

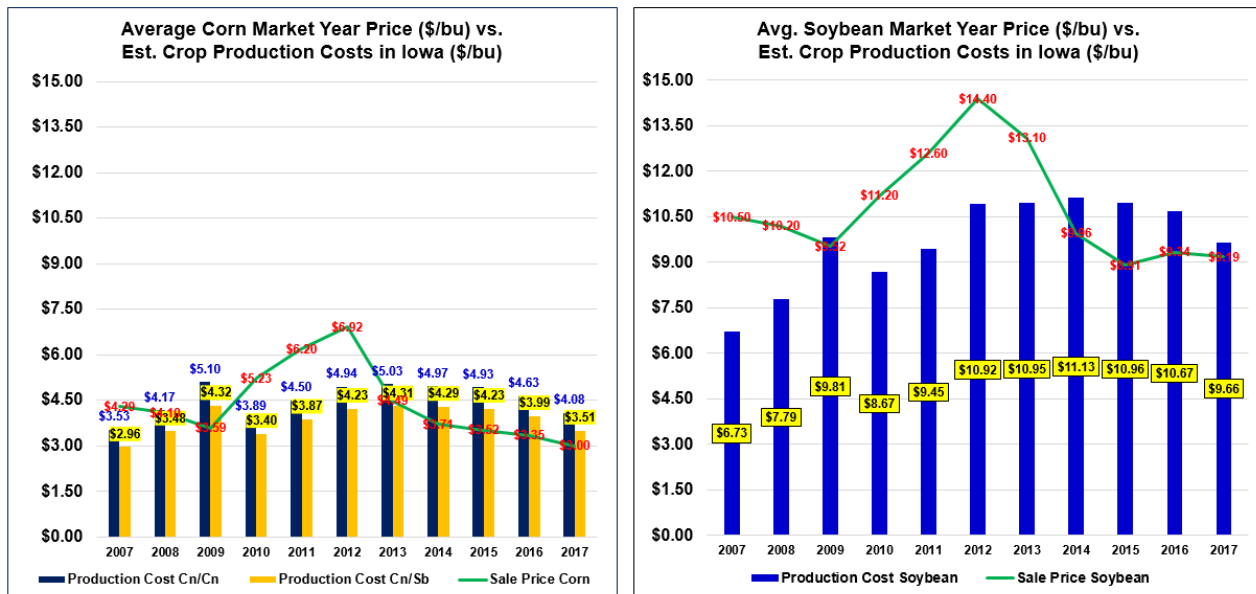
IOWA SOYBEAN ASSOCIATION RESEARCH UPDATE

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Rainfall, Field Management and Soils Impact on Within-Field Profitability

Profitability in crop production is largely driven by crop yield, production costs and commodity prices. Anyone in the industry is aware that much of the art of successful farming involves risk management and mitigation. Farmers have limited control over key factors that significantly drive profitability such as input costs, market prices and the weather. These are the best understood and most readily accepted aspects of risk management.

Markets have not been favorable for commodities in the last four to five years. According to Iowa State University Extension and Outreach (ISUEO, 2007-2017) and the United States Department of Agriculture (USDA) National Agricultural Statistics Survey (NASS, 2018), the average corn and soybean prices in 2010-2012 generated a profit, whereas the average corn and soybean prices in 2014-2017 generated an economic loss (Figure. 1).



Iowa State University Extension and Outreach-(price source: USDA, NASS)

Figure 1: Average Iowa commodity prices and input costs in corn and soybean production, 2007-2017.

Quantifying the interaction between weather, crop productivity and field variability is complex (Muth, 2014; Kyveryga et al., 2012). Modern precision agricultural technologies and publicly available spatial data about weather and soils now provide information that enables focus at subfield levels (Bonner et al., 2014; Brandes et al., 2016). The impact of field management, weather and field spatial variability is often difficult to assess for individual fields or for a group of fields within a given geographic area.

In this publication, profit and return on investment (ROI) maps of many farmers’ fields are used to quantify the impact of in-season rainfall and soil characteristics on within-field profitability in two Iowa landform regions.

Analyzing data collectively

Farmers from Central and Northeast Iowa shared corn and soybean yield data collected between 2007 and 2014. The dataset comprised 380 site-years-worth of yield maps from 77 individual fields (Figure 2). Each field had at least three years of spatial yield data. On average, fields had four years of yield data and some fields had eight consecutive years of data.

