Managing In-Field Spatial Variability

Variable-rate seeding appears to be the logical way.

Drs. L. Longchamps and R Khosla

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Summary: *This study investigates the possibility of increasing crop productivity by optimizing seed rate based on soil fertility levels and productivity potential in various parts of the field. Corn was planted at different planting densities in a research field at Colorado State University. Soil properties were characterized for the entire study area and yield was recorded using a combine harvester equipped with a yield monitor. Results confirm that the relationship between yield and seed rate follows a quadratic curve. Results also indicate that optimal plant population and maximal yields were attained in parts of the field with higher fertility (e.g. higher yield class) than in locations of lower fertility (e.g. lower yield class).*

Spatial variability exists in most farming contexts and farmers are trying to find ways to further increase their productivity by managing this variability. Among the various input management options, variable rate seeding appears as a logical way to manage in-field spatial variability.

Worldwide

Within-field spatial variability of soil chemical and physical properties (Figure 1) exists in most agronomic environments around the world. There are many natural and anthropogenic (human-made) reasons ranging from geological properties, landscape positions, or climates to as simple as uneven hand broadcasting of inputs in small-scale farming, or merging of fields with different crop histories in medium- to large-scale farming.

Quantifying

Over the last two decades of precision farming, precision agronomists and soil scientists have developed methods to quantify spatial variability that exists at the field scale. This has led to the realization that employing average values for managing crop inputs often over-estimates prescription in some parts of the field and under-estimates it in other parts of the field. To avoid these over- and under-estimations, agronomists and farmers are trying to develop site-specific crop management techniques that will enable them to manage the spatial variability that exists in their fields.

Variable-rate seeding

Plant population appears as a legitimate component of site-specific crop management in addressing spatial variability existing in crop fields. There is a growing interest in variable-rate seeding among farmers and practitioners. This, in part, is driven by increasing seed prices. As seed companies stack additional desirable traits into future crop varieties, the cost of seed will continue to rise. Hence, the technology to vary seed rate, coupled with sound scientific knowledge, will chart the way to make cropping more productive, efficient, and profitable. Some may argue that technology to vary seeding rate has arrived. Others may rightly point out that science to support the decision-making process to gainfully use the current technology is lacking.

Objective

The goal of this study was to experiment with variable-rate application of seed in a field and assess its effect on yield.

Methodology

Location. The study was conducted in Colorado during the 2014 crop growing season (April 2014 to October 2014).

Climate. The climate of north-eastern Colorado is considered semi-arid as it receives less precipitation than potential evapotranspiration. However, 2014 received one inch above the normal level

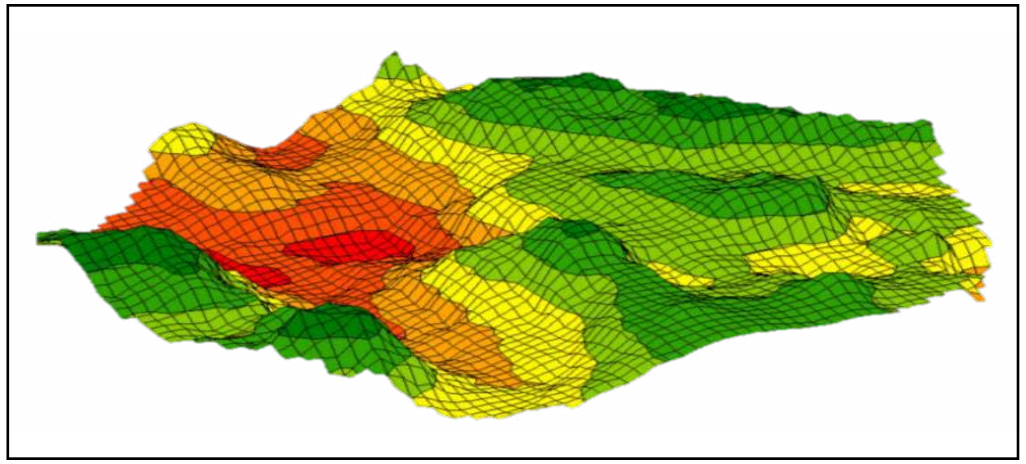

Figure 1. *A field showing spatial variability in soil properties as measured by grid soil sampling.*

