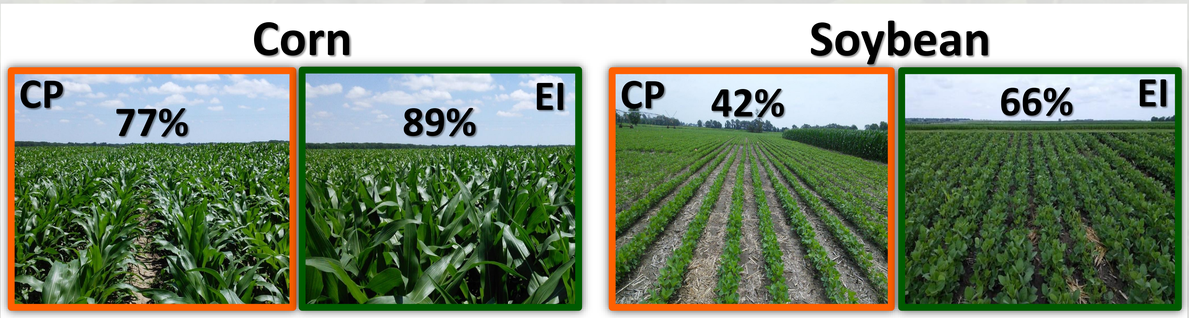

Image 2. Percentage of canopy coverage at vegetative stage in corn (V10) and soybean (V4) for **CP** and **EI**, Scandia, KS (2014).

Results (continuing)

Observed data

Yield gap was greater for soybean under both dryland and irrigated scenarios. For corn, yield differences were not statistically significant for 2014 season (Fig. 1). In 2015 season, under irrigated conditions, EI yielded 8% more than CP treatment.

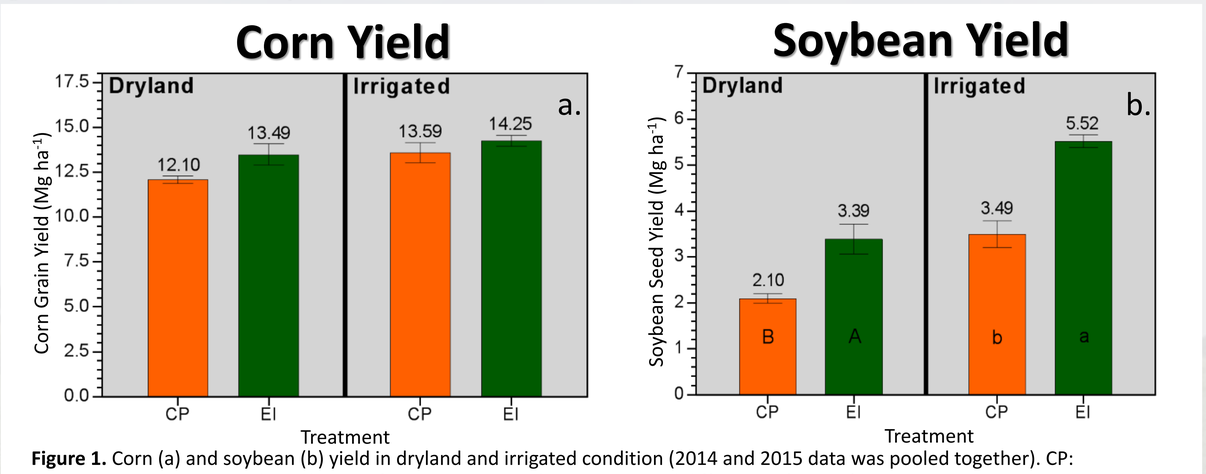

Figure 1. Corn (a) and soybean (b) yield in dryland and irrigated condition (2014 and 2015 data was pooled together). CP: Common Practices; EI: Ecological Intensification. Letters indicates statistical differences ($p<0.05$).

APSIM Simulation results

Table 2. Statistical analysis for different outputs of the model as related to the observed data for corn and soybean, KS (2014-15).

