R2019-10
C. White

2019 Pennsylvania Soybean Board Research Project Mid-Term Report

Using Precision Agriculture Data to Define and Refine Soil Fertility Management in Soybean Production

Project period: 3/1/19 – 2/28/20

Project Leader:
Charles White, Assistant Professor and Extension Specialist, Soil Fertility and Nutrient Management, Department of Plant Sciences, Penn State

Co-Investigator:
John Spargo, Director, Agricultural Analytical Services Lab, Penn State

Project Overview

The overall goal of this project is to develop improved soil fertility management practices for Pennsylvania soybean growers. Our approach is to develop improved methods for zone-based soil sampling within fields and to verify that previously established soil test and tissue test critical levels for phosphorus (P) and potassium (K) are still valid under modern management practices. We are also seeking to determine if sulfur (S) is a limiting factor in soybean yields and whether soil test and tissue test critical levels can be identified to detect sites that will be responsive to S additions.

To develop and test new zone-based soil sampling practices, we are compiling multiple spatial data layers within fields, focusing on yield maps and soil electrical conductivity (EC) maps, to determine how those data layers differentiate zones within a field and how those zones relate to soil fertility levels. To verify soil test critical levels, fertilizer response test plots (20' x 20' plots with added P, K, and S) are embedded throughout two production fields. Soil test and tissue test nutrient levels will be analyzed in relation to yield increases from fertilizer additions to determine critical levels of the nutrients that separate responsive from non-responsive sites.

Activities to Date (March 2019- August 2019)

Prior to the 2019 growing season, two production scale soybean fields were identified to be used as test sites. One field is at the Rock Springs research station and the other field is managed commercially by a farmer collaborator, Ron Connolly. For each field, spatial data layers were compiled as available to determine variability in soil EC and yield maps. At Rock Springs, yield maps and EC maps were both available, whereas at the Connolly farm, only EC maps were available for the field. All EC soil maps were created using a Veris 3100 sensor cart driven across the fields in 60' wide swaths in March and April 2018. Growmark conducted the EC mapping at the Connolly farm while Helena mapped the Rock Springs field.

Within the Rock Springs field, 18 blocks of fertility response plots were established in locations of the field that strategically spanned variation observed in yield maps and soil EC. At the Connolly farm, 24 blocks of fertility response plots were established strategically spanning variation in soil EC. Each block was composed of four 20' x 20' plots arranged in a 2 x 2 grid. The fertilizer plots were established in

June shortly after soybeans germinated and included treatments of (1) P and K added, (2) P and S added, (3) K and S added and (4) P, K and S added.

Just prior to applying the fertilizer treatments, a soil sample was collected from each block (12 cores, 0-6" depth) for a standard soil fertility analysis as well as percent organic matter and soil texture. Those soil samples were submitted to the Penn State Agricultural Analytical Services Lab and results have been received. Preliminary data analysis has been conducted on the soil test results from Rock Springs to determine whether soil EC or yield maps are predictive of different soil management zones. These preliminary results are presented below.

Soybean trifoliate leaves were sampled at the R1 growth stage in July at both field sites. These samples have been dried and ground and we are awaiting results from the Penn State Agricultural Analytical Services Lab. The tissue nutrient concentrations will help us to verify if existing critical levels for tissue nutrient concentrations are still valid under modern management practices.

Soybean yields from each fertilizer plots will be measured at the end of the growing season. We will harvest 10 linear feet of row by hand and thresh out grain samples with a stationary small plot combine. Yields will be used to determine fertilizer responsiveness of each plot and relate fertilizer responsiveness to soil test and tissue test nutrient levels to determine critical levels.

Preliminary Results

The eighteen fertilizer response blocks at Rock Springs were each soil sampled to 6" depth prior to applying fertilizers. Soil fertility parameters from each block were analyzed to determine clusters of blocks that had similar fertility levels within the cluster and different fertility levels between clusters. The clustering analysis identified 3 fertility zones (Table 1).

Table 1: Means by cluster for selected soil fertility parameters in the field at Rock Springs. Means with different letters within a column are significantly different from each other (P<0.05).

