

Two Years of Sulfur Fertilization Responses of Mixed Cool-Season Forages

J.M. Hartschuh¹, D.A. Kreager², D.F. Lima³, C.A. Martin⁴

1. OSU Extension Field Specialist, Assistant Professor, hartschuh.11@osu.edu, 1165 Co. Rd. 43, Fremont, Ohio 43420;
 2. OSU Extension Educator, Licking Co., kreager.5@osu.edu, 771 E Main St, Suite 103 Newark Ohio 43055;
 3. OSU Extension Educator, Belmont Co., lima.19@osu.edu, 101 N. Market St., Saint Clairsville, Ohio 43950;
 4. OSU Extension Educator, Muskingum Co., martin.2422@osu.edu, 225 Underwood St., Zanesville Ohio 43701

Background and Significance

Acid rain from coal production historically led to high soil sulfur content in eastern Ohio. Mitigation of the acid rain had led to soil sulfur levels falling below the sufficient level (less than 15 ppm). Large areas of eastern Ohio are used for grazing and forage production. This multiyear (2023, 2025) experiment was conducted to evaluate whether addition of sulfur to deficient eastern Ohio soil would lead to improved quantity or quality of forage.



Sulfur Plot in Muskingum County Ohio, August 2023

Sulfur is...

A secondary macronutrient with average concentration in most plant tissue of approximately 0.15%

Sulfur is essential for...

Nitrogen use efficiency, grain quality, and animal nutrition

Sulfur is needed for...

Protein synthesis-Amino acids, vitamins, Chlorophyll production, and Nitrogen fixation (legumes)

Sulfur is directly available from...

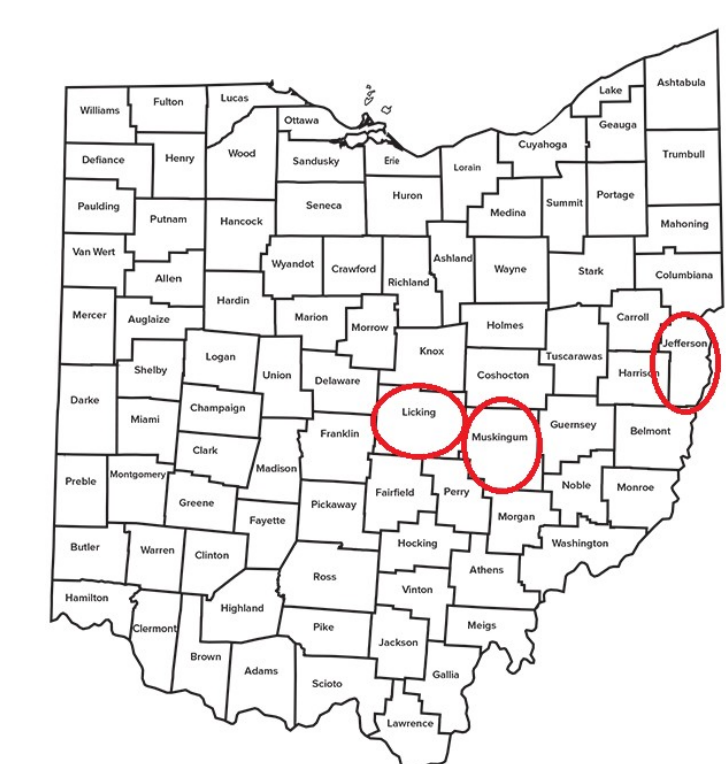
Sulfate forms of nutrients or elemental sulfur after conversion to sulfate over time

Experimental Layout

Three counties in Eastern Ohio were chosen for the study, Jefferson, Licking, and Muskingum Counties. All sites were mixed, cool-season grass fields. Sulfur soil test values confirmed Jefferson at 7.7 & 7.4 ppm in 2023 and 2025 respectively, Licking at 8.6 & 9.8 ppm in 2023 and 2025, respectively. We grouped Jefferson and Licking together because they were *low sulfur* (averaging below 15 ppm). Muskingum was initially analyzed separately and categorized as *high sulfur soil* (averaging above 15 ppm).

Plot sizes were 10' x 45'. All treatments were replicated 3 times in a randomized complete block design at each site for the years 2023 and 2025. **Treatment 1: Control** received no nutrient input.

Treatment 2: Urea received 50 lbs./A of nitrogen. **Treatment 3: Ammonium Sulfate (AMS)** received 50 lbs./A of nitrogen and ~50 lbs./A of Sulfur. Fertilizer/treatment applications were completed late July, at a grass height of approximately 3". The plots were harvested in mid-September and analyzed for dry matter and forage quality.



2'X2' used for harvesting forage in September

Timeline of Experimental Procedure 2023 and 2025

1. Soil test (July)
2. Apply fertilizer (late July)
3. Collect dry matter for each plot and perform forage analysis (early September)

Dry Matter and Forage Analysis

Dry Matter was analyzed using a 2' X 2' square and weighed to determine the fresh forage weight of each plot. Dry matter was calculated by drying 100 g of each sample in a microwave to determine the moisture content. For each site, dry matter readings were averaged by treatment.

