EVALUATING DECISION SYSTEMS FOR USING VARIABLE RATES IN PLANTING SOYBEAN

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ABSTRACT

Increased interest in managing seeding rates within soybean fields is being driven by advances in technologies and the need to increase productivity and economic returns. A wealth of previous research was focused on studying how different seeding rates affect soybean yields at small-plot scales. However, little is known about different site-specific factors influence the responsiveness of soybean to higher or lower plant population densities at field levels, especially across geographic areas with similar soils, weather, and management conditions. In addition, there is no system that farmers can use to evaluate various recommendations for variable rate seeding. The objective of this study was to use on-farm observations to identify major factors that affect yield response of soybean to seeding rates that are slightly above or below the planting rates currently used by farmers. Between 2009 and 2011, farmers conducted 83 field-scale replicated strip trials across Iowa with two soybean seeding rates, high, about 395 K seed ha^{-1} and the low, about 340 K seed ha^{-1}. The two seeding rates were replicated at least four times in each trial. Yield responses to the higher seeding rates were estimated at 30-m grid patterns within each field. Hierarchical modeling and Bayesian analysis were used to identify field and within field-level factors that had significant effect on yield response to the higher seeding rate. For the field-level factors, we considered soybean row spacing, soybean planting dates, monthly and cumulative growing season rainfall. For the within field-level variables, we used relative elevation, slope, soil drainage class, crop suitability rating index, and soil organic matter levels. The Bayesian analyses helped to quantify the uncertainty in the parameters of observed yield response distributions and make predictions for potential yield responses to higher or lower seeding rates at field and within-field areas not studied but assumed to have similar crop management and weather conditions. Based on estimated predictive posterior probabilities of profitable yield response (a yield increase above the marginal cost for the seeds) to higher soybean seeding rates, a decision management system was developed that would help farmers and agronomists make economic decisions regarding where to increase or decrease soybean seeding rates within and across fields.

Keywords: spatial variability, soybean, decision support system, Hierarchical models and Bayesian analysis

INTRODUCTION

Farmers are interested in better managing seeding rates within soybean fields to increase productivity and economic returns. A wealth of previous research was focused on studying how different seeding rates affect soybean yields at small-plot scales. The generalized recommendations for soybean seed planting in Iowa suggest to plant soybean at about 340K seed ha^{-1} of final plant stand (De Bruin and Pederson, 2008). However, little is known of how different site-specific factors influence the responsiveness of soybean to higher or lower plant population densities at field levels, especially across geographic areas with similar soils, weather, and management conditions.

The objective of this study was to use on-farm observations to identify major factors that affect yield response of soybean to seeding rates that are slightly above or below the planting rates currently used by farmers. In addition, using the data in yield response to seeding rates to develop a decision support system

MATERIALS AND METHODS

Eighty three on-farm trials were conducted between 2009 and 2011 across Iowa (Fig. 1). Each trial had two alternated treatments of two seeding rates replicated 3 to 5 times. The seeding rates used by farmers were farmer's normal or optimal seeding rates minus or plus 25 K seed ha^{-1}. Across all years and trials, the average two soybean seeding rates were 395 K seed ha^{-1} for the high and 340 K seed ha^{-1} for the low. The soybean row spacing was in the majority of trials 76 cm.

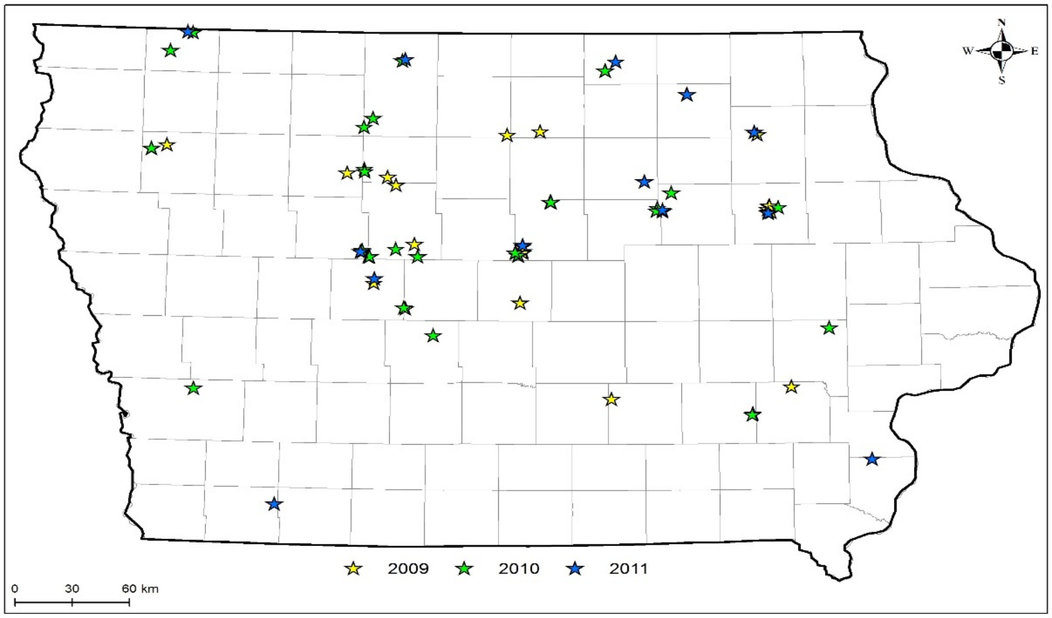

Figure 1. Location of 27 in 2009, 31 in 2010 and 13 on-farm replicated strip trials in 2011 evaluating the effect of field and within field-level factors and variables on response of soybean to a higher soybean seeding rate.

