What data layers are important for variable rate soybean seeding prescriptions?

Ethan Smidt, John Gaska and Shawn Conley, Department of Agronomy ; Jun Zhu, Department of Statistics and Department of Entomology; University of Wisconsin-Madison

Introduction

Growers are collecting many forms of spatial data for their fields, including yield, elevation and soils data. Highly accurate GPS systems along with advances in variable rate technology (VRT) are allowing growers to create and use variable rate planting prescriptions to optimize soybean yields and seed placement (Hoeft et al., 2000). As soybean seed prices continue to rise (USDA-ERS, 2014), growers are looking for ways to optimize seeding rates across their fields (Hoeft et al., 2000). However, growers and researchers alike feel there is an abundance of raw data but a shortage of methods and knowledge on how to use the data for advancements in precision agriculture (Bullock et al., 2007). Therefore, the objectives of this research were:

- **Find the key measureable predictors determining soybean seed yield in Wisconsin**
- **Use those predictors to create accurate, data-based future VRT prescriptions**

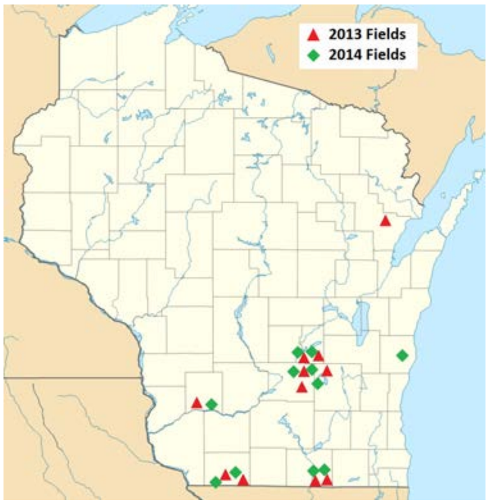
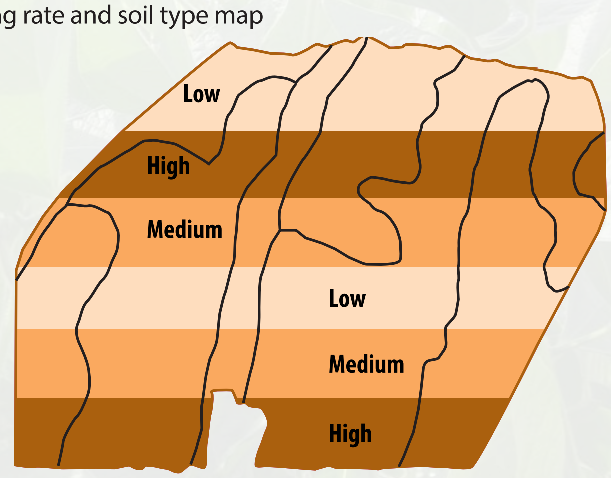
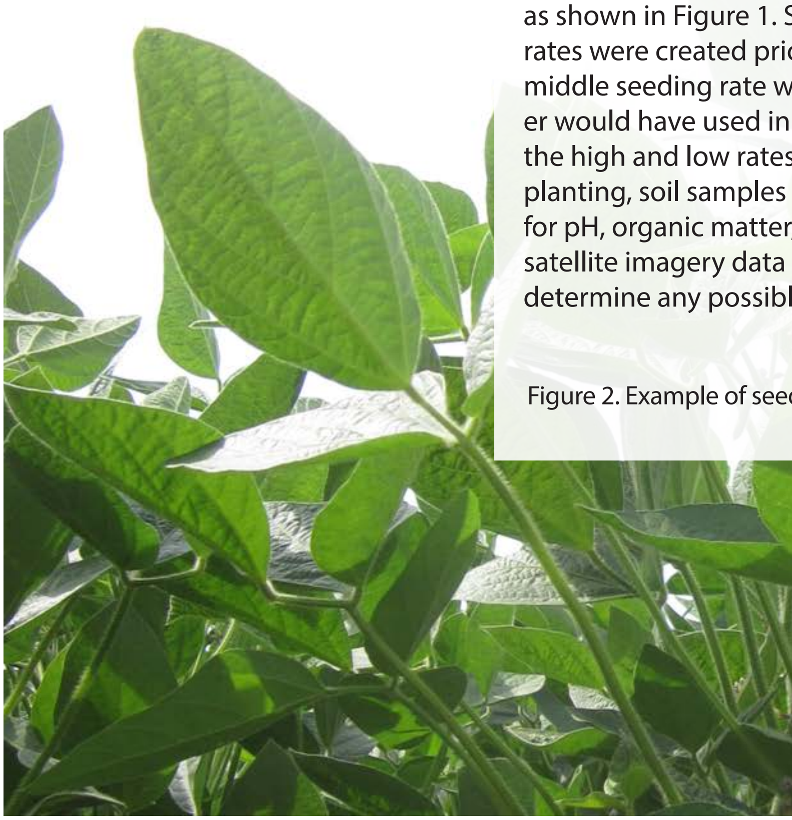


