Project Title: Validation of Soil Management Zone Determination for Efficient Corn Production

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## Project Summary (Issue/Response)

This study validated the use of apparent soil conductivity ($EC_a$) to delineate soil management zones leading to directed soil sampling. Soil $EC_a$ is a quick measurement that is influenced by a number of yield- affecting soil properties. The $EC_a$ measurement depends on clay content and type, organic matter content, cation exchange capacity, soil moisture, mineralogy, water content and others. While soil $EC_a$ does not measure any one soil property, it does delineate soil differences within a field and has related to crop yield in some cases. Soil sampling methodology used in precision agriculture generally involves collecting a large number of samples from a grid in the field. This is costly and time consuming. The use of surrogate datasets shown to be related to yield to direct sampling efforts can reduce the number of samples collected while maintaining the integrity of the soil data and, thus, reduce the cost. Management zones were delineated using $EC_a$ on two corn fields located in Bolivar County, MS. Three management zones were constructed by clustering similar $EC_a$ data into distinct areas within each field. Soil samples taken from these management zones were compared for spatial variation in their properties and relation to corn yield from those same zones. In addition, Variable rate P and K fertilization patterns were developed for, and applied to the fields. Yield data was collected by commercially available monitors at time of harvest. Variability of soil data were compared within and across zones to determine if significant differences existed. In addition, soil data within each zone was compared with corn yield to determine if the delineation technique was reflecting the influence of soil fertility on corn yield. Results in the fields were mixed. In Field 1, soil $EC_a$ was related to clay content, elevation and inversely related to corn yield. Previous research suggested plant available water was the most important soil factor influencing yield and the present study appears to support this finding. In Field 2, $EC_a$ was related to Ca, K, Mg, P, and total N. In this field, soil factors clustered similarly to the zones determined by the $EC_a$ measurements. Yield was not related to the $EC_a$ measurements. It would be beneficial to know which soil properties are going to determine whether soil $EC_a$ will be a useful tool in making management decisions.

## Project Results/Outcomes

Soil $EC_a$ data were used to delineate directed soil sampling maps for two fields located in Boliver Co, MS. Soil data were clustered into distinct areas of each field based on Jenks optimization method. This clustering method determines the best arrangement of values into different classes by reducing the variance within classes and maximizing the variance between classes. This clustering resulted in three distinct zones in each field (Fig.1). These zones were then used to direct soil sampling efforts. A minimum of three soil samples and a maximum of seven samples were collected for each zone in each field. This directed sampling reduced the number of samples from 26 (based on a 2.5 Ac grid) to 15 in Field 1 and from 20 to 11 in Field 2. Based on current charges by the MSUES Soil Testing Laboratory, this reduction in sample numbers would save $66 in Field 1 and $45 in Field 2 for routine soil analysis Soil samples were analyzed for MS soil test extractable K, P, Ca, and Mg, lime requirement, pH, and total C and N. Variable rate application maps for P

## Project Results/Outcomes (Continued)

and K were developed from the samples collected in the $EC_a$ determined zones. No lime was required in either field in any year of this study. Phosphorus and K were applied at rates recommended by the MSUES extension service by a commercial applicator. In the Field 1, $EC_a$ was only related to soil texture and elevation. Yield closely matched directed sampling zones determined by soil $EC_a$ (Fig 2.). In this field, higher yielding areas correlated to zones with lower $EC_a$ measurements. These areas also had lower clay contents. Previous research in this field indicated plant available water was the most important soil factor influencing yield. We feel the lower clay contents in these areas resulted in more plant available water. These results seem to verify those findings in that the zones identified by the $EC_a$ are again related to water characteristics of the field. In the Field 2, $EC_a$ was related to Ca, K, Mg, P, and total N. In this field, these soils factors clustered similarly to the zones determined by the $EC_a$ measurements. Yield in this field, however, did not appear to be related to the $EC_a$ measurements. There are several potential reasons for this lack of agreement when compared to the first field. There is much less variability in both texture (clay content) and elevation leading to less variability in plant water availability and consequently, yield. Variability in the $EC_a$ measurements however was quite high indicating some other soil property or properties were dominating the measurement. The mixed results between the two fields call into question the reliability of the $EC_a$ measurement as a standard decision-making tool for the corn producer. In Field 1, the measurement could be used to make accurate management decisions but in Field 2, any conclusions drawn from the measurement could lead to false conclusions and be detrimental to the profitability of the production system. More research is needed to determine which soil factors and/or how they interact determine the $EC_a$ measurement. Once these factors are known, then the effectiveness of using soil $EC_a$ as a decision-making aid can be determined on a field by field basis can be determined.

