Effect of Nitrogen and Sulfur Rates and Timing on the Strength and Decomposition of Wheat Residue

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Introduction

Globally, more than 500 million tons of wheat straw are produced every year (Zhang et al., 2012). Leaving residue anchored on the soil surface has many benefits in the Great Plains, the most important of which are protection from erosion from both wind and water. Blanco-Canqui and Lal (2009) stated that the indiscriminate removal of crop residue can drastically reduce the erosion benefit from no-till farming. On the other hand, by having large amounts of crop residue on the field, farmers sometimes report problems with establishing a good plant stand (Fig. 1). 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 as a means for decreasing residue to allow them to get a better stand.

One idea that is discussed among farmers and agronomists is whether or not the addition of N and/or S liquid fertilizers applied as a fine mist to the residue would stimulate microbial activity and subsequent decomposition of the residue. Therefore, we conducted research plot experiment to evaluate wheat straw decomposition under different fertilizer rates and combinations at three locations in western Kansas in 2011 and 2012.

Figure 1. Planting a row crop into heavy wheat residue can cause stand establishment issues

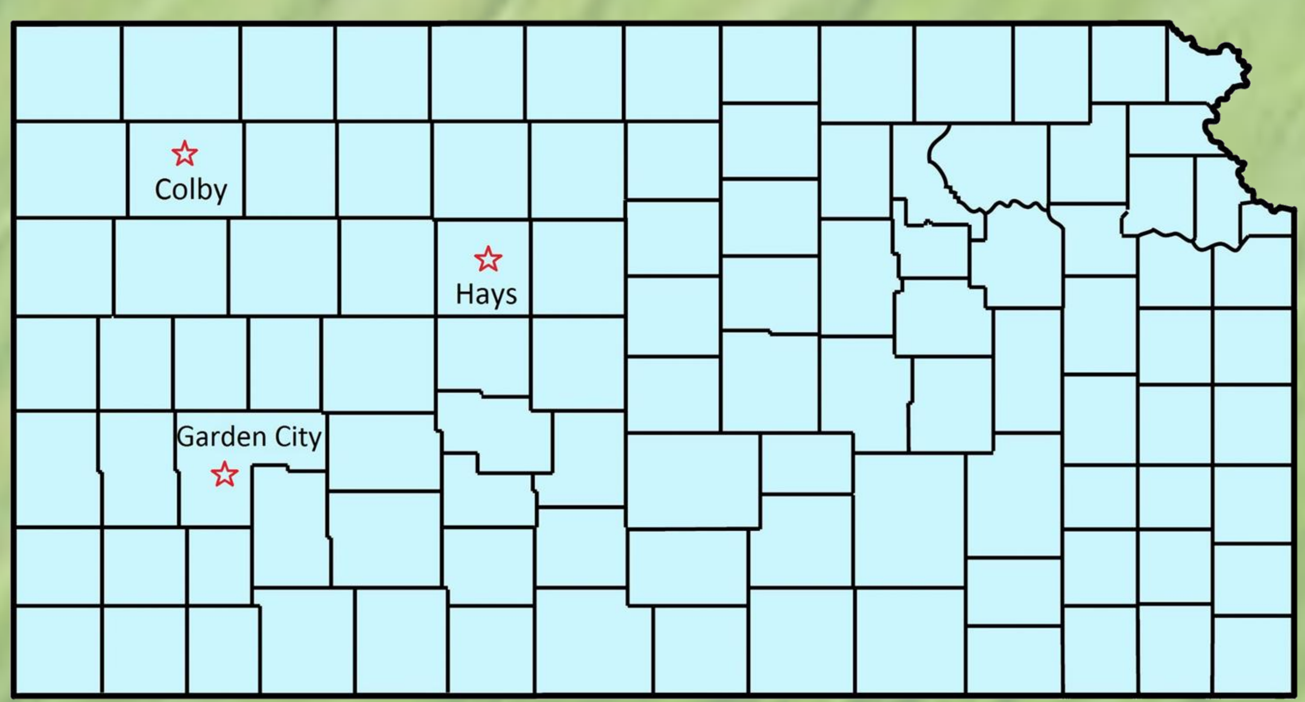
Objectives

- To design an effective and efficient method to measure the cross-sectional area of wheat straw.
- To measure the shear stress of wheat straw sprayed with urea ammonium nitrate (UAN) and/or ammonium thiosulfate (ATS).
- To evaluate the effect of UAN and ATS application rates and timing on the decomposition of wheat straw under field conditions.