Cluster	pH	P (ppm)	K (ppm)	S (ppm)	Mg (ppm)	Ca (ppm)	CEC (meq/kg)	Sand %	Clay %
1	7 a	20 c	168 b	9 b	232 a	1889 a	13 a	15 a	44 a
2	6.4 b	34 b	145 b	11 b	88 b	1471 b	11 a	16 a	37 a
3	6.1 b	71 a	223 a	13 a	64 b	1201 b	11 a	15 a	37 a

Cluster 1 had a higher pH and Magnesium (Mg) and calcium (Ca) concentration than clusters 2 and 3. Clusters 1, 2, and 3 all differed from each other in phosphorus (P) concentration, with cluster 1 being the lowest and 3 being the highest. Cluster 3 had a significantly higher potassium (K) and sulfur (S) concentration than clusters 1 and 2.

We used a canonical discriminant analysis to test which type of spatial data, yield maps or soil EC was best at separating the 18 fertilizer response blocks into their respective fertility clusters. Soil EC was the strongest predictor of the fertility cluster, followed by historical soybean yield maps (Figure 1). This can be seen in Figure 1, which shows that cluster 1 can be separated from clusters 2 and 3 along the X-axis, which corresponds most closely to the AvgEC vector. The discriminant analysis was not able to separate clusters 2 or 3 by any of the yield maps or soil EC map. Cluster 1 differed from Clusters 2 and 3 primarily by the soil pH and the Mg and Ca concentration. Cluster 1 also tended to have a higher cation exchange capacity (CEC) and clay content, though these parameters were not statistically different. This suggests that the EC map could be used to identify zones of the field that had different soil pH and lime requirements. In this particular field, clusters 2 and 3 have a lower clay content and CEC, and thus acidify faster than cluster 1. These zones will need to be limed before cluster 1.

Clusters 2 and 3 could not be separated from each other based on soil EC or yield maps. These clusters differed from each other based on P, K, and S levels. In this case, these fertility levels may have differed from each other based on some aspect not related to soil EC or yield. It is notable that cluster 3 only has a single response plot assigned to it. Thus it represents a small area of the field. The high soil test levels suggest that this area may have had a fertilizer misapplication on it, such as an overlap of spreader passes or a higher rate applied at spreader start up or stopping.

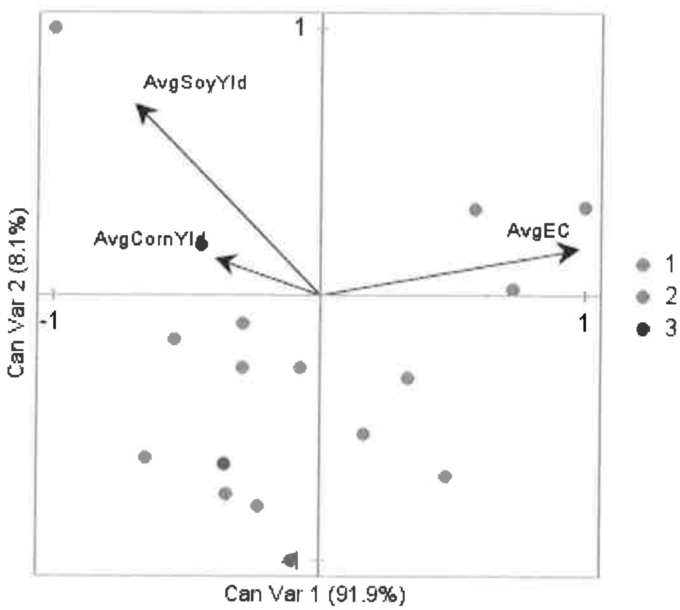

Figure 1. A canonical discriminant analysis for the 18 fertilizer response plots in the Rock Springs field. Each fertility response plot is indicated by a point, which is color coded according to the fertility cluster it was assigned to based on soil test data (Table 1). The x-axis represents an axis along with cluster 1 points are separated from cluster 2 and 3 points. This axis is most closely aligned with AvgEC, which is the average soil EC value measured within the fertility response plot. Therefore, soil EC could be a measurement used to divide this field into zones with different fertility levels. Cluster 3 points could not be effectively separated from cluster 2 points.