## Project Impacts/Benefits

This research has shown that soil apparent electrical conductivity can be an aid in management zone delineation where variability in soil texture and elevation occur. This measurement seems to indicate that this method of delineation works well when yield is limited by plant water availability. This research has also indicated that soil electrical conductivity may have limited use in management zone delineation as a general tool, but may be applicable in fields with certain characteristics. For example, apparent electrical conductivity did not delineate management zones well in fields with low variability. However, these fields may not require site-specific crop/soil management. In fields with areas of higher variability, this method of delineation determined soil management zones that related well to corn yield and lowered the soil sampling costs relative to a traditional grid system. Our research has shown that nutrient management alone may not lead to increased yields and that often plant available water content has been of more importance to yield. This study has also shown that directed soil sampling using management zones determined by apparent electrical conductivity can lead to a reduced number of samples while still describing the fertility status and changes within a field. We speculate that apparent electrical conductivity could be more useful to corn producers if the soil factors and/or their interaction in the measurement could be determined prior to use in the field.

## Project Deliverables

Cox, M.S. and P.D. Gerard. 2012. Crop and Soil Management Zone Delineation Based on Soil Property or Yield Classification. *In* E. Lichtfouse (ed.), Sustainable Agriculture Reviews 11, 223-240 Springer. Dordrecht

# Graphics

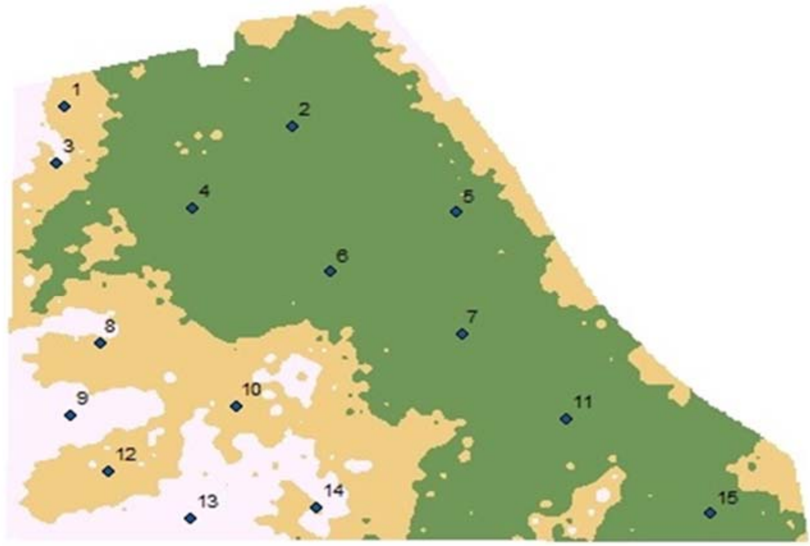


Figure 1. Soil ECa Zones and Soil Sampling Points

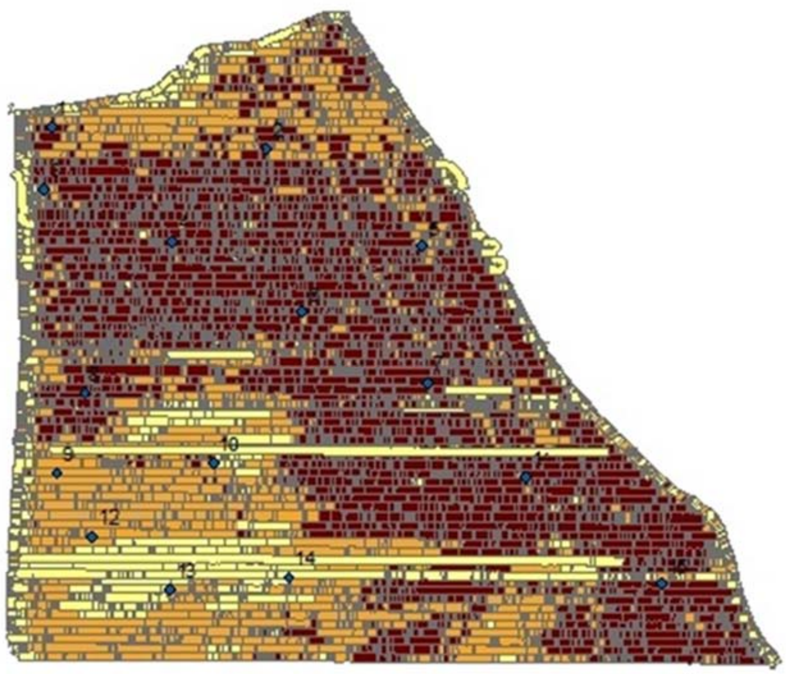


Figure 2. 2012 Corn Yield

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