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Yield Gap Analysis: What Limited Iowa Corn and Soybean Yields in 2015

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Abstract
To evaluate how good corn and soybean yields were in 2015, farmers and agronomists compare their yields to those obtained in previous years. To answer why yields were higher or lower than past years, they develop hypotheses to explain factors that limited yields based on their own experiences, anecdotal evidence from neighbors, knowledge of crop growth and development, and weather patterns. As a next step to the in-season Yield Forecast Project, we can provide an alternative analysis and a yield gap analysis of the 2015 growing season by using the explanatory power that a cropping systems model offers. Our analysis is focused on corn and soybean cropping systems used in the Yield Forecast Project (more information on the cropping systems and the Yield Forecast Project can be found in the June 17th ICM News article). In total, we evaluated eight cropping systems; two locations, two crops, two planting dates.

Keywords
Agronomy

Disciplines
Agricultural Science | Agriculture | Agronomy and Crop Sciences

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We define yield gap as the difference between simulated potential yield and water-nitrogen limited yield, which we showed was closely related to actual yields (December 11th ICM News article). Simulated yield potential is determined by solar radiation, temperature, crop physiology, canopy architecture, and crop management. Potential yield is not fixed but varies from year to year as the weather changes. Water-nitrogen limited yield accounts for water and nitrogen limitations but not weeds, insects, and diseases. It should be noted that yield gaps are influenced by not only by weather and soil characteristics but also changes in individual farm management practices. Figure 1 shows potential (maximum and average) and average water-nitrogen limited yield for each cropping system across 35-years of weather using 2015 management.

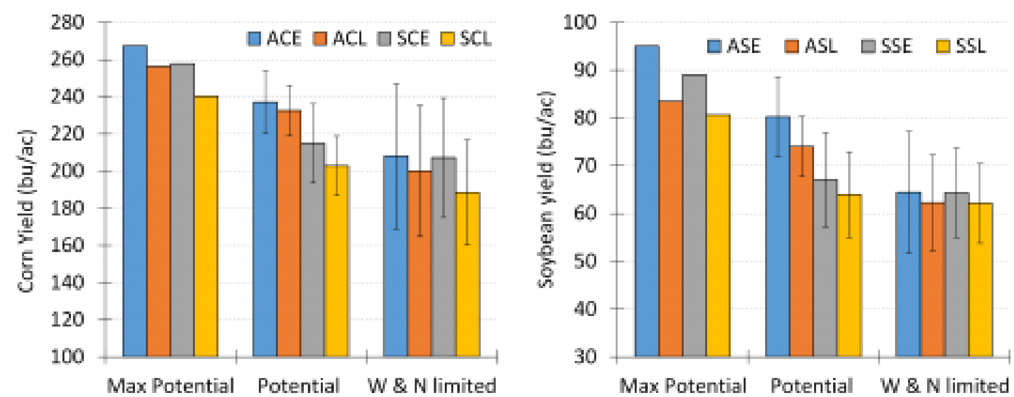

Figure 1. Simulated corn and soybean maximum, average, and water-nitrogen limited yields across 35-years of weather data assuming 2015 management every year for each of the eight cropping systems (ACE: Ames Corn Early planted; ACL: Ames Corn Late planted; SCE: Sutherland Corn Early planted; SCL: Sutherland Corn Late planted; ASE: Ames Soybean Early planted; ASL: Ames Soybean Late planted; SSE: Sutherland Soybean Early planted; SSL: Sutherland Soybean Late planted). The standard error bars show the range of variability that exists across 35 weather years. Click image for larger view.

The average yield gap over 35 weather years with 2015 crop management varied from 3% to 18% across cropping systems, while there were years where the gap was less than 1% and as high as 30% (Figure 2). The 2015 year was an exceptional year as the yield gap was minimal (Figure 3). The average simulated yield gap in 2015 was only 3% and ranged from 0.5% to 6% across the eight cropping systems, meaning that crops nearly reached potential yield levels in 2015.

