Effect of Nitrogen and Sulfur on the Decomposition of Wheat Residue

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Justification

Corn (*Zea mays L.*), wheat (*Triticum aestivum L.*) and sorghum (*Sorghum bicolor (L.) Moench*) are the major crop residue sources in Kansas. Among them, winter wheat is the main crop cultivated in fall, harvested in summer, and is commonly followed by either another wheat crop or by a spring row crop, often corn. Globally, there are more than 500 million tons of wheat straw produced every year (Zhang et al., 2012). When lackingresidue protection, surface soil is vulnerable to negative environmental influences. In the Western Kansas, wind erosion might be the most significant soil degradation process due to the local climate characteristics. By removing the most fertile layer of soil, lowering water-holding capacity, degrading soil structure, and increasing soil variability, wind erosion can reduce soil productivity significantly at certain areas (Presley and Tatarko 2009). No-till farming is an effective way to control soil erosion when used with crop residue. However, Blanco-Canqui and Lal (2009) stated that indiscriminate removal of crop residue can drastically reduce the erosion benefit from no-till farming. Therefore, crop residue has been largely remained in the field after harvest to lessen the possibility of wind erosion.

On the other hand, particularly after years with abundant precipitation, producers report issues with slow residue decomposition that can have negative effects on establishment of a good plant stand in high residue situations. Dry regions have a climate that is not as conducive to residue decomposition as more humid regions. As a result, some producers resort to tillage, residue removal, or even burning as a means for decreasing residue.

Since the residues of wheat, corn, and sorghum have high carbon (C) to nitrogen (N) ratios, one method that would allow producers to keep residue on the field, while speeding decomposition, is to add N fertilizer. In particular, one hypothesis is that the application of the limiting nutrient N directly to the residue might stimulate microbial activity and subsequent decomposition of the residue. Another theory is that a combination of both N and sulfur (S) fertilizer might be beneficial. However, the rate and timing of optimal application has not been well established in Kansas. Meanwhile, the effects of sulfur fertilizer application on residue decomposition has not been well studied either. Finally, an anecdote prompted the investigation of these fertilizers on the brittleness or friability of wheat straws. Assessing the physical properties of residue can reveal the function of fertilizer on decomposition efficiency.

The objectives of this research are to 1. Evaluate the effect of urea ammonium nitrate (UAN) and ammonium thiosulfate (ATS) application rate on the decomposition of surface residues; 2.

Study the timing of UAN and ATS application and the effects on decomposition of residue; 3. Quantify the effect of UAN and ATS on the shear stress required to cut wheat straws.

Materials and methods

Three experiment locations were identified prior to wheat harvest in 2011 and 2012, respectively. They are located in Hays, Colby, and Garden City, Kansas. The experimental design was a randomized complete block with four replications. The plot dimensions at each site are 10 feet by 40 feet. The plots had UAN applied at rates of 0, 10, 20, 30, and 60 lb N/acre and ATS applied at rates of 0, 15, and 30 lb S/acre with a flat fan spray tip. The UAN and ATS were applied at two different timings to separate plots, making a total of 13 treatments (table 1): the first timing occurred in late summer (approximately 2 months after wheat harvest, in order to avoid the hottest months of the summer) and the second timing took place in February (before temperatures increased to favor microbial decomposition).

Treatment	Product	N rate	S rate	Timing
1	Control			
2	Urea	20	0	Summer
3	Urea	40	0	Summer
4	Urea	60	0	Summer
5	ATS	0	15	Summer
6	ATS	0	30	Summer
7	Urea+ATS	60	30	Summer
8	Urea	20	0	February
9	Urea	40	0	February
10	Urea	60	0	February
11	ATS	0	15	February
12	ATS	0	30	February
13	Urea+ATS	60	30	February

Table 1. Treatment Structure for the Effect of Nitrogen and Sulfur on the Decomposition of Winter Wheat. Units are in pounds per acre.

Residue samples were collected from a 4 ft^2 area from all treatments when corn would commonly be planted (April) and when winter wheat would be planted (September). When winter temperatures decreased and microbial decomposition slowed or stopped, a 4 ft^2 area of residue was clipped at the soil surface from the plots with UAN applied in the fall and the 0 lb N/acre plot again. These residue collections have represented both a winter wheat – corn and a winter wheat – fallow rotation. The residue was sieved to remove any soil material that may have been collected from the field. It was dried and weighed to calculate total surface residue. A subsample was then sent to a commercial laboratory for total N and total carbon analysis.

