Carbon, Nitrogen, Phosphorus, and Sulfur Interaction Effect on Soil Biochemical Processes and Corn Grain Yield

Paulo Pagliari, Jeff Strock, Emily Evans, Lee Klossner, Mark Coulter

University of Minnesota, Southwest Research and Outreach Center, Lamberton, MN

Introduction

Over the past few decades increases in crop production, especially corn grain yields, have been mainly a result of genetic improvements and plant population. This can easily be observed in yields of control plots from long-term trials where yields have steadily increased over time even though no fertilizer has been applied to those plots. The advances in technology has allowed the farmer to have a much better view of crop performance throughout a given field by using yield monitor software combined with a GPS system. The use of this technology has shown that even though fertilizer can be applied homogeneously in a field, there will always be areas of high and low yields; this has been termed as field variability. This research was developed to try and understand the nature of this field variability by manipulating C, N, S, and P inputs in a continuous corn rotation. This data set represents the first two samplings from the 2014 season of a 4-year study that was started in 2012 and will be completed in the Fall 2015. In 2014, research efforts focused on enzyme activity as a function of the interactions between C, N and P.

Objectives

1- Investigate the effects of N, S, and P application on soil enzyme activities;

2- Assess the effects of residue management systems (C) on soil enzyme activities;

Materials and Methods

- This experiment was set up as a full factorial design, replicated four times in a completely randomized design. Plot size was 12.2 meters long and 3 meters wide and the rotation was continuous corn. A disk-ripper was used for fall tillage;
- The treatments were: 6 N (urea) rates ranging from 0 to 224 kg N ha^{-1}; 5 P (triple superphosphate) rates ranging from 0 to 112 kg P_2O_5 ha^{-1}; 4 S (K_2SO_4) rates ranging from 0 to 20 kg S ha^{-1}; and residue removed or incorporated. The residue management was considered whole plot and the N, S, and P rates were completely randomized within the whole plot. Fertilizers were applied in the spring and disked in before planting;
- K was applied at the recommended rates to not limit crop yields;
- Soil physical, chemical and biological properties were assessed at three points during the 2014 growing season that coincided with three crop physiological stages (V6, V16, R6);
- Soil samples were collected from 0-15 cm and analyzed for enzyme activity, which included: sulfatase, glycosidase, acid phosphomonoesterase, and FDA (Flourescein Diacetate Hydrolysis);
- All analyses were conducted using four replications and significance was determined using analysis of variance.