Methods and Materials

- Three study sites were identified in western Kansas (Fig. 2). All sites were located on fields that had previously grown wheat and had a large quantity of stubble.
- Thirteen treatments with four replications were arranged in a complete random block design. The plot dimensions were 3 m by 12.2 m.
- UAN and ATS were sprayed onto the wheat stubble at different rates in fall 2011 and spring 2012, respectively. Detailed treatment information is given in Table 1.
- Samplings were conducted at Hays, Colby and Garden City on June 28th, August 22nd, and June 18th 2012, respectively. Wheat straw samples were clipped at soil surface from a 0.19 m^2 area from each plot.
- Straw was oven-dried at 56 °C for 72 hours and then weighed.
- Straw was retained for strength measurements.

Figure 2. Map of Kansas Showing the three Study Locations



- A double shear box was built to test the shear stress required to cut wheat straw. The blade plate moved at 10 mm/min velocity and the applied force was recorded by a strain-gauge load cell (Fig. 3).
- A microscope and camera was utilized to capture images of the cross-sectional area of wheat straw. The images were then analyzed with the software program SigmaScan 5 (Fig. 4).
- The shear stress was then 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 3. Shear box, strain-gauge, load cell, and computer

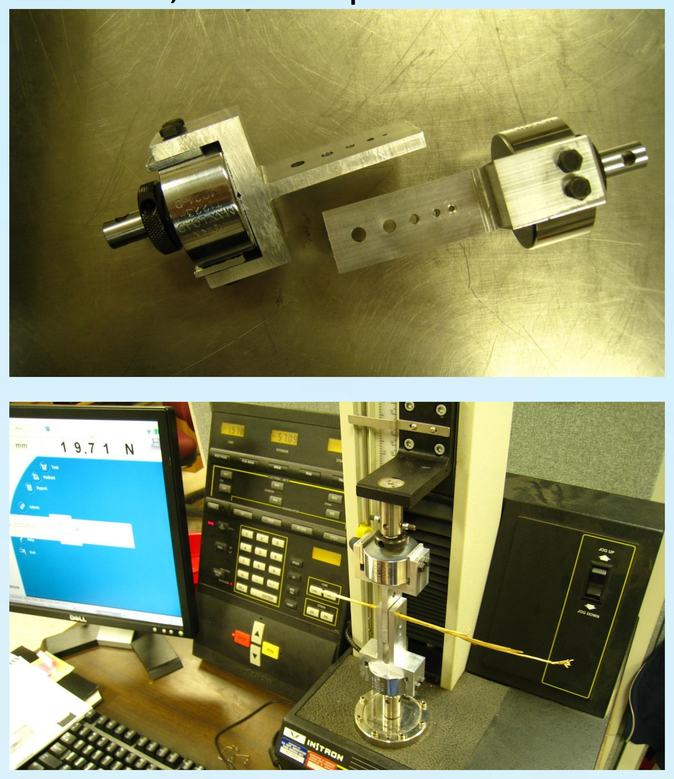
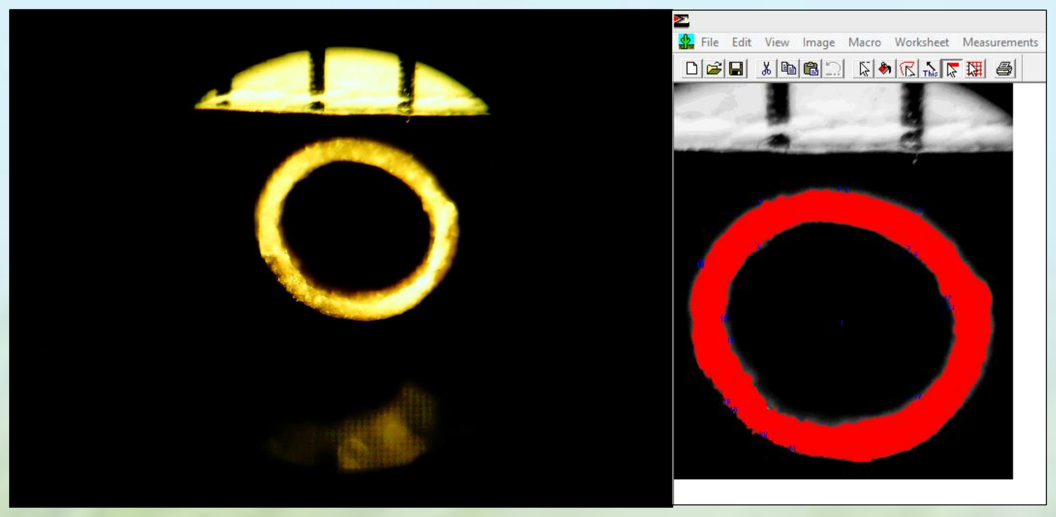


