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Increasing profitability in soybean production by optimizing planting rates

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Introduction

Farmers are interested in better management of seeding rates within soybean fields to increase productivity and economic returns. With seed prices trending higher and soybean commodity prices trending lower during the last two years, there are many questions about optimal seeding rates and factors that influence these rates under specific field conditions.

Research from Iowa State University (ISU) was focused on studying how different seeding rates and row spacing affect soybean seed yields using small-plot research. The generalized recommendations for soybean seed planting in Iowa suggests having a final plant stand of approximately 100,000 plant/acre for both 30 or less than 30 inch row spacing (De Bruin and Pederson, 2008, Optimum Plant Population in Iowa, 2007). The recent studies from the University of Wisconsin showed the optimal seeding rate for untreated seed was 120,000 seeds/acre (Gaspar et al., 2014). However, little is known of how different site-specific factors influence the responsiveness of soybean to higher or lower plant population densities within and across fields, especially across geographic areas with similar soils, weather and management conditions. The knowledge of these site-specific effects is important because modern planters enable farmers to change seeding rates across and within fields.

The primary objective of this study was to use on-farm observations to identify major factors that influence yield response (YR) of soybean to seeding rates that are slightly above or below those currently used by farmers in Iowa. The second objective was to develop a decision support system that can help farmers identify when and where the higher planting rates are more or less likely to produce above break-even soybean YR.

Methods

Eighty-three on-farm trials were conducted between 2009 and 2011 across Iowa (Figure 1). Each trial had two alternating treatments of two seeding rates replicated a minimum of three times. The seeding rates used by farmers were farmer’s normal seeding rates plus and minus 15,000 seed/acre from the normal rate. Across all years and trials, the two average soybean seeding rates were 130,000 and 160,000 seeds/acre. The soybean row spacing was 30 inches in approximately 75% of the trials.

The population trials were harvested with grain combines equipped with GPS and yield monitors. The yield data were cleaned by deleting observations that were located < 50 m from the beginning and end of the strips, and from flooded areas, waterways, and buffer strips. Individual yield observations were aggregated into 100-feet long grid cells along each pair of the treatments.
Figure 1. In 2009 there were 27 on-farm replicated strip trials, 31 in 2010 and 13 in 2011. Each evaluating the effect of field and within field-level factors on YR of soybean to seeding rate. Each trial had low and high planting rates (A) and yield differences between the two seeding rates were estimated in 100-feet long grid cells in each field (B).

Yield responses were calculated as differences in aggregated yields between the treatments. Each trial had from 50 to 300 individual YR. Observations of YR that were two standard deviations above or below the average YR for a trial were also eliminated. All YR data were aggregated for each year and combined with farmer management information and spatial soil data.

Hierarchical modeling was used with Bayesian statistics to identify effects of field-level factors, such as average monthly and cumulative in-season rainfall, and within-field level factors, including relative elevation, slope, compound wetness index, soil drainage class and soil productivity index on YR. The hierarchical analysis deals with random variability observed at different levels. Bayesian analysis was used to estimate posterior predictive probabilities of profitable soybean yield response to extra seeds in new or unobserved situations given the observed data from on-farm trials. For more details about using this type of analysis for data from on-farm trials see Kyveryga et al., (2013). A soybean yield response larger than 0.8 bu acre was considered profitable from planting a higher seeding rate by 30,000 seed/acre.

Soybean population densities were counted in early August of 2010 within nine sampling areas along two pairs of the treatments in each trial.

Predictive probabilities of profitable yield response to higher seeding rates

Figure 2 illustrates examples of using planting date to identify two categories of fields that may differ in probability of economic YR to the higher seeding rate. The “S” shape curves are predictive probabilities of YR to the higher seeding rates in unobserved fields in conditions similar to 2009.

Because field management factors such as planting date or row spacing were not studied within the same trials, to reduce the confounding effect of other factors, probabilistic predictions were made using the observed spatial observations for categories that included at least six trials.

Fields that were planted after May 20 were twice (60 vs 30%) as likely to produce above-break-even YR as those fields that were planted before May 20 (Figure 1). Because the two probability curves do not intersect each other, the data in Figure 2 provide convincing evidence that the late planting would require a higher seeding rate to maximize yield in conditions similar to 2009.
Figure 2. Predictive distributions of the field-level soybean YR to higher seeding rates (approximately 160,000 vs 130,000 seed/acre) for fields planted before and after May 20. The probability of profitable YR can be estimated as the distance from 1 on the Y axis to the intersection of the cumulative probability curve with the break-even YR line shown as the dash line.

Figure 3. An example of a decision tree for identifying field and within-field factors that can predict the probability the seeding rate higher by 30,000 seed/acre than the normal to produce economic YR. Underlined numbers would suggest to increase soybean planting rate.
The probability of profitable YR to the higher seeding rates are shown for two categories based on row spacing, planting date and sand content is shown in Figure 3. Across all trials, the predictive probability of profitable YR was about 40%, suggesting no need to plant higher seeding rates unless more information is available to identify accurately where the higher rates could produce profitable YR.

Predictive probabilities shown in Figure 2 were used to develop a decision tree that can guide farmers and agronomists where and when to increase their common seeding rates. The predicted probabilities of profitable YR larger than 50% would suggest a convincing evidence for increasing a higher seeding rate by 30,000 acre. Fields that were planted after May 20 were twice as likely to have profitable YR to the higher soybean rate than those that were planted before May 20.

By the end of the 2010 growing season, the observed soybean plant densities were on average 16% lower than the farmer planting rates for both high and low seeding rates (Figure 4). Despite the large variability in the data in Figure 4, the stand reduction within fields was the same for fields with narrow and wide row spacing.

![Figure 4](image_url)

Figure 4. Relationship between planting rates used by farmers for the low and high seeding rates and the observed soybean plant density from scouting the trials in early August in 2010.

In 2010, the difference between fields with narrow and wide row spacing was not significant. Similar to the results observed in 2009 (Figure 2), fields planted after May 20 were approximately 20% more likely to produce economic YR than those fields planted before May 20 (data not shown).

In all three years of the study, the effect of spatial factors including relative elevation, slope, soil drainage class and organic matter derived from digital soil map on probability of profitable YR to the higher seeding rate was not significant.
Summary

Across three years of the study, increasing soybean seeding rates from 130,000 to 160,000 seed/acre would produce a profitable YR in approximately 40% of the time. Based on the data observed in 2009 and 2010, fields planted after May 20 were about 1.5 to 2 times more likely to produce profitable YR than fields planted before May 20.

Based on estimated predictive probabilities of profitable YR, a decision support system can be developed to help farmers and agronomists make better decisions where and when and at what risk to increase or decrease common farmer soybean seeding rates within and across fields.

References


Optimum plant population in Iowa. 2007. Iowa State University Extension.