Figure 1. Phosphatase Activity

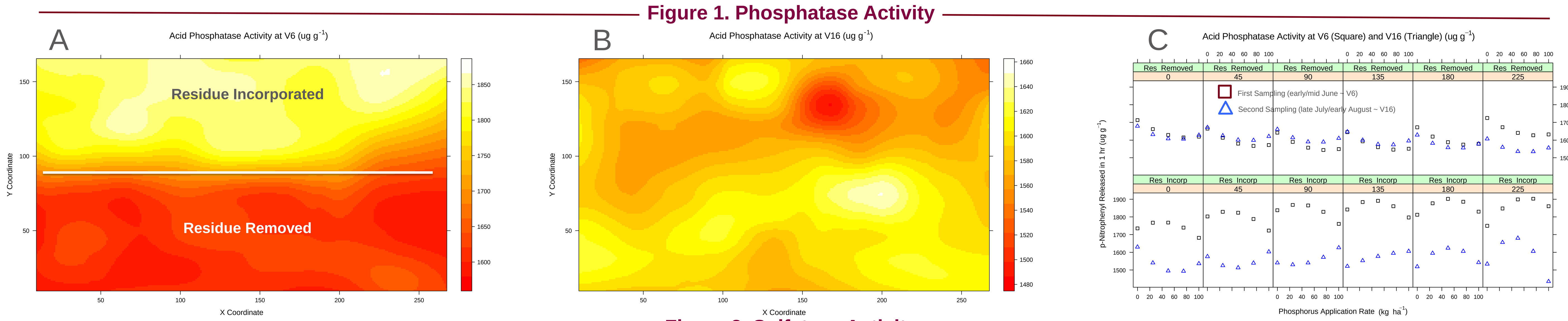


Figure 2. Sulfatase Activity

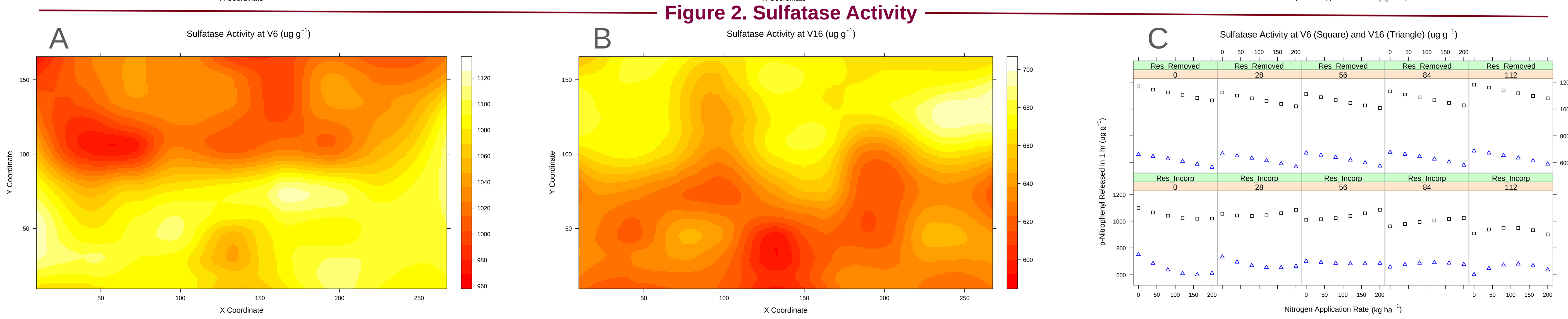
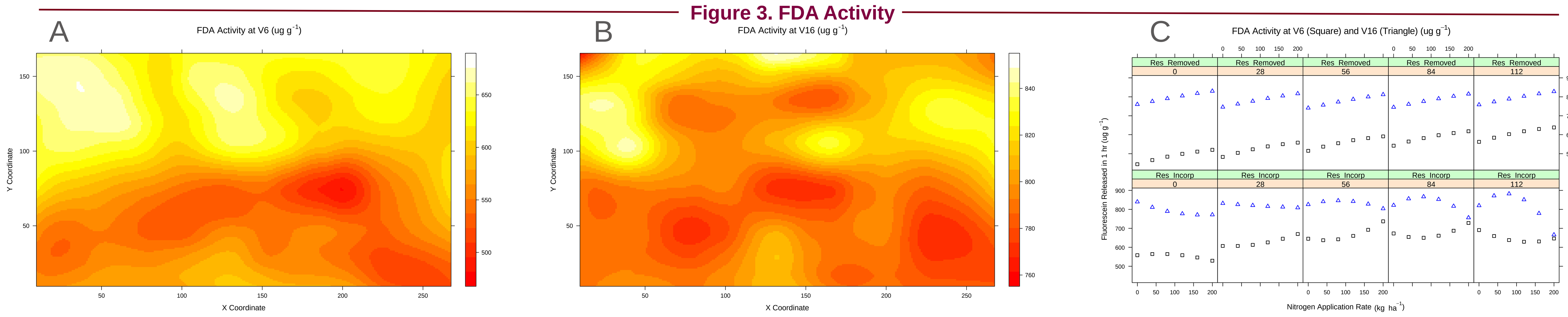


Figure 3. FDA Activity



Results and Discussion

- The results of this study showed that all three nutrients, C, N, and P, had significant effects on activity of the enzymes acid phosphomonoestarase, sulfatase, and FDA, and different results were observed between the two sampling times. Overall, time caused a decrease in phosphomonoestarase and sulfatase and an increase in FDA activity.
- Figures A and B, 1 through 3 show the enzyme activities for the first two sampling dates, at V6 and V16. The effect that residue management had on the enzyme activity is easily seen in Figures A for all three enzymes. The north part of both Figures A and B was where the residue was incorporated, while the south, was the area where the residue was removed;
- The effect of residue could be related to temperature and soil water content. In the residue incorporated plots, soil water content was usually high compared with residue removed plots;
  - As the season progressed and the moisture in the north plots was utilized by the crop, evaporated, and/or leached, the soil in the north plots warmed up and the activity of the enzymes started to shift (Figs 1, 2, 3, A and B). The shift in enzyme activity could be related to a change in the microbial community that was active during each sampling date;
- Figures C 1 through 3 shows the effects of sampling time, and P and N application rate on the enzyme activity;
  - In Fig 1A (x axis is P rate), the plots where residue was removed showed no consistent phosphatase enzyme response to N and little response to P; P tended to lead to lower enzyme activity. In contrast, where the residue was incorporated there was a clear response to C, N and P; the enzyme activity reached a peak as N and P rate reached 160 and 60 kg ha^{-1}. Further addition of either P or N caused a reduction in enzyme activity. The combination of fertilizer N and residue led to the greatest enzyme activity in the first sampling, but the lowest in the second sampling suggesting that no enzyme was needed as a result of inorganic P addition or there was a change in microbial community;
  - The sulfatase activity tended to decrease with increasing N rates (Fig 2C, x axis is N rate), regardless of residue management. However, the response to P rates did depend on residue management. P had no effect on sulfatase activity when residue was removed; however, where residue was incorporated sulfatase activity tended to decrease as P application rate increased.
  - FDA activity (Fig 3C) tended to increase with P application rate for the first sampling only, regardless of residue management. N addition tended to increase FDA activity where residue was removed, and tended to decrease where residue was incorporated.

UNIVERSITY OF MINNESOTA | EXTENSION

Minnesota Corn GROWERS ASSOCIATION