18-2023: Understanding Spatial Response to Phosphorus/Potassium Fertilizer Application

Annual Report

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Rationale/Justification for Research

Immobile nutrients phosphorus (P) and potassium (K) are the two greatest applied nutrients in soybean production. While mobile nutrient recommendations such as nitrogen and sulfur are generally based on yield approximation, P and K recommendations are based on a sufficiency index of estimated plant availability of soil reserves. Sufficiency index recommendations depend on the notion that crops grown in a soil below the critical level (below 100% sufficiency) will have reduced yield, while crops grown in soils with above critical threshold nutrient levels will not have yield reduced. Correlation/Calibration studies conducted by Mississippi State University and others are used to develop critical values for the state, which are expected to be accurate across all fields in Mississippi.

Evolution of precision agriculture technology has led to an increased interest in variable rate technology (VRT), specifically for nutrients/lime. Fertilizer application using VRT allows for areas within a field to that need more fertilizer to receive the correct amount of fertilizer required in that location, while simultaneously applying less fertilizer in areas that do not need as much. Variable rate fertilizer application requires that current fertilizer recommendations are accurate enough to discern where nutrient responses will occur not only between different field, but *within* fields.

Research across the US ranging from Arkansas, Iowa, Kentucky, and Oklahoma has shown that the immobile nutrient recommendations are on average accurate, but are not accurate enough to predict site-by-site responsiveness based on soil test values alone. Research trials that look at within location responsiveness report similar results: soil test values alone aren't accurate enough to predict nutrient response. There are other factors not measured in a soil test within locations that are causing nutrient responses to occur.

Objectives:

Determine Soil Physical and Chemical Properties that cause yield response differences to immobile nutrient applications within fields.

Report of Progress/Activity

Trials were established at 6 on-farm locations, and 2 research stations (Verona and Pontotoc) (see figure below) in soybean fields, most to field length, or 350 ft, whichever length was shorter shortly after fields were planted. The treatment structure consisted of nutrient rich strips of P and K applied at a non-yield limiting rate, as well as a "Check" strip in between, where no fertilizer was applied by either producers or researchers. Soil samples were collected at establishment for background information.

Due to complications with harvesting, only 2 of 6 on-farm locations were harvested, and both research stations were harvested. Of the total 4 locations, one location provided significant response to P application (Four Farms Heavy), and one location provided a positive response to K application (Verona). Yield by plot, sufficiency values for both P and K, and relative texture values can be seen below in Figures 2-5.

Generally, areas of the field with positive yield responses to the application of P or K fertilizer had low soil test values, and weren't necessarily correlated with a relative soil texture value. However, soils with low (or very low sufficiency levels of P and/or K) did not predicate a positive nutrient response in many

cases. Four Farms Light site had levels of K of less than 50% sufficiency, yet, still did not provide a positive response to the application of K.

Additionally, with the data collected, we were able to create a correlation figure for each nutrient, to see if there were any trends on the correlation between soil test values and nutrient response. Figures 6 and 7 below show the P and K correlation responses. The vertical dotted line represents current recommendations, where any soil test above that point, P/K fertilizer would no longer be recommended. The horizontal line is where relative yield is 1.0, meaning that there was no difference between the check strip and the P nutrient strip. Points below the line suggest a positive response to the application, and values above the line suggest no/negative response to the application of P.

Phosphorus provided very poor correlation between soil test values and relative yield in year 1, with over half of the points falling above the vertical line, suggesting a negative response to the application of P. We do not believe that this was a negative response to the application of P, but an artifact of the variability across a field horizontally, something that this study seeks to understand. We did see an overall positive response on one location with low soil test P values, where we would expect a P response.

Potassium nutrient responsiveness, for the most part, provided a high correlation with soil test potassium. We did see some artifacts above the line (similar to P), that we do not attribute to a negative response, but again, variability in the soil. This correlation looks very similar to what we would expect from long term collection of correlation calibration studies.