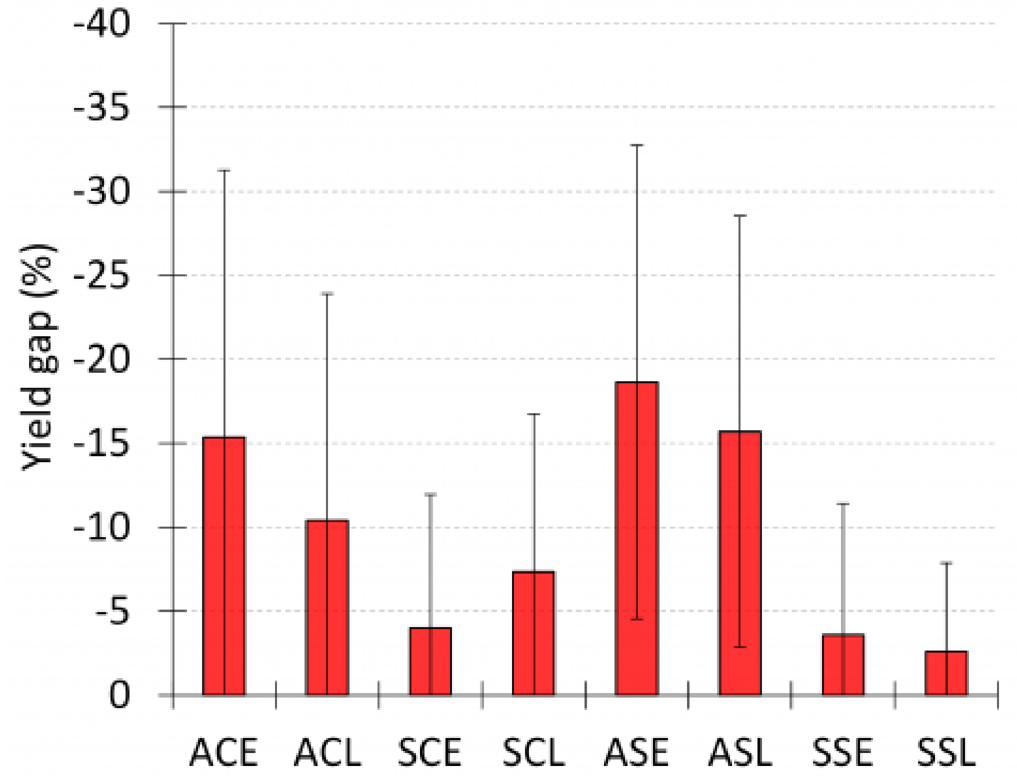

Figure 2. Average yield gap, the difference between average potential and water-nitrogen limited yield, for the eight selected cropping systems. Standard error of means is indicated by the whiskers on each bar. Click image for larger view.

