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Making use of soil and topography data to improve corn seeding rates

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Introduction

Since the introduction of hybrid corn in the 1930s, the corn grain yield trend has been increasing in Iowa and across the U.S. Corn Belt. In Iowa, there has been an increase of corn plant densities of approximately 400 plants per acre per year since 2000. Corn grain yield and yield components are greatly influenced by plant densities. Corn grain yields respond to plant densities with a curvilinear or quadratic response if plant densities are increased to supra-optimum densities. At plant densities below the optimal plant density for maximum yield, additional plants offset kernel number per plant reductions (Duncan, 1984; Duvick, 1997). Above the optimum seeding rate for maximum yield, there are reductions in kernel number per plant, kernel weight, and greater occurrence of plant barrenness (Tetio-Kagho and Gardner, 1988; Maddonni and Otegui, 2006).

There is little knowledge as to how corn grain yield and yield components are affected by interactions of seeding rate with soil attributes or topographic characteristics. Plant density yield response curves are also influenced by field variability such as topography and soil physical and chemical properties. Shanahan et al. (2004) found that the optimal plant density increased from areas of low to high productivity within fields and that in-field elevation was influential. In-field elevation influences corn grain yields differently depending on environmental conditions. Under dry conditions yield productivity suffered at higher in-field elevations with lower soil organic matter, higher slopes, and convex slopes, whereas, productivity in depressions was reduced under conditions with adequate to surplus rainfall (Kravchenko and Bullock, 2000; Kravchenko et al., 2003; Kaspar et al., 2004). The spatial variability of topography and soil attributes can be determined and when combined with precision agriculture technologies there is the potential to manage this variability.

The use of site-specific field information combined with technological advancements in equipment capabilities is the premise upon which precision agriculture is based. The use of soil attributes and topographic characteristics as the basis variable rate seeding is only useful if a consistent relationship exists between seeding rate and field attributes from year to year and field to field. The goal of this research was to characterize the spatial variability of soil properties, topographic characteristics, and corn yield productivity to make better site-specific seeding rate decisions while improving yield productivity and grain quality.

Methods

Field experiments were conducted over three growing seasons from 2012 to 2014 at three locations in central Iowa. All fields were in the Clarion-Nicollet-Webster soil association. The same three sites (Ames, 42º00'N, -093º44'W; Kelley, 41º57'N, -093º41'W; and Ogden, 42º00'N, -094º00'W) were used each of the three years of the experiment in a corn following corn rotation. The experimental design was randomized complete block with a minimum of four replications. Experimental treatments consisted of five seeding rates (25,000; 30,000; 35,000; 40,000; and 45,000 kernels per acre) planted in plots 12 to 16 rows wide by field length in a 30-inch row spacing. Field length was approximately 1,300 feet at Ames and Kelley and 2,360 feet at Ogden.

Subplots were established within each replicated seeding rate treatment 100 feet apart. At each subplot soil samples analysis was determined for available P, exchangeable K, pH, soil organic matter, cation exchange capacity, and soil texture. Theoretical available water holding capacity was determined using soil texture and organic matter. Topographic indicators were determined from the LIDAR 3m Digital Elevation Model (DEM) of Boone and Story counties (https://programs.iowadnr.gov/nrgislibx/). Ear samples were collected the day of combine harvest from each subplot for determination of yield components. Yield components selected for direct determination were zipper ears, kernel rows per ear, and kernel weight. Whole sample weight, individual kernel weight, and ear sample count were used to calculate kernel number per ear. Grain yields were determined from calibrated combine yield monitor data surrounding each subplot. Additionally, early summer and harvest stand densities were determined for each subplot. Statistical analysis was conducted using SAS software (SAS, 2012).

Results

The site years of this study proved not only to have large variable of soil and topographic attributes but also considerable corn grain yield and optimum seeding rate variability. Individual sites exhibited different corn yield and seeding rate responses due in part to differences in field variability. Slope, curvature, in-field elevation, and soil organic matter seemed to consistently be correlated with corn yield in dry climatic conditions of 2012. When the planting and growing season had normal to cool/wet conditions corn yield correlations to variables were less consistent. Regression models for all site-years were inconsistent in the amount of yield variability accounted for by the soil and topographic variables (16% to 77%).

