Modeling Approach to Quantify Long-Term Impact of Management Practices to Close Yield Gap in Soybean

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I.Introduction

The Agricultural Production Systems sIMulator (APSIM) can simulate cropping systems and be utilized as a tool to determine yield gaps in crops.

II. Objective

The objectives of this research were to:

I) evaluate different combination of management practices to close yield gap in soybean,

II) implement modeling techniques to evaluate the long-term effect on yield gap relative to diverse weather patterns.

III. Materials and Methods

I. Field data

Experiment setup: soybean (*Glycine max* L.) plots were established in a rotation with corn (2014-2017) under rainfed and irrigated conditions at Scandia, KS. Treatments are presented in Table 1.

Table 1. Treatment description, Scandia KS.

Treatments	CP (1)	CF (2)	PI (3)	EI (4)	AD (5)
Seeding rate (Seeds/A)	111,000	111,000	134,000	134,000	134,000
Row spacing (in)	30	30	15	15	15
Fertilization	No	(P-K-S)	No	(N*-P-K-S)	(N*P-K-S)
Micronutrients	No	No	No	1x (Fe, Zn, B)*	2x (Fe, Zn, B)**
Fungicide/Insecticide	No	No	No	1x**	2x**

CP, common practices; CF, comprehensive fertilization; PI, production intensification; EI, ecological intensification; AD, advance plus.

Canopy coverage was estimated via imagery analysis with Siscob ®

II. APSIM calibration

- CP and EI treatments
- Model setup: rotations, genotype, weather, and soil data.
- Output variable was yield.

III. Long-term simulation

- 37 years: from 1980 to 2017.

IV Weather patterns

- Based on mean daily temperature and mean cumulative precipitation for the growing season (Figure 2).

V. Yield gap analysis

- One simulation with no water and nutrient restriction was added to determine potential yield for each year (1980-2017).
- Results were grouped by weather.

Statistical analysis

Soybean yields coming from field experiments were analyzed by ANOVA. For mean separation, LSD Fisher test was performed (*p= 0.05)*.

IV. Results

Canopy coverage

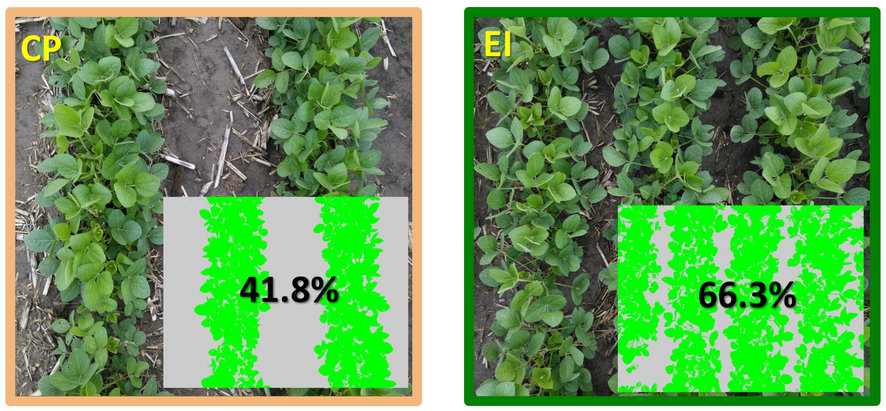

Image 1. Soybean canopy coverage via imagery analysis for common practices (CP) and ecological intensification (EI) at V4 stage, Scandia, KS (2014). Software; Siscob ®

IV. Results (continuation)

I. Field data

Intensified treatments in rainfed conditions yielded more than CP and CF. Under irrigation EI and AP presented the maximum yield.

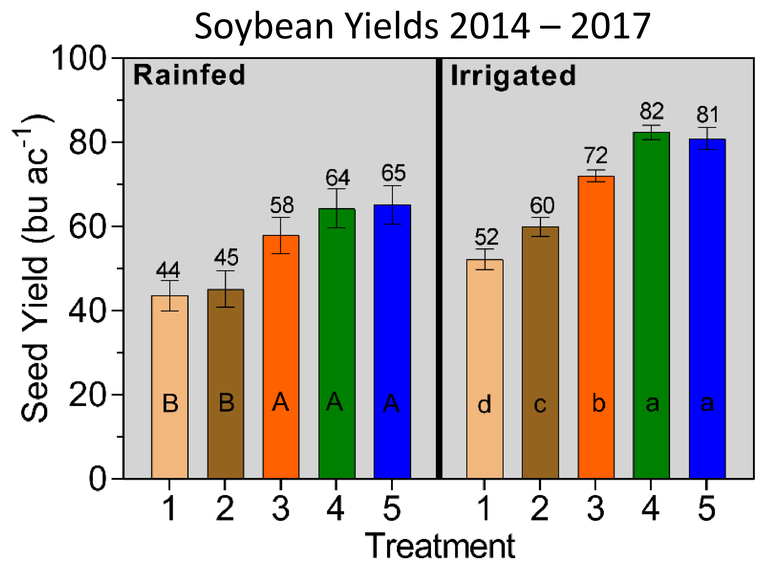

Figure 1. Soybean seed yield per treatment under rainfed and irrigated environment. Different letters indicate statistically differences within water scenario (p<0.05). Treatments: 1, Common Practices (CP); 2 Comprehensive Fertilization (CF); 3, Production Intensification (PI); 4, Ecological Intensification (EI); ad 5, Advance Plus (AP).