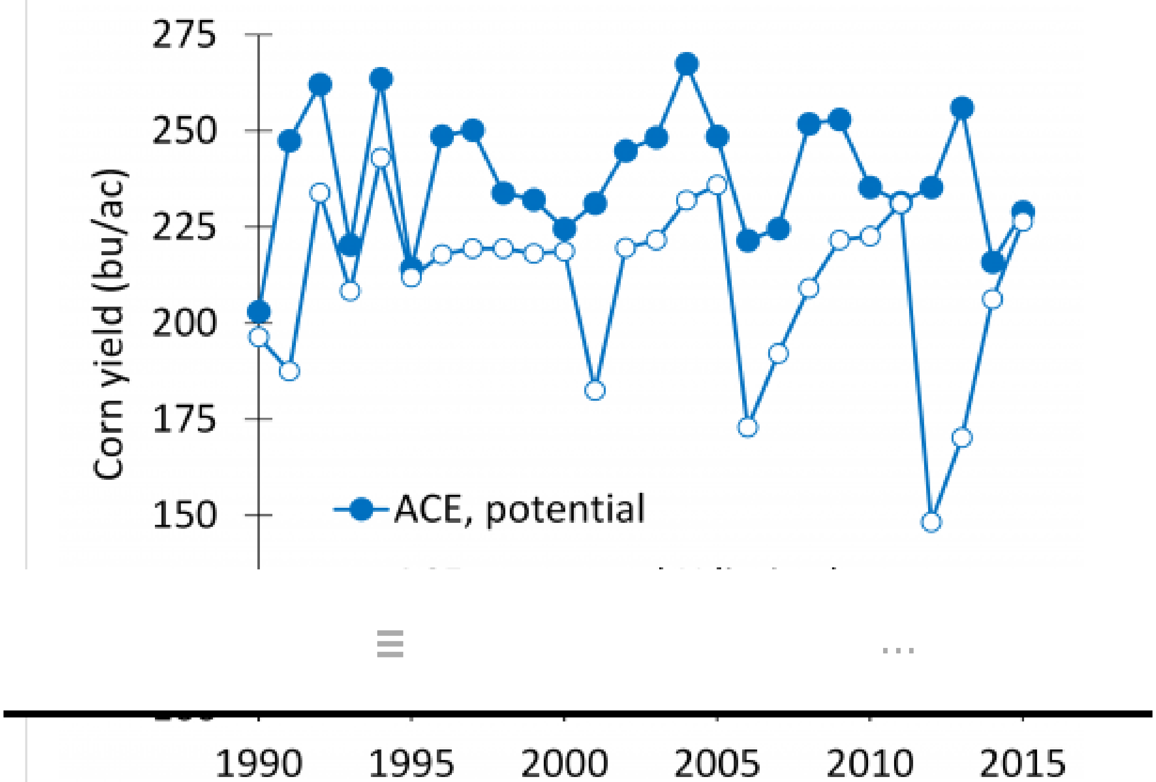

Figure 3. An example of temporal variability in potential and actual yield for the Ames Corn Early planted (ACE) system. Click image for larger view.

The yield gap can be narrowed by either increasing the actual yield or decreasing the potential yield. Interestingly, the yield gap in 2015 did not close because of the perfect management decisions (raising actual yield) but because the potential yield decreased (limited by weather; Figures 3 and 4). The main reason potential yield was reduced in 2015 was due to less solar radiation caused by rainy/cloudy weather during the summer. Radiation is the main driver of photosynthesis. The reduction in radiation in Ames and Sutherland (as compared to an average year) was about 150 MJ/m^2 over the growing season (Figure 4). On a sunny day, the average radiation is 20 MJ/m^2 per day. For 2015 in Ames and Sutherland this translates into 7.5 lost days of radiation (150 MJ/m^2 ÷ 20 MJ/m^2/day). Assuming a typical crop growth rate for corn in July-August and a harvest index of 0.5; a 150 MJ/m^2 reduction in radiation equals about 24 bu/ac of lost corn yields. The measured corn yields were about 220 and 190 bu/acre for Ames and Sutherland, respectively. Thus by adding 24 bu/acre, the water-nitrogen limited yield would approach the average potential for each site. Other factors such as June water stress in Sutherland and low temperatures during the grain fill period (period August 18^{th} to 28^{th}) in both Ames and Sutherland imposed further reductions in the yield potential. However, the radiation was by far the most important limiting factor.

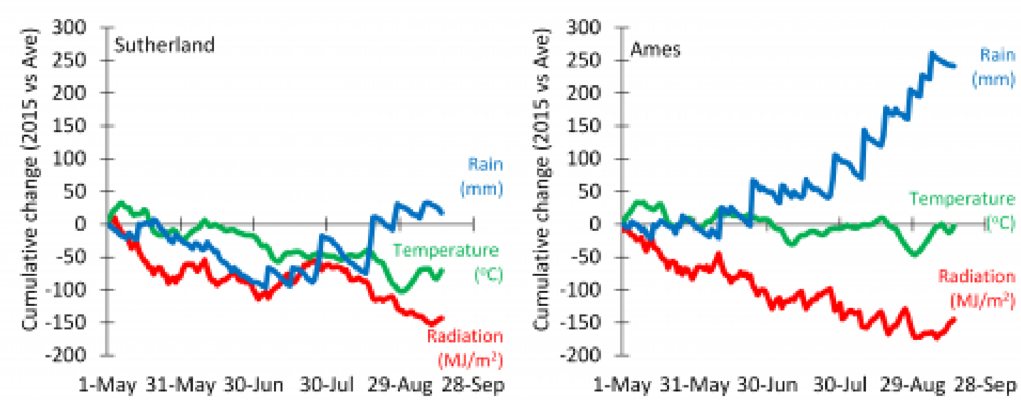

Figure 4. Observed deviation in cumulative radiation, temperature and precipitation over the 2015 growing season in Ames and Sutherland. Click image for larger view.

Our analysis, though specific for the studied cropping systems, reflects what happened in many corn and soybean fields across Iowa. A positive feedback of the lower potential (i.e. lower crop demand for resources) was that the soil resources of water and nitrogen (i.e. soil supply) were sufficient to meet the demand in 2015 according to our analysis.

Category: Crop Production

Crops:
Corn

Soybean

Tags: Yield gap | corn management | soybean management

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