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On farm studies to determine seeding rate in corn

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Abstract.
Seeding rate (SDR) is one of the most critical production practices impacting productivity and economic return for corn (Zea mays L.) By changing SDRs in different zones within a field, herein termed as site-specific management, better economic results can be produced as the outcome of reducing SDRs in low productivity areas and increasing SDRs under high-yielding environments, relative to the uniform SDR management performed by the producer. The aim of this study was to analyze yield responses to SDR factor at on-farm research (OFR) studies with precision agriculture techniques. Five OFR corn SDRs were conducted in 2014 (two) and 2105 (three) in the central region of Kansas, US. Seeding rates for all OFR studies ranged between 40,000 to 90,000 seeds per hectare. The experimental design employed at all OFR studies was completely randomized design with three replications in strips across the field. Treatments were harvested with combine equipped with yield monitor and GPS. Yield response to SDR factor was estimated via the following equation: Yield=a+bSD+cSD2. All parameters in the fitted equation were modeled using spatial statistics by GeoDa™ software. Spatial autocorrelation of the data analyzed was considered in the spatial statistics. Agronomical Optimum Seeding rate (AOSR) and Economical Optimum Seeding Rate was calculated as: AOSD= -b/(2c) and EOSR= (Seed Price/Corn Price)-b/2c. Corn and seeds prices were expressed in U$S per kilogram and U$S per seed, respectively. Corn yield responses to SDR factor were statistically detected in 3 among all 5 sites. All parameters obtained for model calibration are site-specific (soil-weather-genotype). By conducting OFR studies in a wide array of environments, site-specific response models are generated that can incorporate inter annual temporal variability. On-farm research studies help to better understand the complexity of the soil-weather-genotype interaction and can be utilized as support decision tools when temporal and spatial data is aggregated at the local- and regional-scales.

Keywords. *Variable seeding rate, Variability, economical optimum, site specific management.*

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Introduction

Optimal seeding rate (SDR) determination is one of the most critical production practices impacting productivity and economic return for corn (*Zea mays* L.) management. The SDR response is strictly connected to availability of resources (e.g., radiation, light, nutrients, and water) at both plant- and canopy-scales. In the US Corn Belt, Bullock et al. (1998) observed differences in the economically optimal plant densities as a function of yield potential. Genotype, soil and weather factors (e.g., temperature and available water) interact in a complex manner critically impacting corn yield responses to the SDR factor. By changing SDRs in different zones within a field, better economic results can be found, which might result on reducing SDRs in low productivity areas and increasing SDRs under high-yielding environments. Following this rationale, University extension programs could offer guidance on experimental design for on-farm research trials as well as interpreting spatial analysis (Griffin et al., 2008). The aim of this study was to analyze yield responses to SDR factor at on-farm research (OFR) studies with precision agriculture techniques.

Material and methods

Five OFR in corn SDRs were conducted in 2014 (two) and 2105 (three) growing seasons in central KS (Salina, KS. US). Seeding rates for all OFR studies ranged between 40,000 to 90,000 seeds per hectare. The experimental design employed at all OFR studies was completely randomized design with three replications in strips across the field. Treatments were harvested with combine equipped with yield monitor and GPS. Yield response to SDR factor was estimated via the following equation:

$$Yield = a + bSDR + cSDR^2 \qquad (1)$$

where SDR is seeding rate and a, b and c are the parameter of the regression.

All parameters in the fitted equation were modeled using spatial statistics by GeoDa™ software. Spatial autocorrelation of the data was considered in the spatial statistics analysis implemented. Agronomical (AOSR) and economical optimum seeding rate (EOSR) were calculated as:

$$AOSD = \frac{-b}{2c} \qquad (2)$$

$$EOSR = (\frac{SeedPrice}{CornPrice}) - \frac{b}{2c} \qquad (3)$$

Reference seed price was 0.0064 \$ seed^{-1} and corn price was 0.055 \$ kg^{-1}.