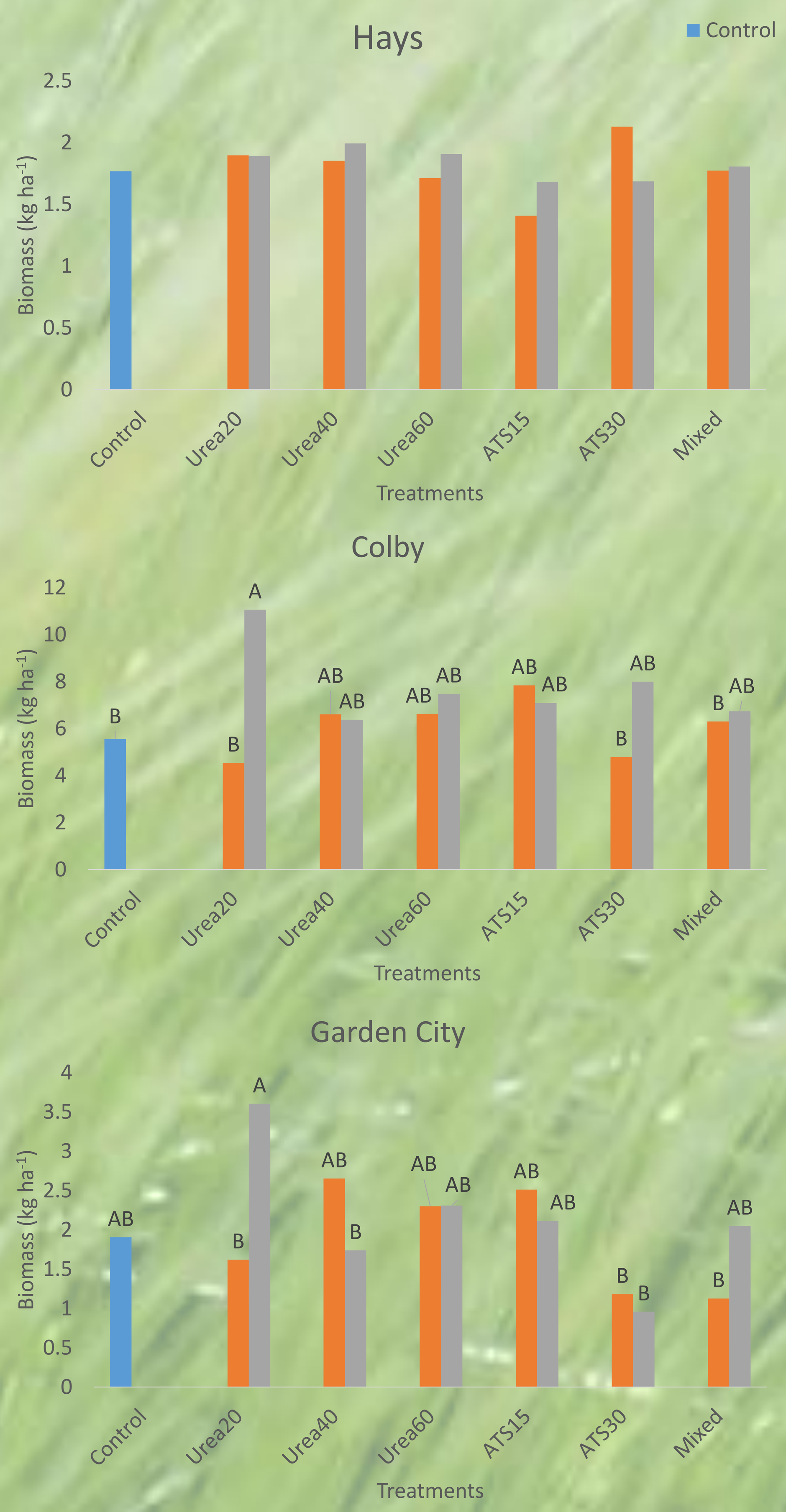
Figure 4. Cross section of straw (left) and image analysis for area of the annulus