When seeding rate optimization was performed, only three of nine site-years resulted in meaningful seeding rate response curves that warranted use of variable seeding rate across fields. A fourth site-year resulted in a seeding rate optimization with a range of seeding rates (37,630 to 38,635 seeds per acre) too narrow to justify variable rate seeding. There was considerable variation of attributes included in the optimization model. The optimization model utilized slope curvature, in-field elevation, and pH interactions with seeding rate to determine the slope of the optimization response curve at Ogden in 2012, 2013, and 2014 respectively. Even in those site-years, there was considerable variation of the optimization model. These findings support the notion that for variable rate seeding to be viable there is a need for seeding rate to be influenced by soil attributes and topographic characteristics (Bullock et al., 1998) but an additional need is for consistency of seeding rate interaction with soil attributes and topographic characteristics from year to year and field to field.

The importance of corn seeding rate on grain yield components was evident in this research. As seeding rates increased, kernel weight, kernel rows, and kernel number per ear decreased. Additionally, increases in seeding rate resulted in a higher occurrence of zipper ears and plant barrenness, especially in 2012 when rainfall and soil moisture was limiting. The results did not show consistent evidence of seeding rate interactions with soil attributes or topographic characteristics, however, the main effects of available P and soil pH did influence kernel number per row, kernel weight, and kernel density. Additionally, there was strong evidence that in-field elevation combined with reliable rainfall forecasts can be used to determine field areas with potential for greater kernel weight and kernel density.

Determining a single optimum seeding rate methodology based on soil and/or topographic variables across a farming operation seems unlikely due to seeding rate response and interactions with variability of climatic conditions and field characteristics. Based on this study, further research needs to be conducted to better understand how seeding rate optimization can be accomplished effectively. Development of seeding rate response curves for individual management zones based on indices that can account for the influence of soil fertility, water holding capacity, and landscape position on seeding rate response curves would be of great value.

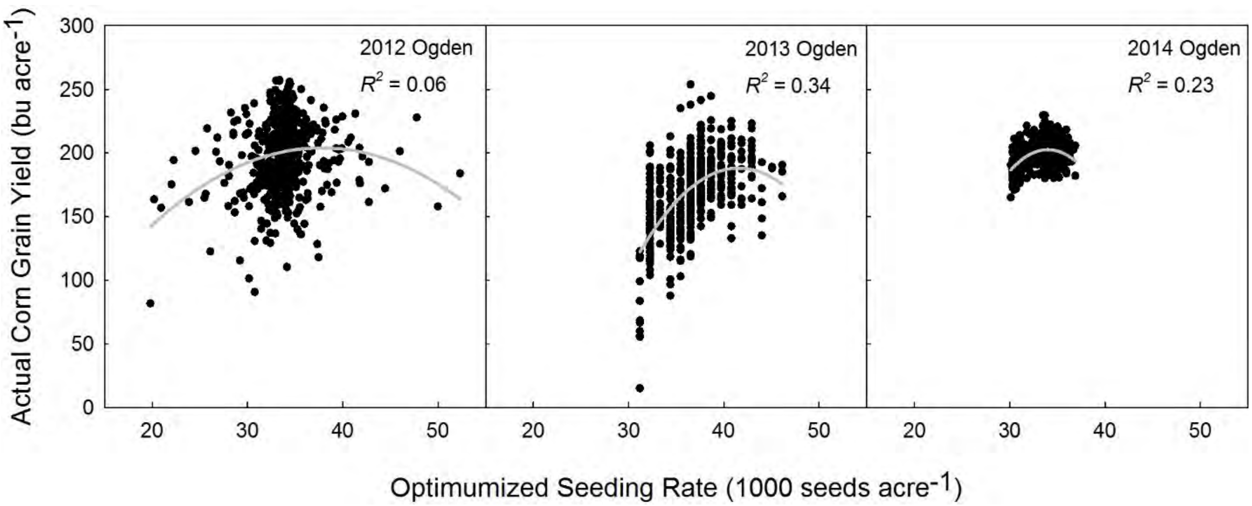

Figure 1. Corn grain yields at optimized seeding rates for Ogden in 2012 to 2014.

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