Figure 1. Map of field locations

This study was conducted on a total of 22 sites between 2013 and 2014 as shown in Figure 1. Seeding rate prescriptions containing three unique rates were created prior to planting for each site as shown in Figure 2. The middle seeding rate was equivalent to the single rate each individual grower would have used in their respective field without VRT capabilities and the high and low rates were targeted at ±30% from the medium rate. After planting, soil samples were taken at geo-referenced points and submitted for pH, organic matter, phosphorus and potassium levels. Soil survey and satellite imagery data were also obtained during the growing season to determine any possible relationships with soybean yield.

Figure 2. Example of seeding rate and soil type map





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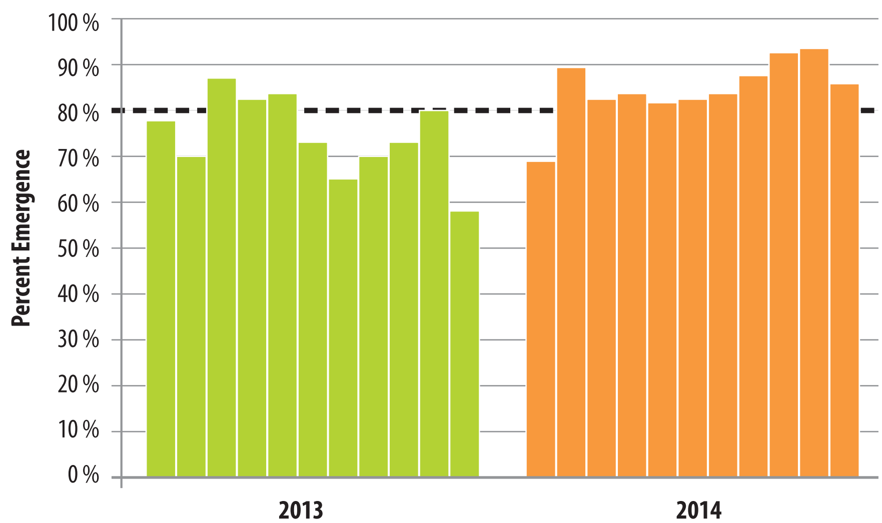
Climate and Planting Factors

Soybean plant counts were taken at the same geo-referenced points used for soil sampling to verify the prescriptions were applied correctly. Relative emergence compared to the planted rate is shown for each field in Figure 3 and the 80% emergence level is highlighted. The 2013 growing season was more stressful, both early and late in the season, compared to 2014 (National Climate Data Center, 2015). There were some noticeable patterns in the emergence levels of the 2013 graph, almost all of which were segregated by the grower and their respective equipment. Discussions with the growers revealed that planting conditions (soil moisture, air temperature, etc.) and planter setup (coulters, age of disc openers, etc.) were the most likely culprits of these differences.