- Analysis of variance and means separation was conducted with using the Proc Mixed procedure in SAS 9.3 statistical software.

Results and Discussion

Figure 5. Wheat straw residue biomass

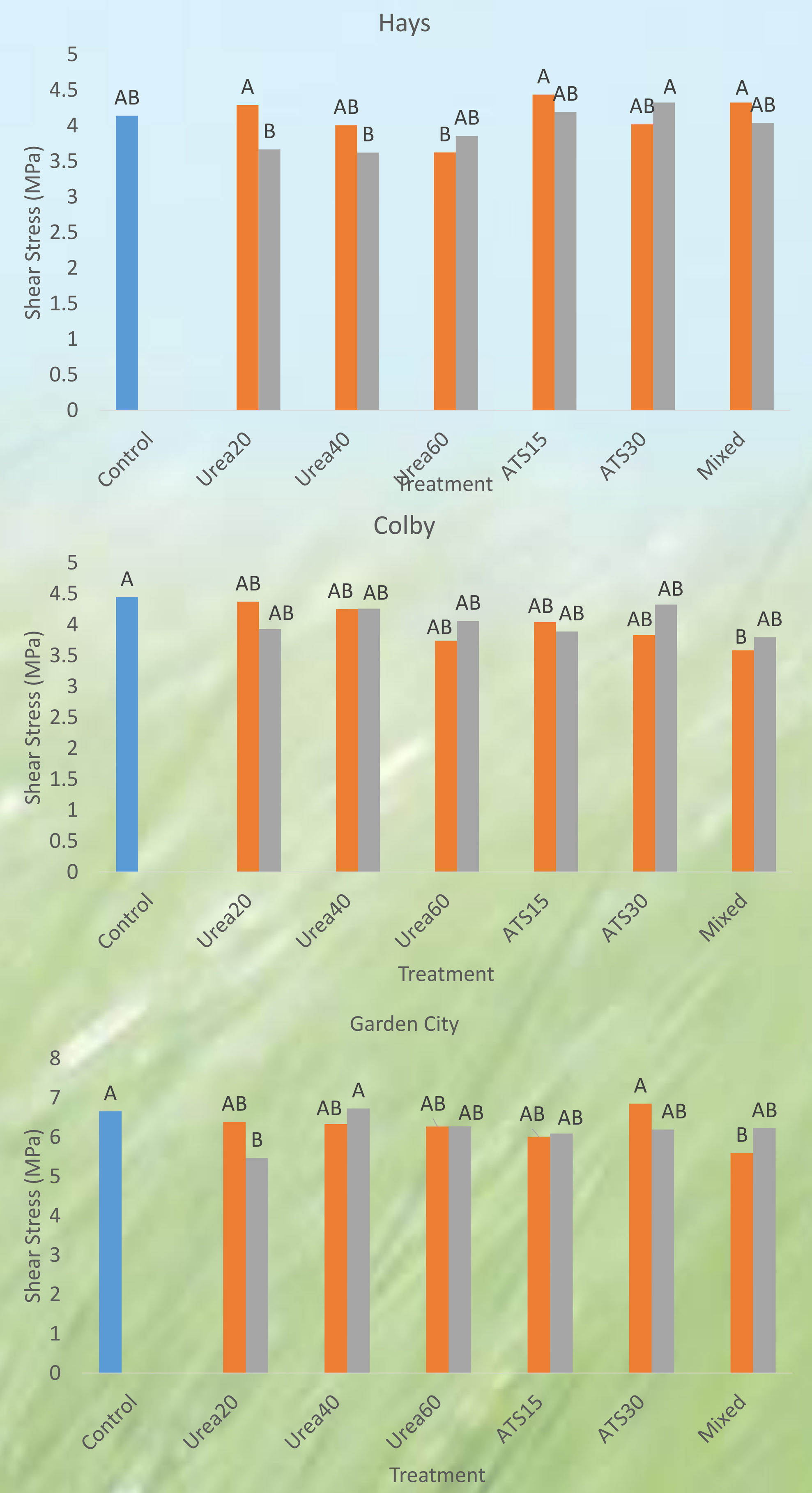


- Hays had the least biomass of the sites.
- There were no treatment effects.
- Colby had the most abundant wheat residue of the sites.
- Relative to the control plots, the fertilizer had no effect on biomass.
- It is unclear why many treatments appear to contain more biomass than the control.
- Garden City was intermediate in residue levels.
- Relative to the control plots, there were no differences between treatments.
- Local weather may have considerable impacts on remaining residue biomass. Wind speeds and directions vary between the sites.
- Effects of treatments and weather could be confounded, in that if the residue was weakened by a particular treatment, it would be more subject to removal.

Table 1. List of treatments, including rate and timing.

	Treatment	N rate (kg/ha)	S rate (kg/ha)	timing
1	Control	0	0	
2	Urea20	11.2	0	Sept. 2011
3	Urea40	22.4	0	Sept. 2011
4	Urea60	33.6	0	Sept. 2011
5	ATS15	7.7	16.8	Sept. 2011
6	ATS30	15.5	33.6	Sept. 2011
7	Mixed	49.1	33.6	Sept. 2011
8	Urea20	11.2	0	Feb. 2012
9	Urea40	22.4	0	Feb. 2012
10	Urea60	33.6	0	Feb. 2012
11	ATS15	7.7	16.8	Feb. 2012
12	ATS30	15.5	33.6	Feb. 2012
13	Mixed	49.1	33.6	Feb. 2012

Figure 6. Wheat straw residue shear stress



- At Hays, none of the treatments differed from the control.
- At both Colby and Garden City, the highest stress was for the control, and was lower for most treatments.
- At both Colby and Garden City, The fall-applied mixture of UAN and ATS had significantly lower shear stress than the control.

Conclusions

- Relative to the control, there were few differences in either biomass remaining, or the shear stress.
- One treatment that had significantly lower shear stress at two sites was the fall-applied mixture of UAN and ATS. This treatment was also among the lowest for the biomass.
- Local weather conditions can impact the sample quality. High variability might have been caused by wind. A future direction for research might be in a greenhouse under more controlled environmental conditions. The greenhouse might not be an adequate substitute for the field, , however, it might aid in determining the effects of the nutrient sources and rates on the decomposition of wheat straw.

References

- Blanco-Canqui, H., and Lal, R. 2009. Crop residue removal impacts on soil productivity and environmental quality. *Critical Reviews in Plant Science*. **28**: 139-163.
- Zhang, Y., Ghally, A. E., and Li B., 2012. Physical properties of wheat straw varieties cultivated under different climatic and soil conditions in three continents. *American Journal of Engineering and Applied Sciences*, **5 (2)**: 98-106

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