Presentations from this project:

1. Reed, V. (2023) Pontotoc Ridge – Flatwoods Branch Experiment Station Field Day. 8/24/2023. Pontotoc, MS.
2. Reed, V. (2023) North Mississippi Research and Extension Center Field Day. 8/22/2023. Verona, MS.

Figure 1 Relative textuure map and nutrient response data from Four Farms Light location. Shades of blue represent sufficiency levels. Darker shades represent lower sufficiency levels, meaning, lower soil test values, with a higher chance of positively responding to P/K nutrient application. Yields are represented in the white label, in bu/ac. Yield values in red represent a statistical positive response.

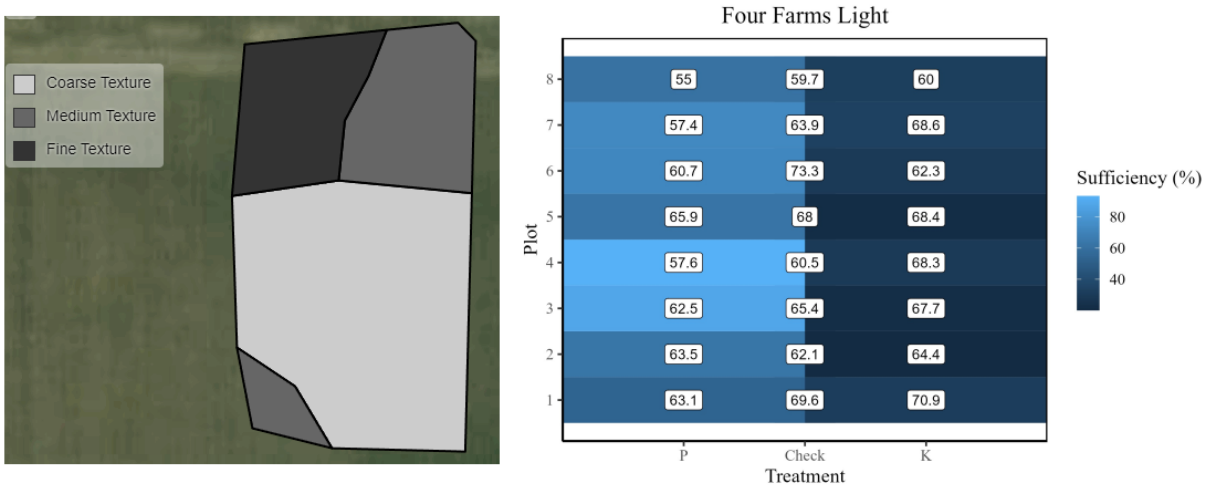

Figure 2 Relative texture map and nutrient response data from Four Farms Heavy location. Shades of blue represent sufficiency levels. Darker shades represent lower sufficiency levels, meaning, lower soil test values, with a higher chance of positively responding to P/K nutrient application. Yields are represented in the white label, in bu/ac. Yield values in red represent a statistical positive response.

