In-Season Forecasting of Plant Growth, Soil Water-Nitrogen, and Grain Yield

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Introduction

Throughout 2015, a Yield Forecasting project was initiated with the objective of forecasting in-season soil water-nitrogen dynamics, in-season plant growth, and end-of-season grain yields. This concept was initiated to help farmers and agronomists make in-season management decisions, plus look back on the growing season to see what management practices could have been changed to improve grain yields and net profits, but also reduce nitrogen loss.

Materials and Methods

This project combines the use of the Agricultural Production Systems sIMulator (APSIM) cropping systems model, the Weather Research and Forecast (WRF) model, and in-field data collection. Forecast simulations were based on current year weather up to the date of the simulation, followed by a 10-day weather forecast, and then a 35-year weather file to the end of the season. In-field data were collected from both corn and soybean planted at two dates. The corn was planted on April 29 and May 19 with P0506 at 32,000 seeds/acre. A nitrogen application rate of 200 lb N/acre was applied because the previous crop was corn. The soybean was planted on April 30 and June 1 with P22T61R at 133,000 seeds/acre in 30-in. rows. In-field data collection included crop staging, soil temperature and moisture, soil nitrate-nitrogen, crop biomass, and grain yield. The in-field data collection was used to validate the forecast simulation.

Results and Discussion

The results illustrate the simulated median yield (50% probability) at crop emergence is a good proxy of the final simulated yield for both corn and soybean (Figure 1), but there is a lot of uncertainty (10% and 90% probability). Near the time of pollination the uncertainty of corn yield predictions for corn significantly decreases. For soybeans the uncertainty of yield predictions decreased during the grain filling period rather than at flowering.

In the corn cropping systems (Table 1), the trends were the same for scenario impacts on both the early-planted and late-planted systems. Applying two-thirds less nitrogen had minimal impacts on yield but reduced nitrogen losses and increased net profits. This is because the initial soil nitrate at planting time was exceptionally high (20 ppm NO_3-N at 1 ft). Reducing row spacing to 20-in. increased yields and net profits while reducing nitrogen losses. Irrigation had positive effects on yields and net profits but also increased nitrogen losses. Planting a longer maturity without additional nitrogen balanced yield and net return, while not changing nitrogen losses.

In the soybean cropping systems (Table 2), results were very similar to that of the Ames soybean cropping systems. Soybean yield, net returns, and nitrogen loss benefits were realized by reducing row spacing to both 15-in. and 20-in. row spacing (scenarios 4, 5, and 6) and by increasing soybean maturity in combination with increasing seeding rate and decreasing row spacing (scenario 9). Coincidentally, when rainfall was limited during a portion of the growing season (July), irrigation had only slight yield benefits but increased nitrogen loss (scenarios 10, 11, and 12).

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Table 1. Scenario analysis of Yield Forecast project at Sutherland for corn planted April 29, 2015 (left) and May 19, 2015 (right).[a]

Sutherland – corn		Early planted (April 29, 2015)			Late planted (May 19, 2015)		
Scenario description		Yield	N loss	Net return	Yield	N loss	Net return
1	Split 200 lb N/acre at planting and 6th leaf stage	0.0%	-11.2%	-2.9%	0.0%	-7.2%	-2.9%
2	Applied 1/3 of nitrogen rate	-0.3%	-44.7%	11.7%	0.1%	-57.0%	12.5%
3	Increased seeding rate 15%	1.0%	-5.6%	-2.2%	1.1%	-9.3%	-2.2%
4	Decreased seeding rate 10%	-1.2%	5.0%	0.7%	-0.1%	16.5%	2.4%
5	Switched to 20-in. rows from 30-in. rows	2.0%	-5.5%	2.9%	1.4%	-8.0%	2.0%
6	Switched to 20-in. rows and increased seeding rate 10%	3.0%	-8.9%	1.8%	3.1%	-3.7%	2.0%
7	1-in. irrigation at 6th leaf stage	2.6%	21.1%	1.8%	2.2%	19.8%	1.3%
8	1-in. irrigation at 14th leaf stage	1.6%	11.6%	0.5%	2.1%	23.5%	1.2%
9	1-in. irrigation at both 6th leaf stage and silking	2.6%	34.3%	1.4%	2.2%	34.1%	0.8%
10	Shorter maturity (from 2500 to 2350 GDD)	-4.5%	-1.7%	-6.4%	-6.8%	1.0%	-9.7%
11	Longer maturity (from 2500 to 2800 GDD)	2.5%	-0.7%	3.6%	1.7%	-0.1%	2.5%
12	Longer maturity and 1-in. irrigation at 6th leaf stage	5.9%	19.7%	6.6%	7.8%	26.2%	9.3%

[a]The impact of the scenarios is expressed as a percent difference from the default management practices used in 2015: 200 lb N/acre on April 29, 2015; 107-day CRM; 32,000 seeds/acre; 30-in. row spacing.