A double shear using shear box will be applied to test the shear stress required to cut wheat straw. Figure 1 is showing the design of the shear box. The shear box consists of two parallel aluminum plates that create a channel 6 mm apart. Between them, the third plate (blade) can move up and down along the central axis freely. Five holes with diameters that range from 2 mm to 6 mm are drilled on all three plates to accommodate different wheat straw sizes. The shear box is going to be attached to a tension/compression testing machine. The blade plate will moved at 10 mm/min velocity and the applied force will be recorded by a strain-gauge load cell. The shear stress will be calculated as:

$$\tau_s = \frac{F}{2A}$$

Where
τ_s is the shear stress (MPa)
F is the shear force at failure (N)
A is the wheat straw wall area at failure cross-section (mm^2)

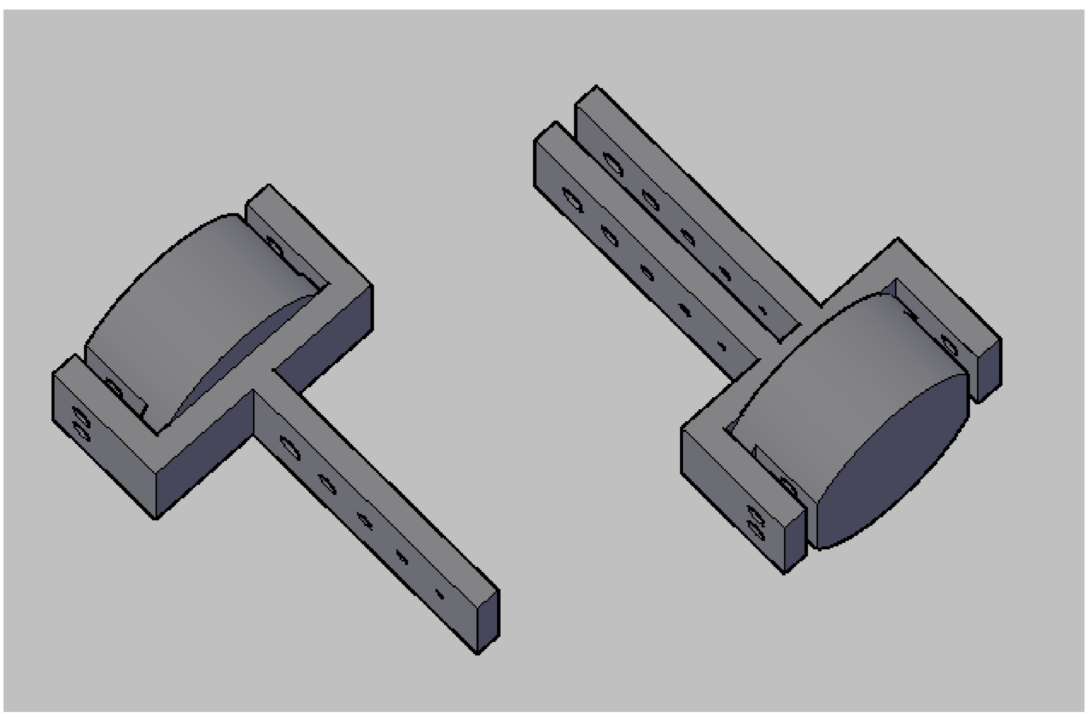

Figure 1. Design of shear box in AutoCAD 2010.

All data were/will be statistically analyzed using SAS 9.2 software and summarized.

Results and Discussion

The results we have summarized thus far are the field residue biomass at three sites in early summer, 2012. Treatments were applied to those plots in 2011 fall and 2012 spring. Figure 2, 3, and 4 are showing the wheat straw biomass left in field in June, 2012 at Hays, Colby and Garden City, respectively.

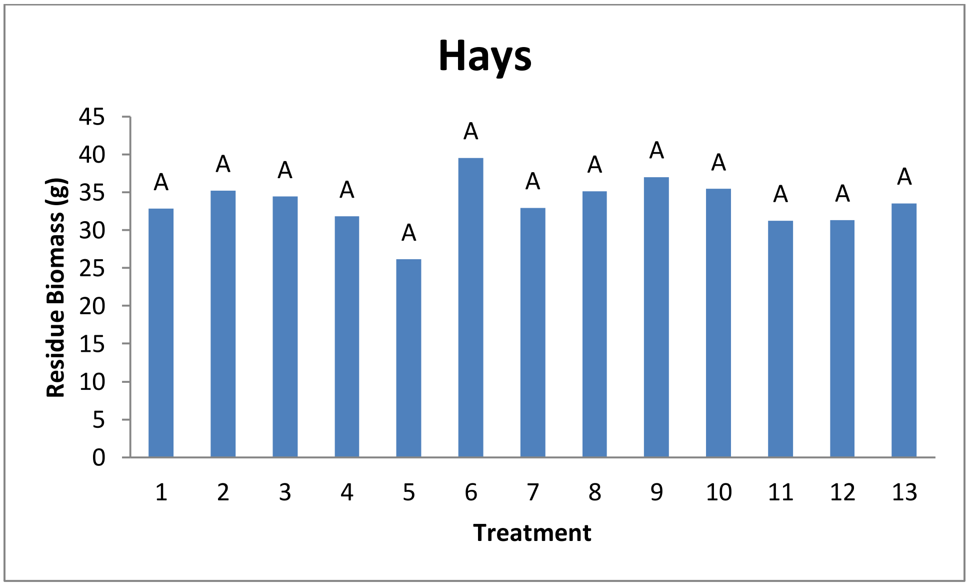

Figure 2. Residue biomass (g) Hays, Kansas (June, 2012). Treatment 1 is the no-fertilizer control. Late summer applied treatments are 2-7 and late winter applications are 8-13.