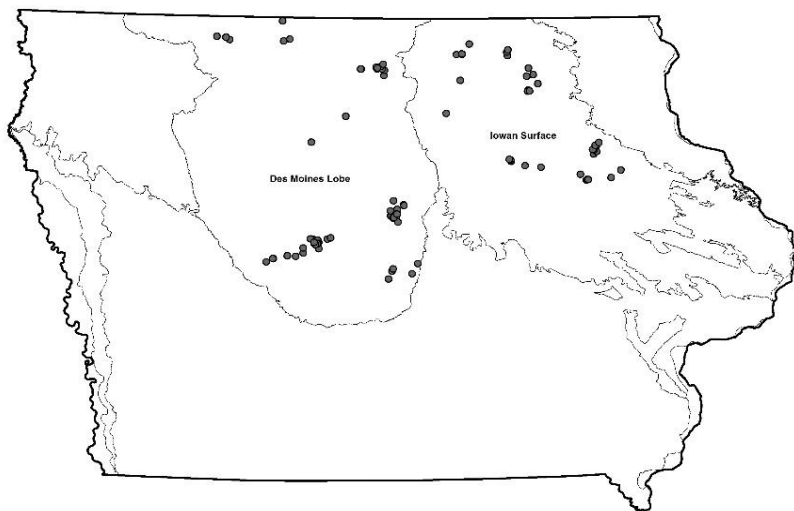


Figure 2. Locations of 77 corn and soybean fields in Central (Des Moines Lobe) and Eastern (Iowan Surface) Iowa used in profitability analyses.

Spatial yield data collected by GPS-enabled yield monitors were provided by farmers. Additional information about field management, field history and the cropping system were collected as well. While some farmers also provided field-specific crop budget information, analyses relied on current and historical cost of production estimates (Estimated Costs in Crop Production in Iowa, Iowa State University). The production cost information includes, among other items, the state average cost for fertilizer and chemicals, planting, application and harvest machinery, land rent and labor, insurance and loan interest. Since relative within-field spatial profitability remained constant regardless of budget template, standard production costs were employed to eliminate this variable, thereby making differences related to the factors we were studying more apparent.

A commercial software, Profit Zone Manager (AgSolver, 2015), was used to produce profitability and ROI maps. Standard deviation in profit across all available years was calculated from profit, creating the three maps in Figure 3.

In addition, ISA divided the profitability and ROI maps into 30 x 30-foot grid cells and added field management, landform region, soil characteristics and rainfall information.

Spatial data layers used in the analyses include Soil Conditioning Index, erosion estimates, SSURGO soils (NRCS), elevation and slope (National Elevation Dataset) and LiDAR Pothole and Wetlands images (Iowa DNR). Profitability and ROI raster images were converted to vector point files. Spatial data were analyzed at 30 x30-foot resolution. Data were resampled to maintain constant resolution. Monthly rainfall values from the 4 km rainfall estimates in the Iowa Environmental Mesonet database were added to each field.

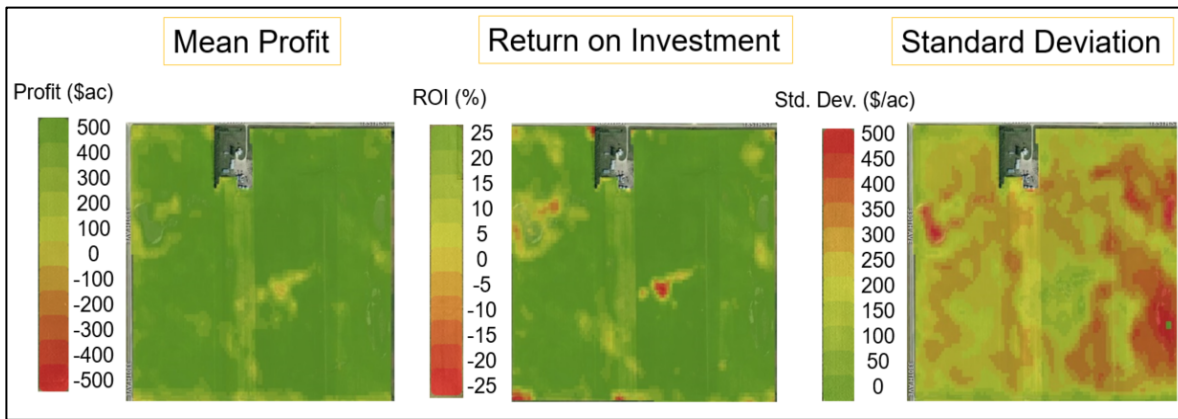


Figure 3. Maps of Mean Profit, ROI and Standard Deviation of profit across four years for a field in corn-soybean rotation.