Table 2. Scenario analysis of Yield Forecast project at Sutherland for soybean planted April 30, 2015 (left) and June 1, 2015 (right).[a]

Sutherland – soybean		Early planted (April 30, 2015)			Late planted (June 1, 2015)		
Scenario description		Yield	N loss	Net return	Yield	N loss	Net return
1	Split 200 lbs N/acre at planting and 6th leaf stage	2.5%	-2.9%	1.3%	2.3%	-10.7%	0.3%
2	Increase seeding rate 15%	4.5%	-4.8%	2.1%	4.1%	-19.7%	0.0%
3	Increase seeding rate 30%	-2.9%	4.3%	-1.7%	-2.5%	13.0%	-0.5%
4	Decrease seeding rate 15%	10.0%	-9.3%	11.0%	11.1%	-44.4%	12.9%
5	Switched to 20-in. rows from 30-in. rows	14.3%	-11.4%	15.7%	14.1%	-56.0%	16.4%
6	Switched to 15-in. rows from 30-in. rows	16.8%	-11.9%	15.5%	15.4%	-64.1%	13.1%
7	Switched to 15-in. rows and 30% higher seeding rate	-2.3%	4.3%	-2.5%	-0.2%	-0.5%	-0.2%
8	Shorter maturity (matured 1 wk earlier)	1.6%	2.9%	1.7%	-0.7%	0.8%	-0.8%
9	Longer maturity (matured 3 wk later)	16.2%	-9.8%	16.3%	14.5%	-59.5%	14.3%
10	Longer maturity and 15% higher seeding rate in 15-in. rows	0.5%	22.2%	-1.2%	0.0%	30.3%	-1.9%
11	Single 1-in. irrigation on June 25	0.7%	15.2%	-1.0%	0.1%	46.4%	-1.8%
12	Single 1-in. irrigation on July 20	0.0%	5.8%	-1.7%	0.0%	25.3%	-2.0%

[a]The impact of the scenarios is expressed as a percent difference from the default management practices used in 2015: MG 2.2; 133,000 seeds/acre; 30-in. row spacing.

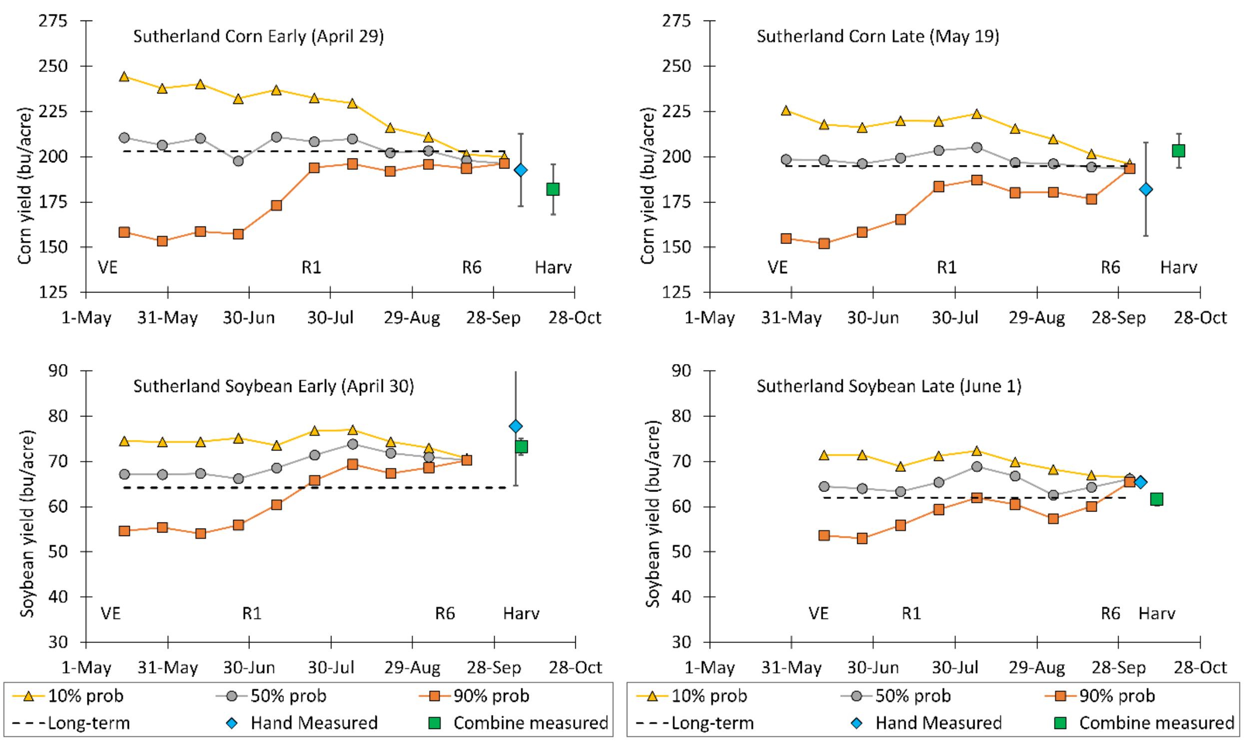

Figure 1. Yield Forecast yield predictions of corn grain yield over the 2015 growing season. Yellow triangles, grey circles, and orange squares show the probabilities of yield being above that level. Hand-measured (blue diamond) and combine-measured (green square) yields are also shown.