There is no statistical significance between the different treatments at the Hays location for 2012 (Figure 2). Numerically, the late summer applied treatments have slightly lower residue amounts than the early winter treatments.

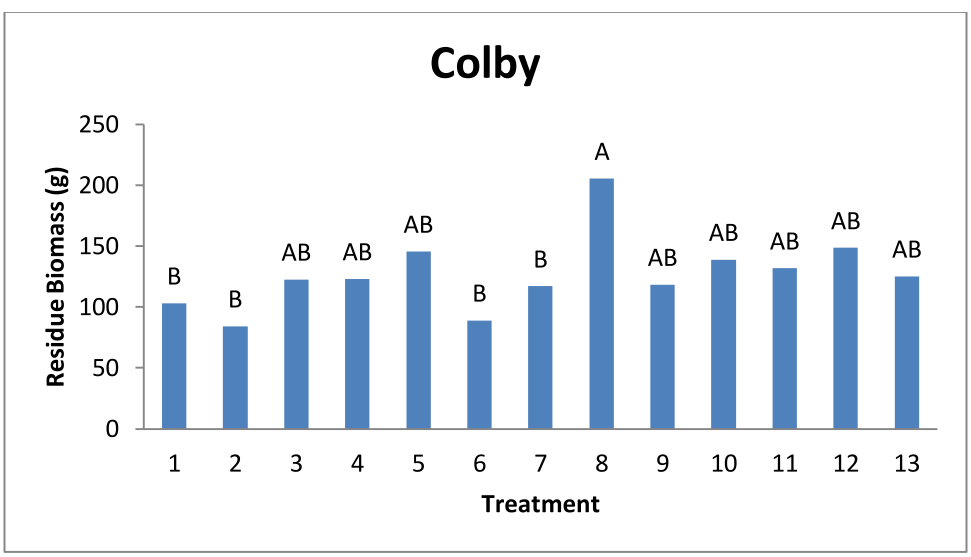

Figure 3. Residue biomass left in field after treatments have been applied at Colby (June, 2012). Treatment 1 is the no-fertilizer control. Late summer applied treatments are 2-7 and late winter applications are 8-13.

At Colby there were some small treatment differences. Similar to Hays, the treatments applied in the late fall have lower biomass than the late winter treatments.

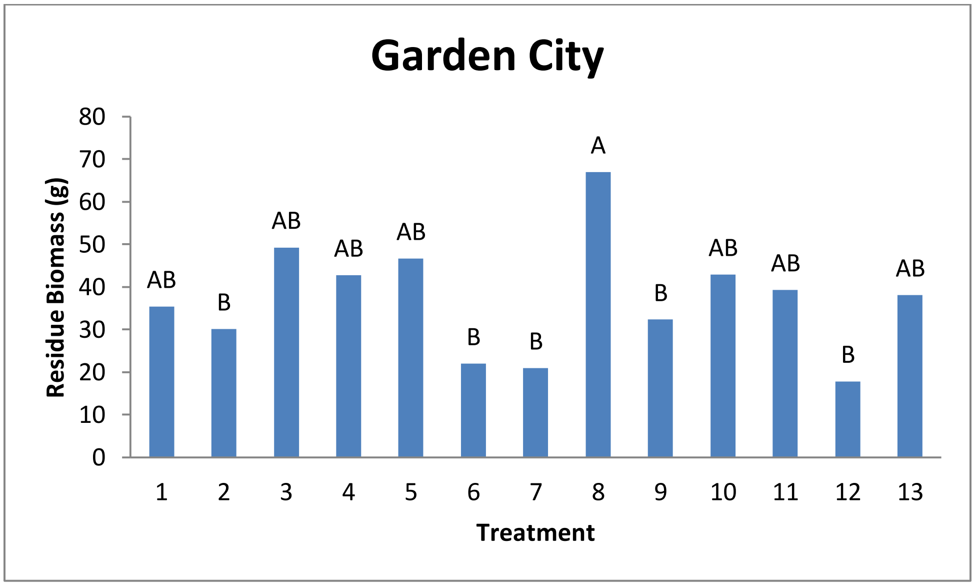

Figure 4. Residue biomass, Garden City, Kansas (June, 2012). Treatment 1 is the no-fertilizer control. Late summer applied treatments are 2-7 and late winter applications are 8-13.

Like the other sites, the late summer treatments were generally lower than the late winter treatments. Treatments 6 and 12 contained

Preliminary Conclusions

These first year data are inconclusive as to the effects of rate and source and so we decline to make any conclusions at this time. We are more confident about the timing in that the first treatments which were put out in late fall generally have lower residue masses versus those plots where fertilizer was applied 3-4 months later in late winter.

Work in progress

1. We submitted residue samples to a commercial testing facility and recently received the data and will perform statistical analyses.

2. Shear stress testing will be conducted in spring 2013 for the straw samples collected in 2012.

3. Residue samples will be collected in all plots in spring 2013 and analyzed for mass, C:N ratio, and shear stress.

References:

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