II.APSIM calibration

III. Long term simulation: 1980-2017

IV. Weather patterns

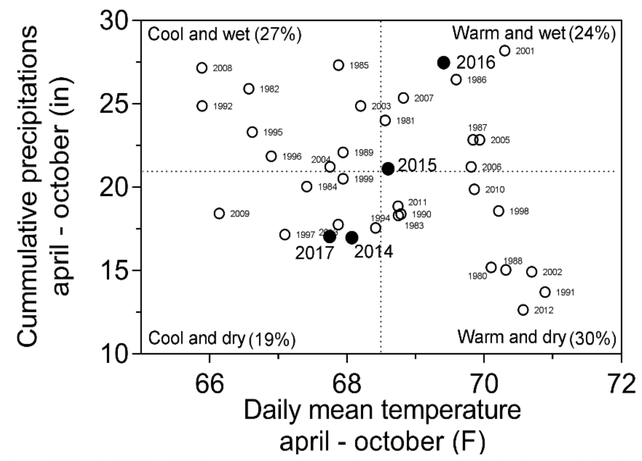

Figure 2. Yearly (1980 – 2017) mean temperature and mean precipitation for the period April – October. Black circles, field data; empty circles, simulated data. Dotted vertical and horizontal line indicates mean temperature (F) and mean cumulative precipitations (in) for the period. In parenthesis percentage of years in each pattern.

V. Soybean Yield Gap Analysis

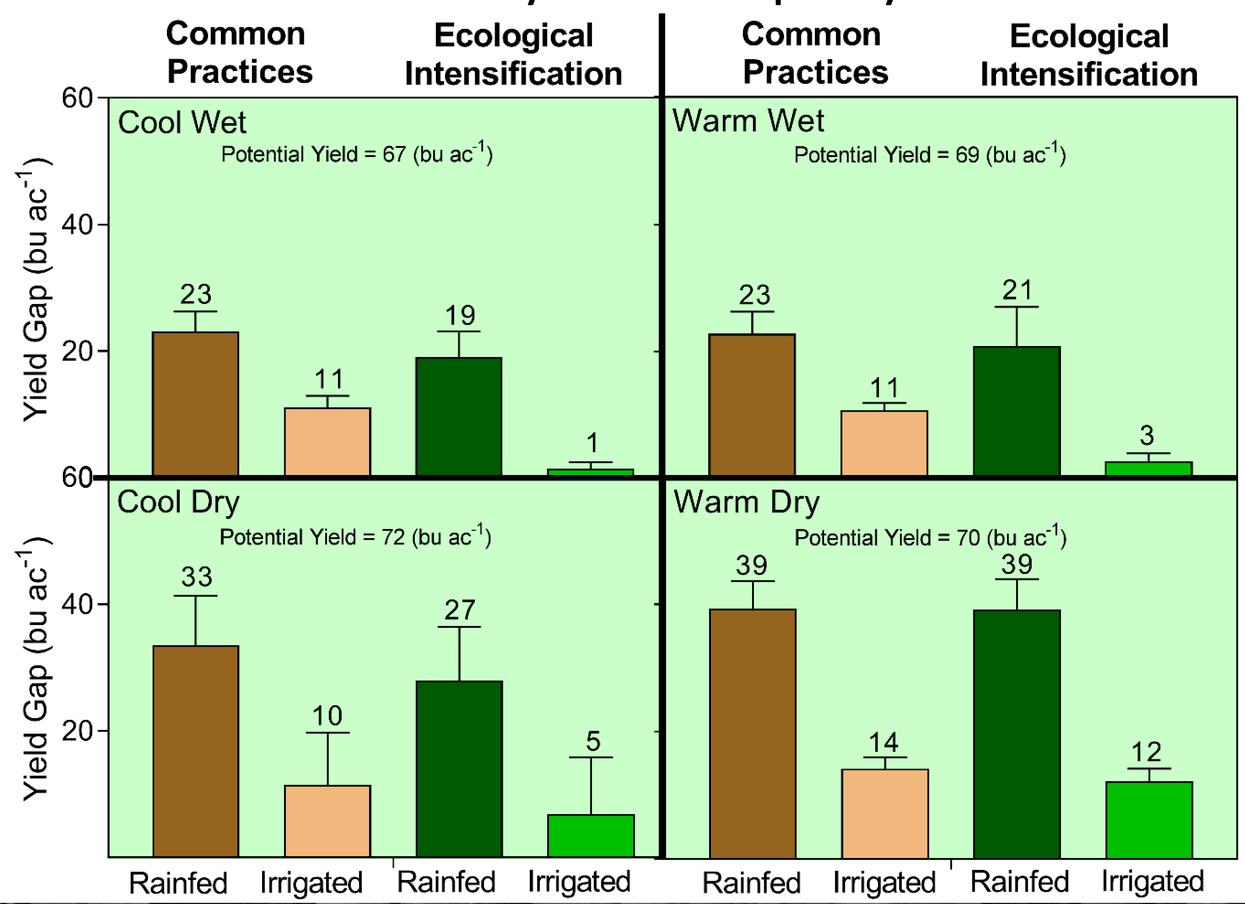

Figure 3. Soybean potential yield and yield gap for long-term simulation (1980 – 2017) for Common Practices (low input) and Ecological Intensification (high input) under rainfed and irrigated conditions for and soybean (cool and wet, warm and wet, cool and dry, warm and dry).

V. Conclusions

- Ecological intensification (EI) treatment positively impacted soybean yield across all weather patterns.
- An integrated approach, simultaneously considering multiple management factors (nutrients, crop production and protection) in a farming system, is needed for closing exploitable yield gaps at the field-scale.
- Simulation with APSIM allowed to quantify the impact of the contrasting management systems evaluated through different weather scenarios from 1980 to 2017.
- Ecological intensification (EI) treatment decreased 50% the yield gap under irrigation compared to common practices (CP). In addition, under irrigation, all simulations (weather) showed a yield benefit for EI over CP.