Treatments were harvested with grain combines equipped with GPS and yield monitors that recorded yield observations every 1 sec. 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 50 m long grid cells along each pair of the treatments. Yield responses (YR) were calculated as differences in aggregated yields between the treatments. Each trial had from 50 to 300 individual YR. Yield response observations that were two standard deviations above or below the mean YR for a trial were also eliminated.

Hierarchical models with Bayesian statistics were used to identify effects of field-level factors (average monthly and cumulative rainfall) and within-field factors (soil organic matter, relative elevation, slope, compound wetness index, soil drainage class or soil productivity index) on YR. Hierarchical analysis deals with random variability observed at different levels, and in Bayesian statistics prior distributions are assigned to parameters of distributions to represent knowledge of possible values of these parameters before the data are observed. More details about using Hierarchical models for analyzing data collected from on-farm trials see Kyveryga et al., (2013).

We used posterior predictive distributions of field level means to predict a mean YR for a field that was not studied or observed. Posterior distributions were obtained by using Markov Chain Monte Carlo simulation method with 5000 runs.

A mean YR larger than 60 kg ha^{-1} was considered profitable from planting a higher seeding rate by about 55 seed ha^{-1}.

RESULTS AND DISCUSSION

Figure 2 illustrates examples using field and within-field level variables and factors to identify management categories that may differ in the probability of economic YR to the higher seeding rate. The posterior predictive probabilities indicate the distribution of YR in unobserved fields in conditions similar to 2009.

Larger soybean YR and higher probability of profitable YR to higher seeding rates were observed in fields with less than normal cumulative summer rainfall (Fig. 2A) or within field areas with lower soil productivity (Fig. 2B).

Posterior predictive probabilities shown in Figure 2 were used to develop a decision tree to guide farmers and agronomists where and when to increase their normal or common seeding rates.

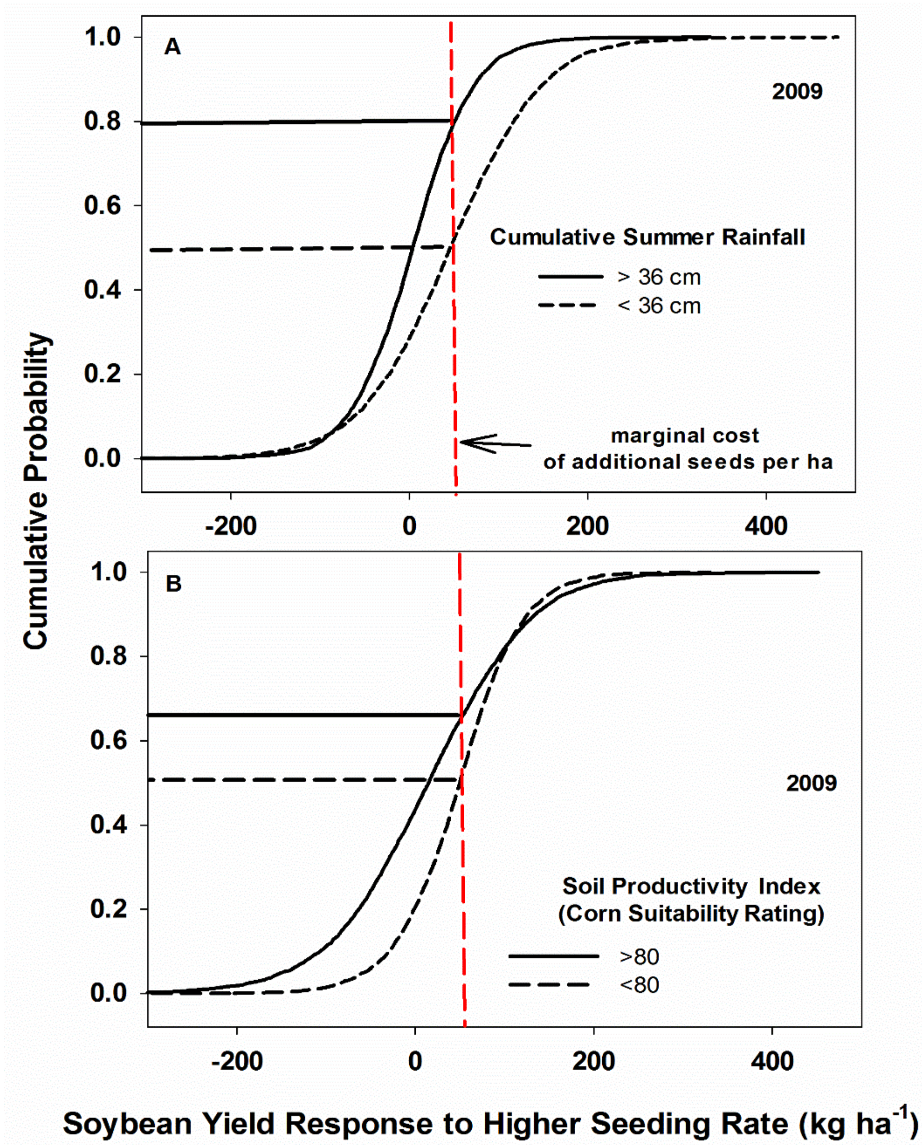

Figure 2. Examples of using posterior predictive distributions of the field-level soybean yield response (YR) to increased soybean seeding rates as affected by field and within field- level factors. The probability of profitable YR can be estimated as the distance from 1 on the Y axis to the intersection of the cumulative probability curve with the break-even YR line shown in red.

CONCLUSIONS

The approach described here enables farmers to collect a sufficient amount of data in on-farm evaluation studies comparing yield response to higher seeding rates and providing researchers with the aggregate data to identify factors that influence response across and within fields.

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