Central Iowa results

Distributions of within-field profit values for fields planted to soybean, corn after soybean and corn after corn from 2008-2013 indicate that areas with economic loss ranged from 5 to 45 percent (Figure 4). The effect of low grain prices and increased land rent prices were more pronounced in 2013. The histograms for 2009 and 2011 show bimodal distributions of profit values, indicating some other factors affected profitability in addition to market price and production cost.

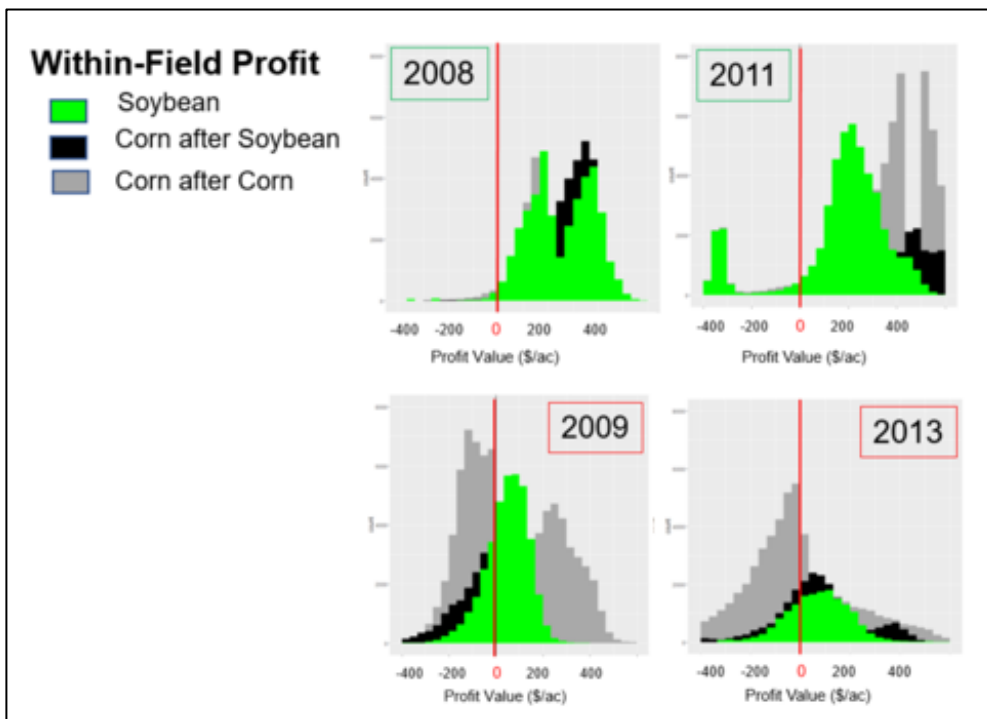


Figure 4. Histograms of 30 x 30-foot profit cells across 52 fields in Central Iowa from 2008-2013. The red vertical line separates grid cells with positive and negative profit.

The cumulative distributions in Figure 5 indicate that a corn crop was more likely to be profitable than soybean, and that the field-level profit was substantially reduced in pothole areas compared with upland areas – especially when spring rainfall was excessive. Although soybean fields tended to have a lower profit, they also were less affected by the excessive rainfall and poorly drained pothole areas.