Results and discussion

Corn yield responses to SDR factor were statistically detected in 3 among all 5 sites (Table 1). All parameters obtained for model calibration are site-specific (soil-weather-genotype).

Table 1. Regression coefficient, agronomical (AOSR) and economical optimum seeding rate (EOSR) for all five sites considering spatial correlation of the data.

Site	Year	a	b	c	AOSR (pl ha^{-1})	EOSR (pl ha-1)
1	2014	-570.8*	0.026*	-0.000000114*	75,199	69,991
2	2014	1036.5*	-0.061*	-0.000000122*	61,872	66,450
3	2015	538.2	-0.022	0.000000508	35,647**	-
4	2015	325.4	-0.006	-0.000000035	46,040**	-
5	2015	76.68*	0.029*	-0.00000019*	75,119	63,588

(*) Statistical difference (p<0.01). (**) lower plant population tested in the experiment.

Sites 3 and 4 did not present a statistical significant spatial yield response to SDR, yield decreased as SDR increased; thus the minimum SDR evaluated on those studies was assumed to be the optimal SDR based on the spatial analysis. Yield maps at each site evidenced a significant yield variability, this point should be properly acknowledged for future OFR studies, specially knowing the benefits of delineating management zones to optimize SDR (Zhang at al., 2002).

An example of the experiment layout (Site 5, 2015 season) with the SDR strips and the yield map at harvest is presented in figure 1. Differences in yield can be appreciated across de strips. Both AOSR and EORS were calculated with the parameters obtained from the spatial model (Table 1).

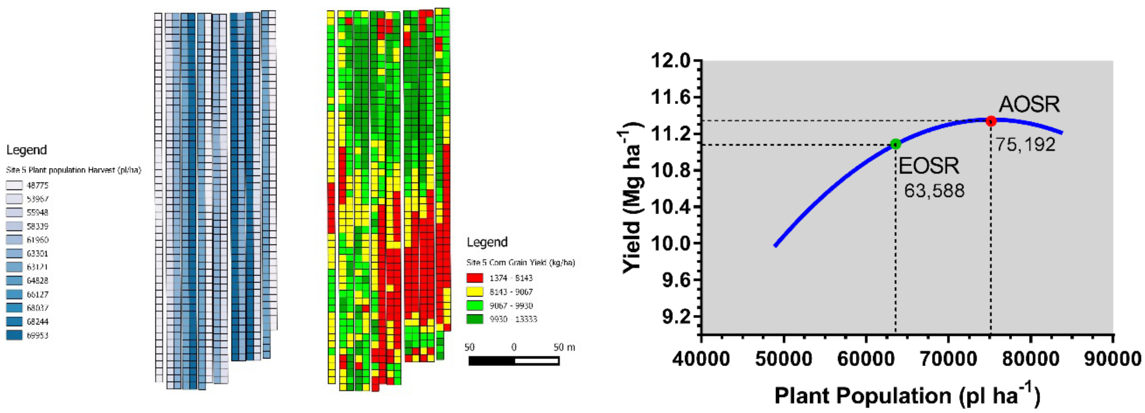

Fig 1. Site 5 Season 2015: a) Plant population (pl ha^{-1}) measured at harvest for each strip, b) grain yield (Mg ha^{-1}) and c) agronomical (AOSR) and economical optimum seeding rate (EOSR) for corn.

All farmers from each site collaborating on this project have participated in annual workshops to analyze and discuss the results obtained from each OFR with university extension on-farm research leader. The OFR studies helped farmers in providing value to the information obtained from yield maps but also equally importantly to understand the spatial variability of their own fields.

Conclusion

By conducting OFR studies in a wide array of environments site-specific response models are generated that can incorporate interannual temporal variability. The OFR studies helped to better understand the complexity of the soil-weather-genotype interaction and can be utilized as decision support tools when temporal and spatial data is aggregated at the local- and regional-scales.

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