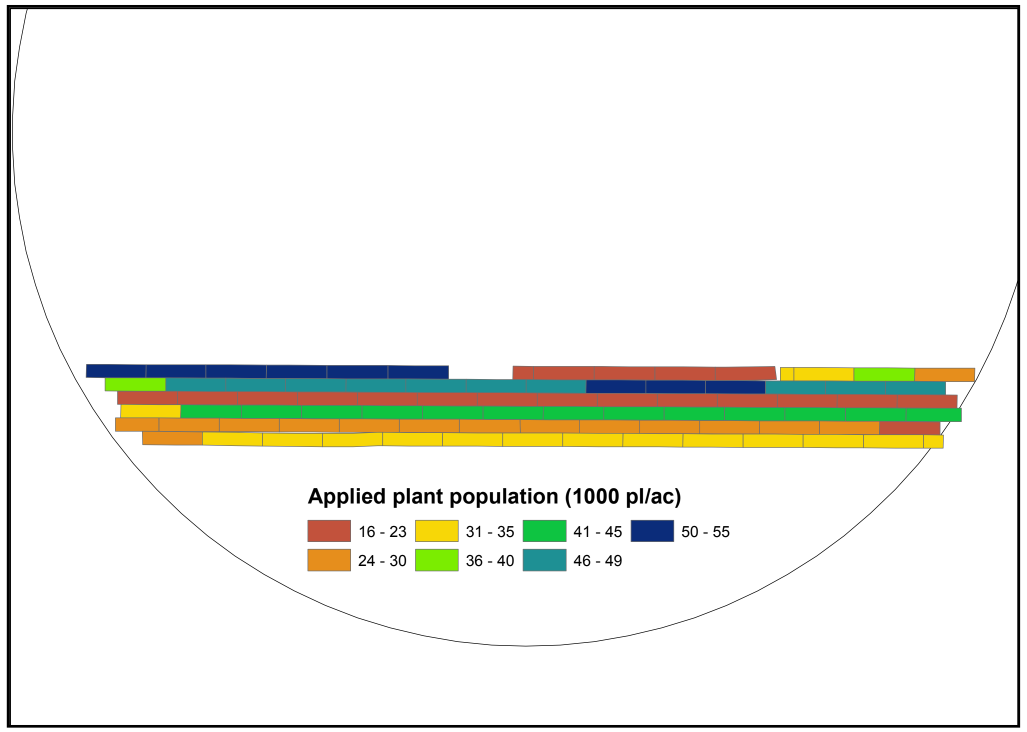

Figure 2. *Applied map of the plant population.*

of precipitation during the crop growing season.

Field. The 22-acre field is located at Colorado State University's Agricultural Research Development and Education Center in Fort Collins, Colorado.

Soil at this site is classified as a fine-loamy, mixed, super-active, mesic Aridic Haplustalf. Based on soil samples, texture was classified as a sandy clay loam.

Slope. Field slope is lower than two percent in a single plane gradient.

Site history is one of continuous maize production for ten years with conventional tillage.

Population. Corn hybrid Dekalb 4620 was planted at a population of 20,000, 27,000, 34,000, 41,000, and 48,000 plants/A (depending on plant population treatment strips) on April 29th 2014.

Seeds were planted using a precision planter in long strips crossing the entire field. The sequence of the population strips was randomly assigned.

Fertilizer. Monoammonium phosphate (100 lbs/A of 11-52-0) was applied in early spring (April 1), followed by a fluid fertilizer (UAN 32%) rate of 75 lbs of N/A at planting and 150 lbs of N/A at growth stage V8 of the crop.

Irrigation was supplied with a sprinkler irrigation system to compensate crop evapotranspiration, using the web-based irrigation scheduler eRams (www.eRams.com).

Vacuum planter. Plant population targets were programmed in a 6 rows Monosem (NG+3 Series) precision vacuum planter. This planter is equipped with sensors that monitor the actual seed rate at every location of the field and create an "as-applied" map of plant population (Figure 2). This map was used rather than the target map to analyze the data.

Harvesting. Corn was harvested on October 30th at corn maturation with a 6-rows Case IH combine harvester equipped with a yield monitor.

Data analysis

Cleaning. Yield data were cleaned to remove outliers using an algorithm rejecting all data above and below the average plus or the average minus three times the standard deviation.

Cluster. Yield was clustered in two classes based on productivity potential.

Groups. The low group was below average, while the high group was above yield average.

Quadratic function was used to model the relationship between yield and plant population, forcing the intercept to 0 on the basis that at plant population zero the yield has to be zero. The maximum of the quadratic function was considered as the optimal plant population to maximize yield.