Figure 3. Average soybean emergence levels at each site based on initial seeding rates



Pooled Results

The average soybean yield for the 2013 sites was 52 bu/a with individual field averages ranging from 37 bu/a to 68 bu/a, and the pooled average for the 2014 sites was 55 bu/a with individual fields yielding from 30 bu/a to 69 bu/a on average. Random forest method (Breiman, 2001) determined predictor importance in each data set, and the ranked results are found in Table 1 with soil symbol as the most important factor regardless of year.

Table 1. Random forest results from 2013 and 2014 pooled data

2013 Most Important Predictors (Pooled)	2014 Most Important Predictors (Pooled)
Soil Symbol	Soil Symbol
Soil Phosphorus	Soil Phosphorus
Soil Organic Matter	Elevation
Available water supply from 0-39 in.	Soil Potassium
Soil Potassium	Soil Organic Matter
Elevation	
Soil pH	

Individual Field Results

The results from similar analyses for individual fields were in general, quite different compared to the pooled dataset from the same growing season. The predictor rankings were averaged (value in parentheses) and elevation was the top predictor for soybean yield across both years (Table 2). The commonly used soil sampling variables of organic matter, potassium, phosphorus and pH made up the rest of the top 5 predictors in both years. Soil symbol fell to 6th most important on average when looking at individual fields. The National Commodity Crop Productivity Index (NCCPI) was not determined to be an important predictor at any site.

Table 2. Average random forest results from 2013 and 2014 individual field analyses

2013 Individual Field Predictor Rankings	2014 Individual Field Predictor Rankings
1. Elevation (1.55)	1. Elevation (2.00)
2. Soil Organic Matter (3.18)	2. Soil pH (3.09)
3. Soil Potassium (3.36)	3. Soil Potassium (3.27)
4. Soil Phosphorus (4.09)	4. Soil Organic Matter (3.45)
5. Soil pH (4.09)	5. Soil Phosphorus (3.82)

Satellite Imagery and Quantile Regression Results

In 2013, satellite images were gathered for 2 sites from June-September and in 2014, 3 sites had images taken during the same time period. Early-season (June) images showed no correlation to final soybean yield in either year. At both sites in 2013, the late-season (early September) NDVI values showed high correlation to yield (r values of 0.762 and 0.857). The 2014 sites showed less correlation overall, with the highest correlation appearing in the mid-season (July/Aug) images at 2 sites (0.425-0.77) and the remaining site showing the highest correlation in September (0.486).

Quantile regression was used to see if the seeding rate impacted yield across the yield ranges in each field. Only 4 of the 22 sites (18%) had a majority of the data points fall outside the linear regression, meaning the remaining sites had a consistent relationship between seeding rate and yield throughout the field. However, over 36% of the fields had a negative linear regression slope, which showed yield decreased as seeding rate increased.

Conclusions

Soil symbol was by far the most important variable for predicting soybean yield in both the 2013 and 2014 statewide pooled data sets. This could be useful for wide-ranging recommendations and statewide research. However, elevation and the soil sampling factors of phosphorus, potassium, organic matter and pH were the most important predictors when looking at fields on an individual basis. Since this type of analysis is possible for many growers and agronomists, these factors should be more useful for specific fields if the data are available. NDVI and other aerial imagery data were unable to accurately predict soybean yield until mid- to late-Summer and were more accurate during the 2013 growing season when many fields were exhibiting late season stress. It also appears that scale is an important factor when determining the predictors best for characterizing soybean yield due to the differences between the pooled and individual data sets. The pooled results can be used for general recommendations, however if accurate data are available for specific fields, more accurate results would be likely and should be addressed in order of importance. In short, VRT soybean prescriptions are useful in certain cases, but other factors are better predictors of soybean yield and should be analyzed and addressed first. A 'one size fits all' approach for creating the prescriptions is not recommended due to the numerous possible differences between fields.

Elevation and the soil sampling factors of soil phosphorus, potassium, organic matter and pH were the most important predictors when looking at fields on an individual basis...

References

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