Fraction	Crop	RRMSE	EF	R^2
Yield	Corn	11	0.59	0.81
	Soybean	23	0.51	0.79
Plant Biomass	Corn	32	0.90	0.96
	Soybean	20	0.68	0.87
Stem Biomass	Corn	27	0.81	0.92
	Soybean	54	-0.08	0.69
Leaf Biomass	Corn	82	-2.37	0.49
	Soybean	72	-1.31	0.37
Plant N Uptake	Corn	54	0.26	0.38
	Soybean	85	0.11	0.36

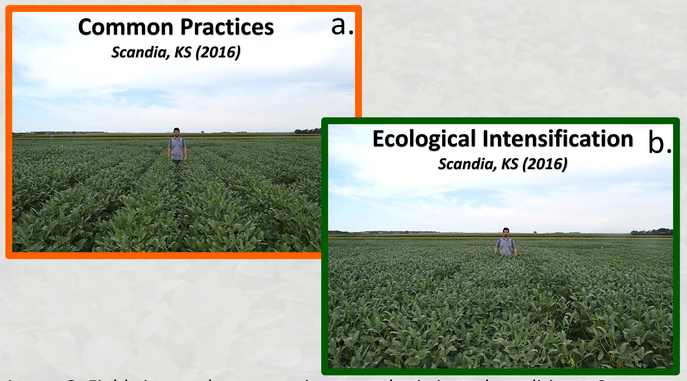

Image 3. Field view soybean experiment under irrigated conditions: Common Practices (a) and Ecological Intensification (b), Scandia, 2016.

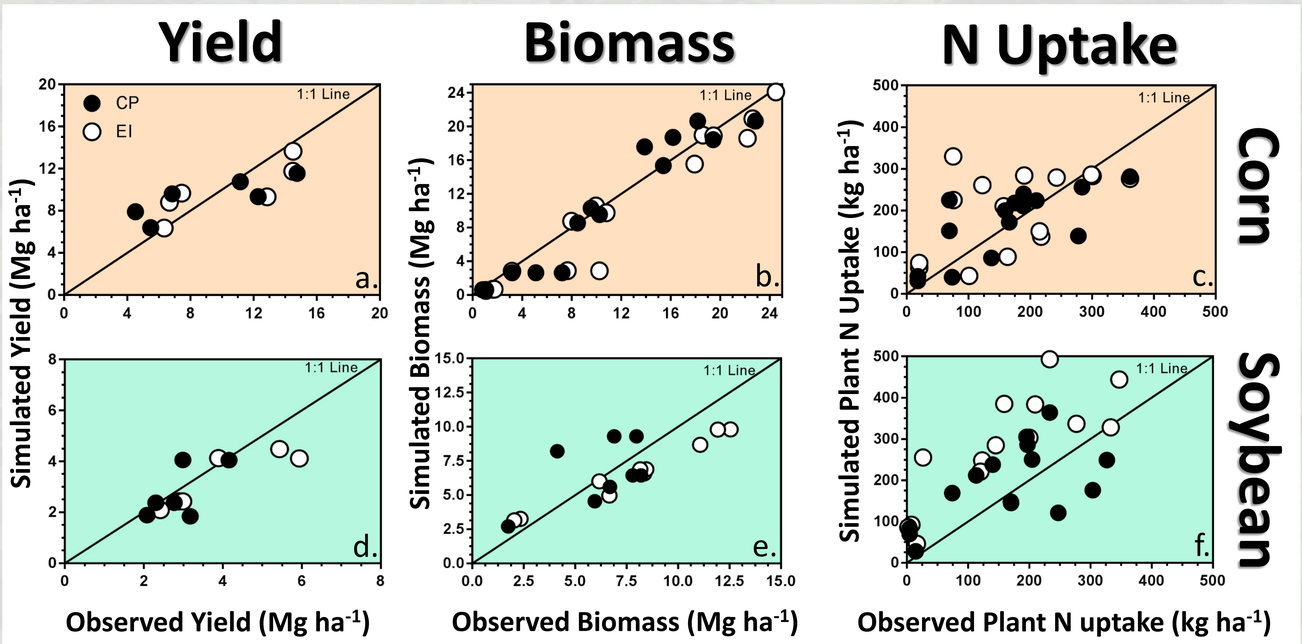

Figure 2. Yield, biomass and N Uptake observed vs. simulated for corn (a, b, c) and soybean (d, e, f). **CP**: Common Practices; **EI**: Ecological Intensification. Statistical outcomes for testing model accuracy of each parameter evaluated are presented in Table 2.

Conclusions

- APSIM demonstrated better performance to model plant biomass and yield as compared with plant N uptake simulation for both crops in the rotation.
- Yield prediction was more efficient for corn (EF 0.59) than for soybean (EF 0.51).
- APSIM underestimated leaf fraction in all simulations (EF -2.37 for corn and -1.31 for soybean) but final total plant biomass simulation presented an adequate EF for both crops.