> ***"Seed rate potent way to measure variability in soil properties."***

Soil properties were monitored at the location of each yield data point using geographic information system software. The soil properties investigated were:

- Percent sand, clay, and organic matter
- Cation exchange capacity
- Soluble salts, nitrates, phosphorus, potassium, magnesium, and calcium.

T-test. A Student's t-test was used to compare soil properties between the low and high yield data with a level of significance of 0.05.

Results

Grain yield ranged from 100 to 215 bu/A.

Quadratic relationship between plant population and yield was strong for the whole dataset, which is consistent with observations in other studies on the effect of seed rate on yield.

Dataset. When dividing the dataset in lower and higher yield based on yield average, it was possible to observe a higher optimal plant population for the higher yield dataset than for the lower yield dataset (Figure 3).

For the lower yield dataset, the optimal plant population was 37,500 plants per acre with a maximal modeled yield of 159 bu/A.

For the higher yield dataset, the optimal plant population was 40,550 plants per acre with a maximal modeled yield of 172 bu/A. The results are consistent with observations of Doerge, et al. (2015) who observed an increase in optimum economic seeding rate with increasing local yield potential.

Student's t-test. As per Student's t-test, several soil properties were significantly different between the locations of the lower yield level and the locations of the higher level (data not presented). In general, soil properties in the higher yield locations tended to indicate a more fertile soil (e.g., higher organic matter and phosphorus content, higher CEC, etc. in the higher yield locations).

However, even though Student's t-test p-values showed strong significant differences between the two classes, in an agronomic perspective, the differences are not considered very strong. Nevertheless, a synergetic combination of all these factors may have explained the higher yield obtained in these locations and hence the potential to reach higher yield with higher seed rate.

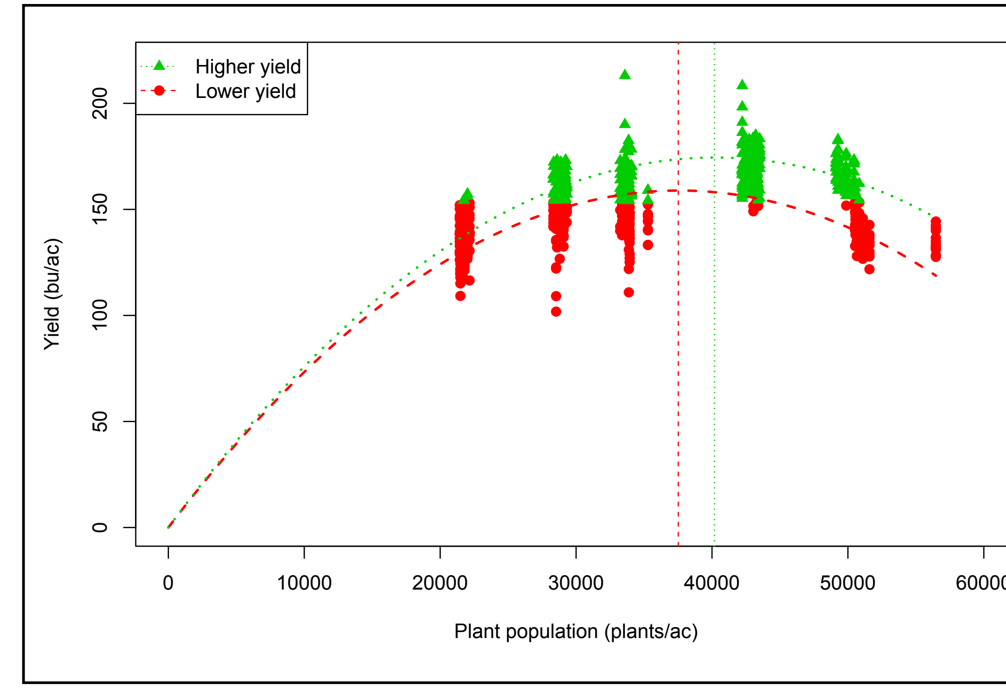

Figure 3. *Relationships between plant population and yield for two yield classes (lower or higher than yield average). Vertical lines indicate optimal plant population for each yield class.*

Summing up

Variable seed rate stands as a potent way to manage spatial variability in soil properties existing at field scale. This study showed that the relationship between plant population and yield follows a quadratic function where an optimal plant population can be applied to reach maximum yield. A higher level of fertility such as higher phosphorous or high organic matter content can potentially indicate a higher optimal seed rate.

Dr. Longchamps is an Assistant Professor and Dr. Khosla is Professor of Precision Agriculture at Colorado State University in Ft. Collins, Colorado.