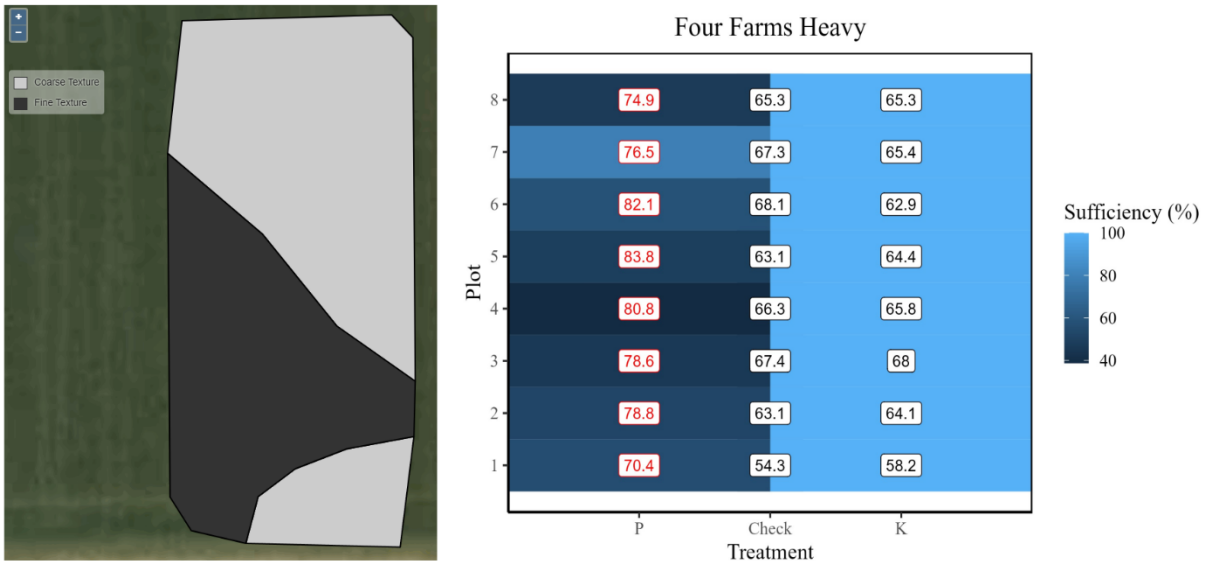

Figure 3 Relative texture map and nutrient response data from Pontotoc location. Shades of blue represent sufficiency levels. Darker shades represent lower sufficiency levels, meaning, lower soil test values, with a higher chance of positively responding to P/K nutrient application. Yields are represented in the white label, in bu/ac. Yield values in red represent a statistical positive response.

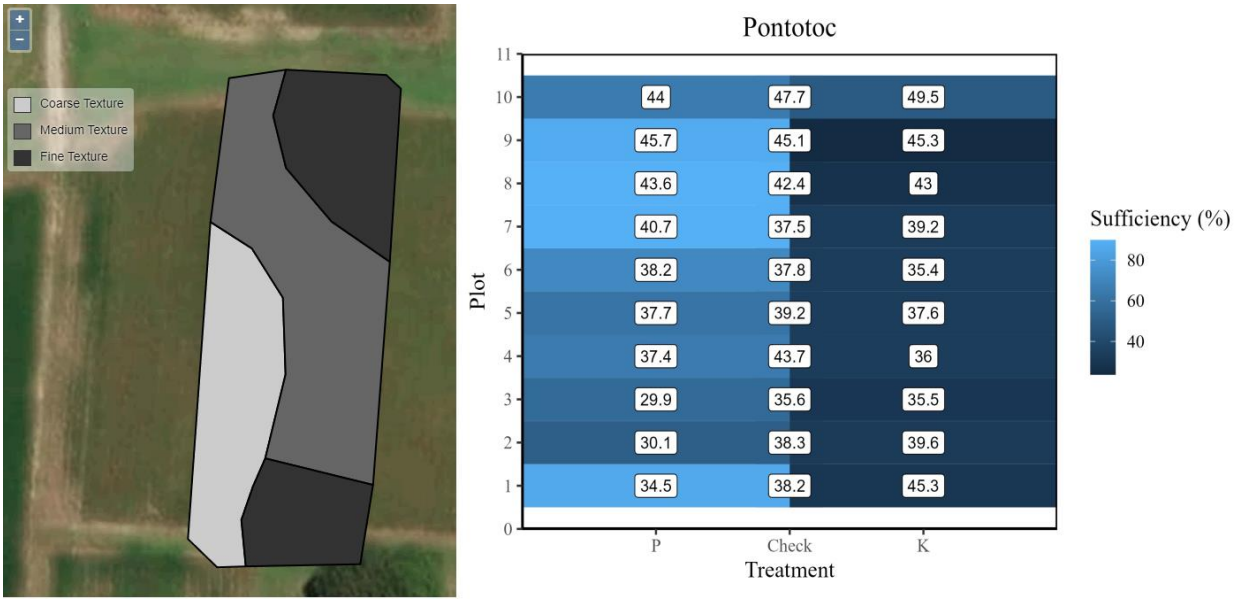

Figure 4 Nutrient response data from Verona location. Shades of blue represent sufficiency levels. Darker shades represent lower sufficiency levels, meaning, lower soil test values, with a higher chance of positively responding to P/K nutrient application. Yields are represented in the white label, in bu/ac. Yield values in red represent a statistical positive response.