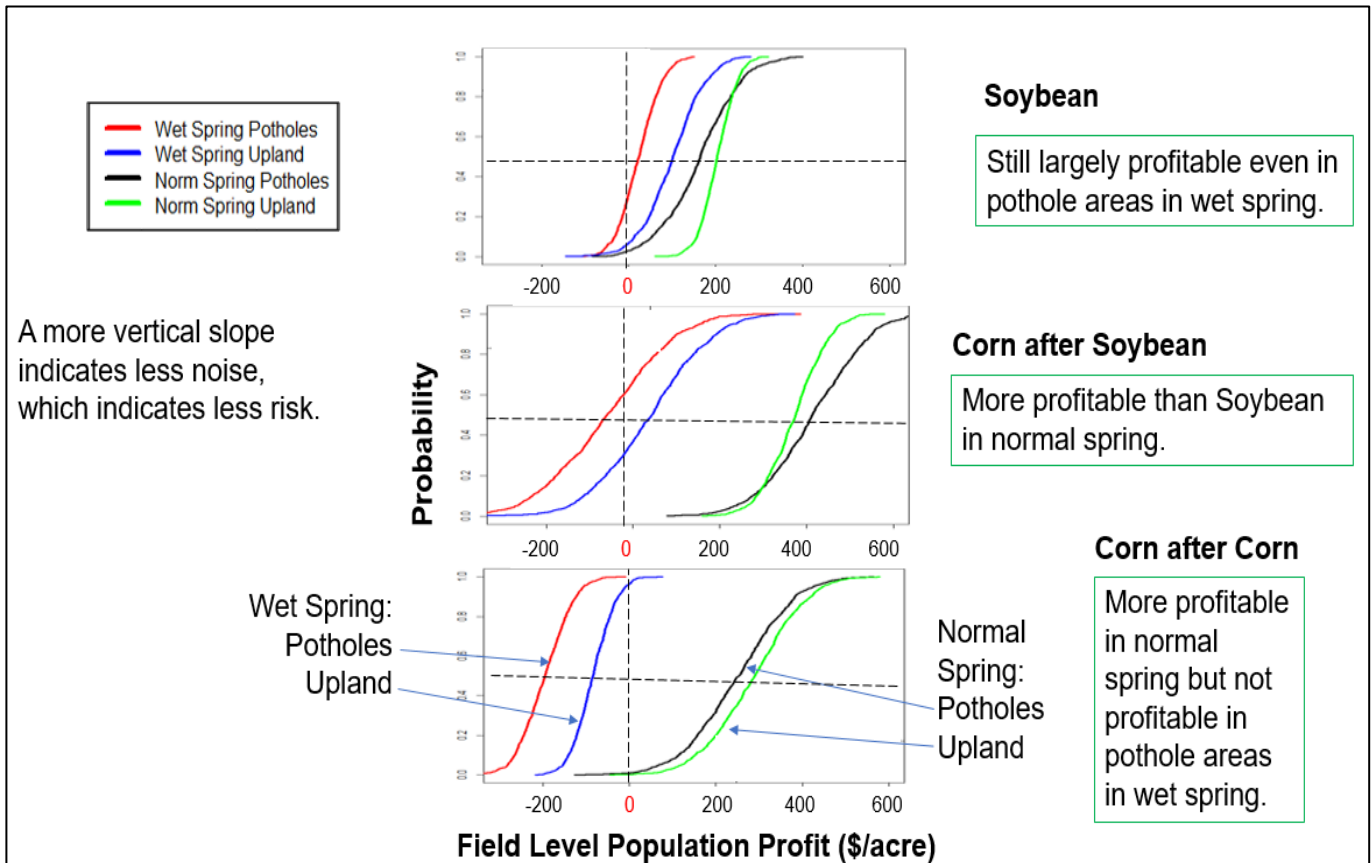


Figure 5. Distribution of profit values in pothole and upland areas within corn and soybean fields of Central Iowa from 2007 through 2014. The profit grid cells were classified based on the spring rainfall: wet (>12 inches) and normal. The cumulative distribution curves indicate the probability of a profit value at specific value and below. The difference between two categories is significant if two cumulative distribution curves do not cross each other.

Multivariate analyses of field-level median profit values suggested that early season rainfall was one of the driving factors in reducing profitability within the Des Moines Lobe (data not shown). With each additional cm of rainfall in May or June, median field level profit was reduced by \$22 to \$55 an acre for fields planted to corn (Figure 5). As shown in Figure 6, compared with corn, soybean fields were unaffected by May rainfall and less affected by June rainfall.

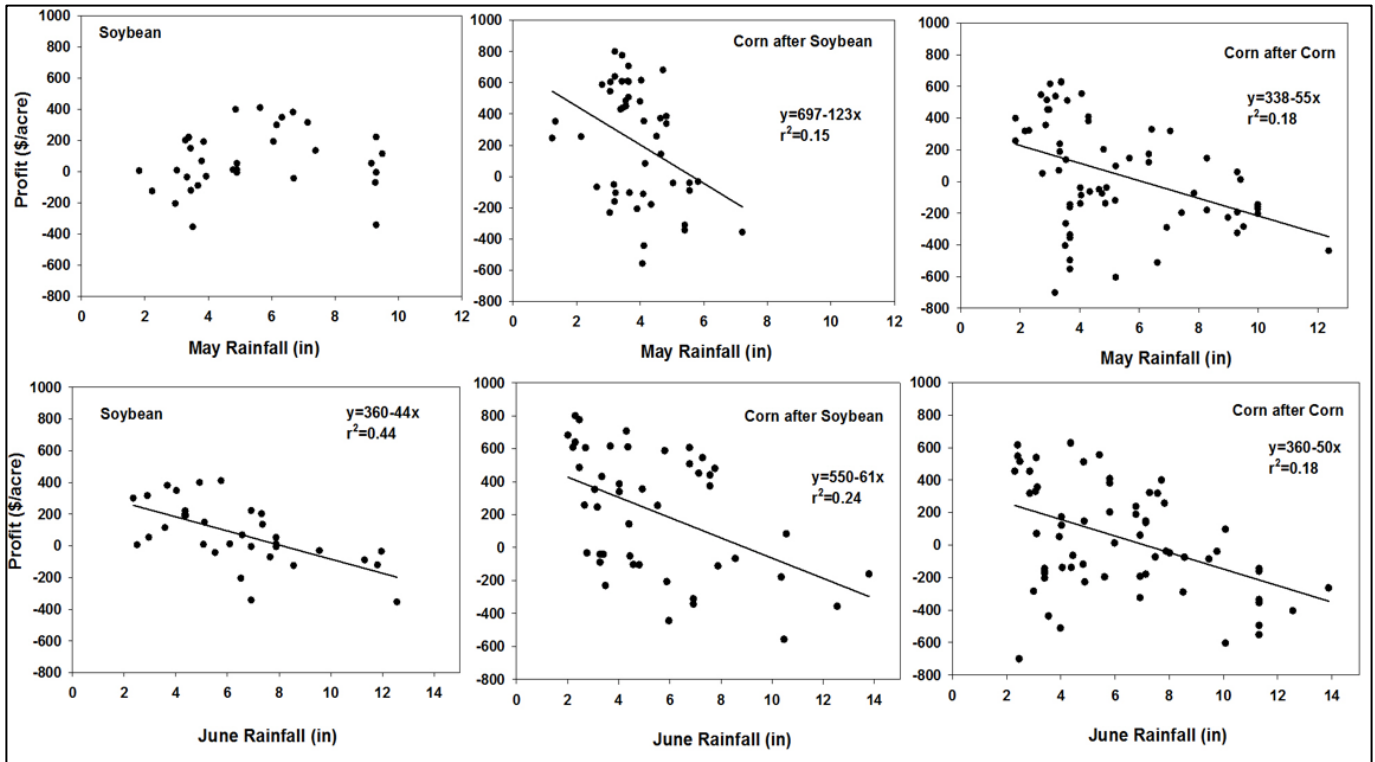


Figure 6. Effect of May and June rainfall on field-level median profits for fields planted to soybean, corn after soybean and corn after corn within the Des Moines Lobe landform region.

Eastern Iowa results

Similar to Central Iowa, analyses of 25 fields with 111 site years of data in Eastern Iowa (Iowan Surface) showed that substantial portions, up to 50 percent, had economic loss, especially during 2013 and 2014 (data not shown).

The effect of early season rainfall was different in Eastern Iowa than in Central Iowa. Excessive spring rainfall had no significant effect on field level profitability (Figure 7). However, field median profit values tended to increase with above-normal July rainfall. This indicates that some of the areas (likely those with sandy soils) ran out of water during midsummer and benefited from additional rainfall in July.