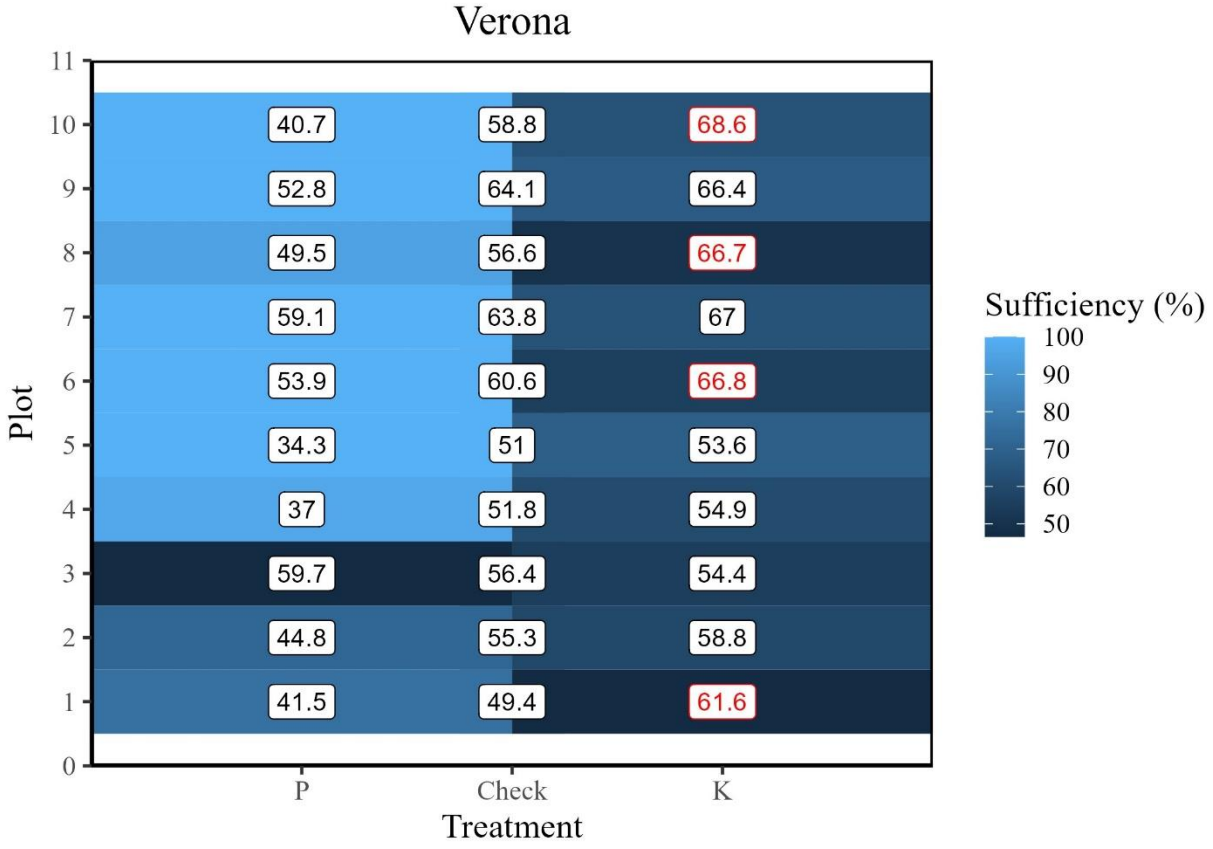

Figure 5 Correlation plot between relative yield and Mehlich 3 Extractable Phosphorus. The horizontal solid line represents a relative yield of 1.0, where the yield of the check plot and the plot receiving nutrients were equal. The dashed vertical line represents the critical value of Mehlich 3 Extractable Phosphorus. Above this point (or nutrient concentration), a fertilizer application will not be recommended.