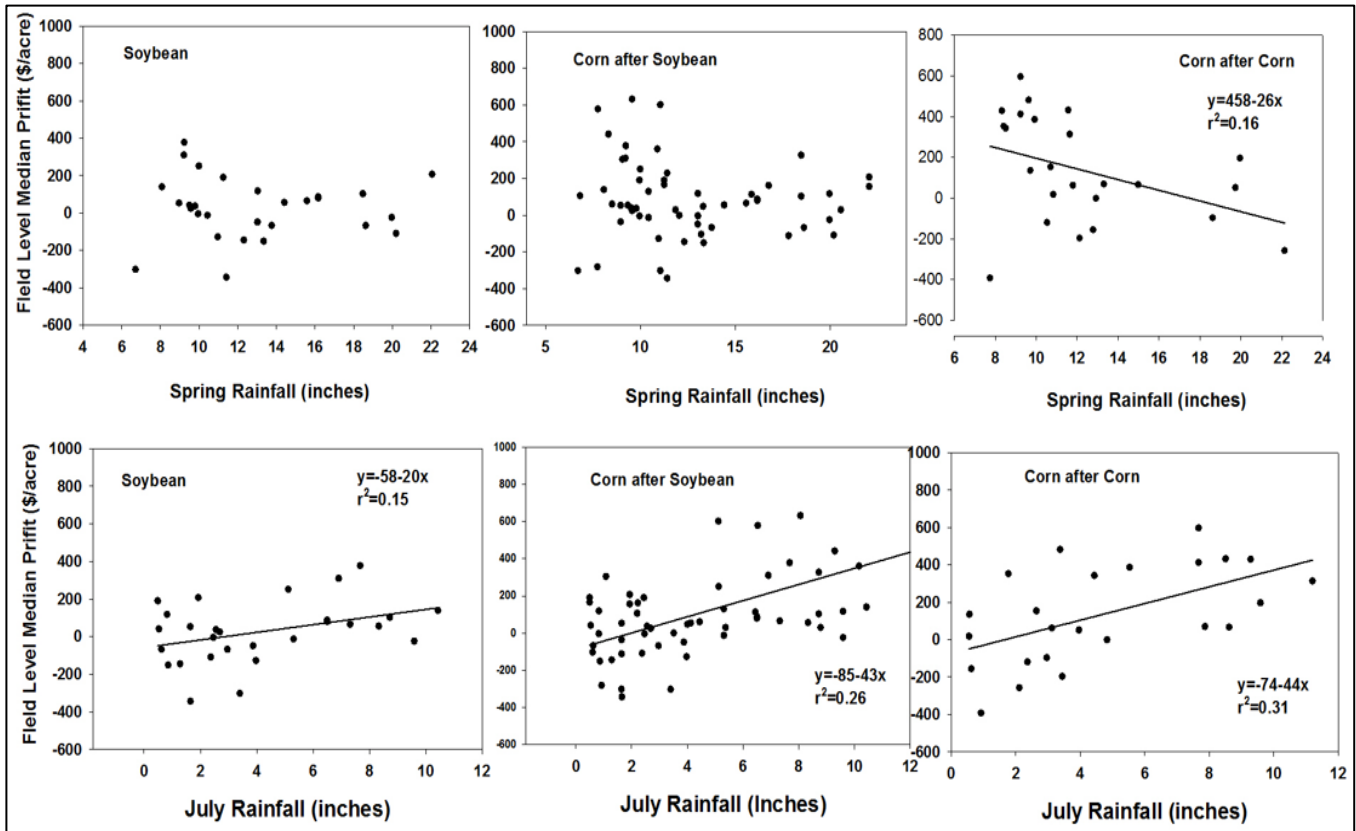


Figure 7. Effect of spring (March through May) and July rainfall on field-level median profits for fields planted to soybean, corn after soybean and corn after corn within Eastern Iowa.

The cumulative distribution functions of profit values in Figure 8 suggest that excessively drained within-field areas in Eastern Iowa had lower profit compared with the poorly or well drained areas, except in corn on corn fields. Some soybean fields, however, tended to be more affected by soil drainage than corn fields.

The effect of rainfall in Eastern Iowa was different than in Central Iowa. Specifically, the profitability increased by about \$20 an acre with each additional inch of July rainfall.

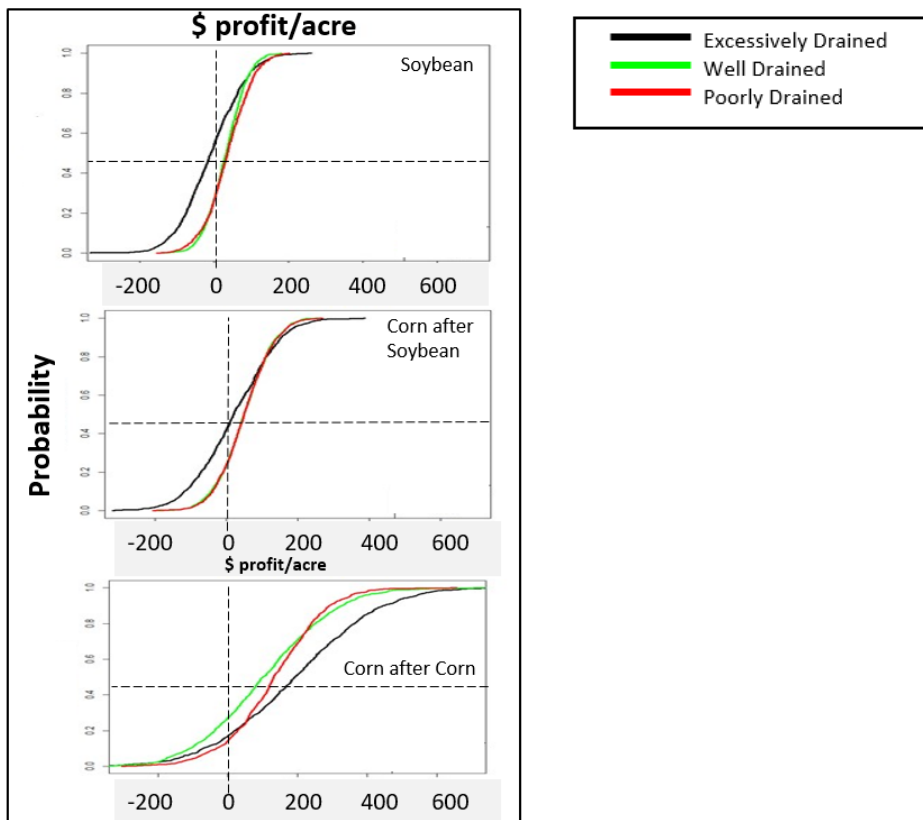


Figure 8. Cumulative distribution functions of field-level profit values for excessively, poorly, and well-drained areas within fields planted to soybean, corn after soybean and corn after corn within Eastern Iowa between 2007 and 2014.

Analysis of spatial variability in profit, ROI or standard deviation values across several years suggest that only a small percentage of within-field variability could be explained by spatial variables. For example, in several fields, corn suitability rating (CSR) index explained about 16 percent of spatial variability, drainage explained 22 percent and soil organic matter explained about 15 percent of the spatial variability in Eastern Iowa. Soils with higher productivity, higher CSR and less excessive drainage tended to have higher profitability and ROI along with lower standard deviation values than those fields with lower soil organic matter and lower productivity.

Logically, the fact that spatial variables could only explain a small percentage within-field variability in profit could be the result of largely uniform tracts of land within the fields evaluated. Fields selected for in-depth spatial evaluations were limited to those with five or more years of spatial data. More study is required to support this hypothesis.

Conclusion

In central Iowa, potholes had consistently larger economic losses (15 to 75 percent), with greater losses occurring during a wet spring with more than 12 inches of rainfall between March and May. While fields planted to corn tended to have higher profitability than those planted to soybean, the corn profitability was reduced more by poor soil drainage, especially during wet springs.

During a normal spring in Central Iowa, corn fields were more likely to have a larger profit than soybean fields. For the pothole areas, soybean fields were less negatively affected by spring rainfall and had lower economic losses than corn fields. Therefore, soybean is less affected by excessive moisture and poorly drained soils within pothole areas.

Within the lowan Surface, half of the within-field areas had economic loss, especially in 2013 and 2014. Compared to corn, excessive drainage had a pronounced negative effect on within-field profitability in soybean. The effect of rainfall in the lowan Surface region was different than that within the Des Moines Lobe. Above-normal July rainfall tended to increase profitability in corn fields by about \$20 an acre with each additional inch of rainfall, indicating that some of the areas (likely sandy or excessively drained) may have run out of moisture during midsummer.

This study used spatial corn and soybean yield data and crop budgets in conjunction with site-specific rainfall and soil characteristics to identify the degree to which a combination of several factors can be used to help farmers make the best land-use decisions. The presented analyses are critical for guiding the design and development of further studies that can lead to the creation of risk mitigation tools for farmers.

We would like to thank the Iowa farmers who generously shared their data with us and On-Farm Network[®] staff who helped to collect and process the data. We would also like to thank AgSolver, Inc., Ames, Iowa for recruiting participants, the mass generation of custom datasets, for responsive customer service and delivery on special requests.

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