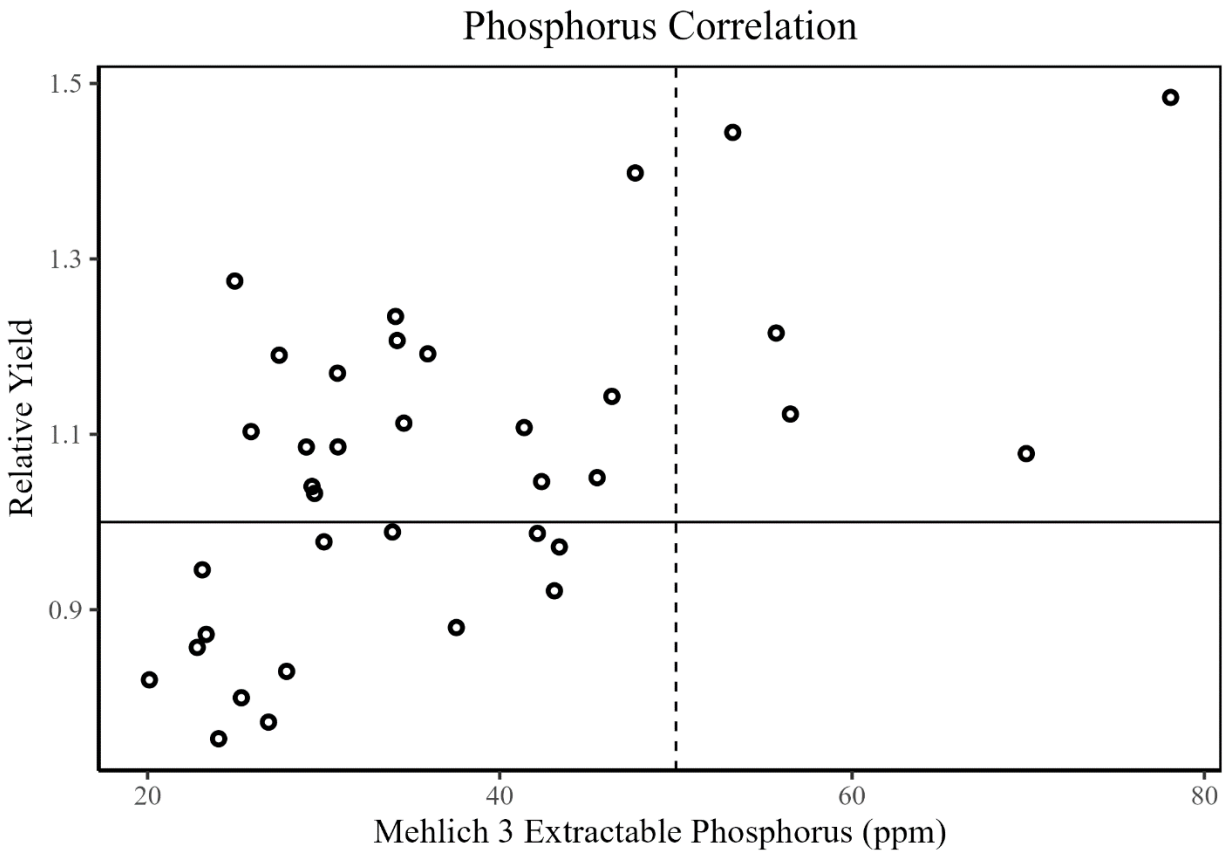

Figure 6 Correlation plot between relative yield and Mehlich 3 Extractable Potassium. The horizontal solid line represents a relative yield of 1.0, where the yield of the check plot and the plot receiving nutrients were equal. The dashed vertical line represents the critical value of Mehlich 3 Extractable Potassium. Above this point (or nutrient concentration), a fertilizer application will not be recommended.