Quality Analysis was determined by sub-sampling from each plot by treatment and sending the samples to a forage analysis lab for Near-Infrared Spectroscopy.

Results: Forage Quality Analysis

Table 1. Forage analysis of all sites, years 2023 & 2025:

Location	Treatment	CP%	ADF%	TDN%	Sulfur %
All sites and Years	Control	14.97	31.68	62.52	0.28
	Urea	19.53	29.72	61.92	0.32
	AMS	19.82	29.55	62.72	0.37

Green indicates a significant difference at p < 0.1, Grey indicates trend based on p-value P < 0.25

When examining the effects of both urea and AMS: crude protein (CP) (P<.0004) and acid detergent fiber (ADF) (P<.05) both had significant changes independent of fertilizer types. Total digestible nutrients stayed constant through the treatments and a trend of increased sulfur uptake in the AMS compared to the urea was noted. There was no significant effect of year on forage quality.



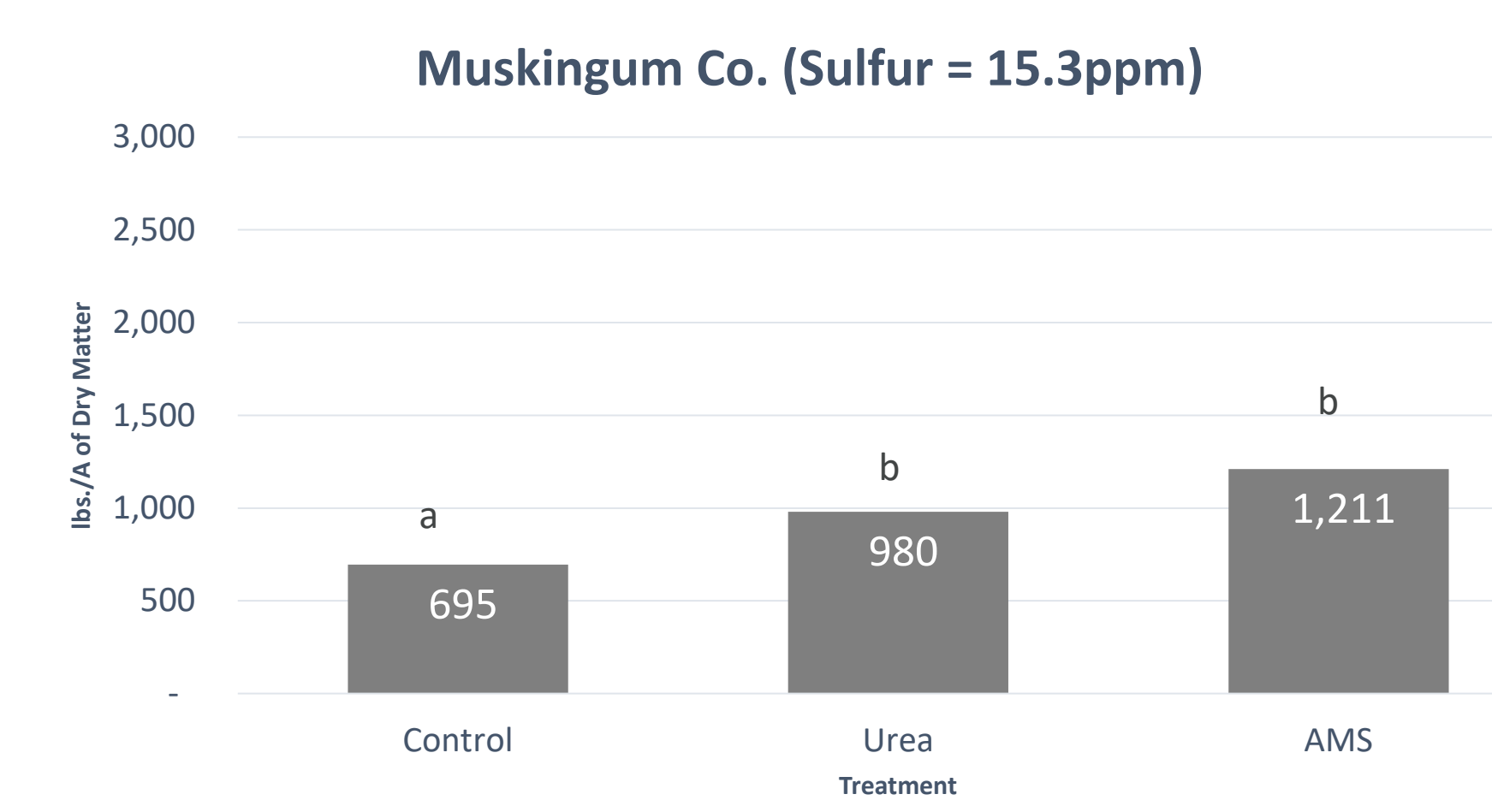
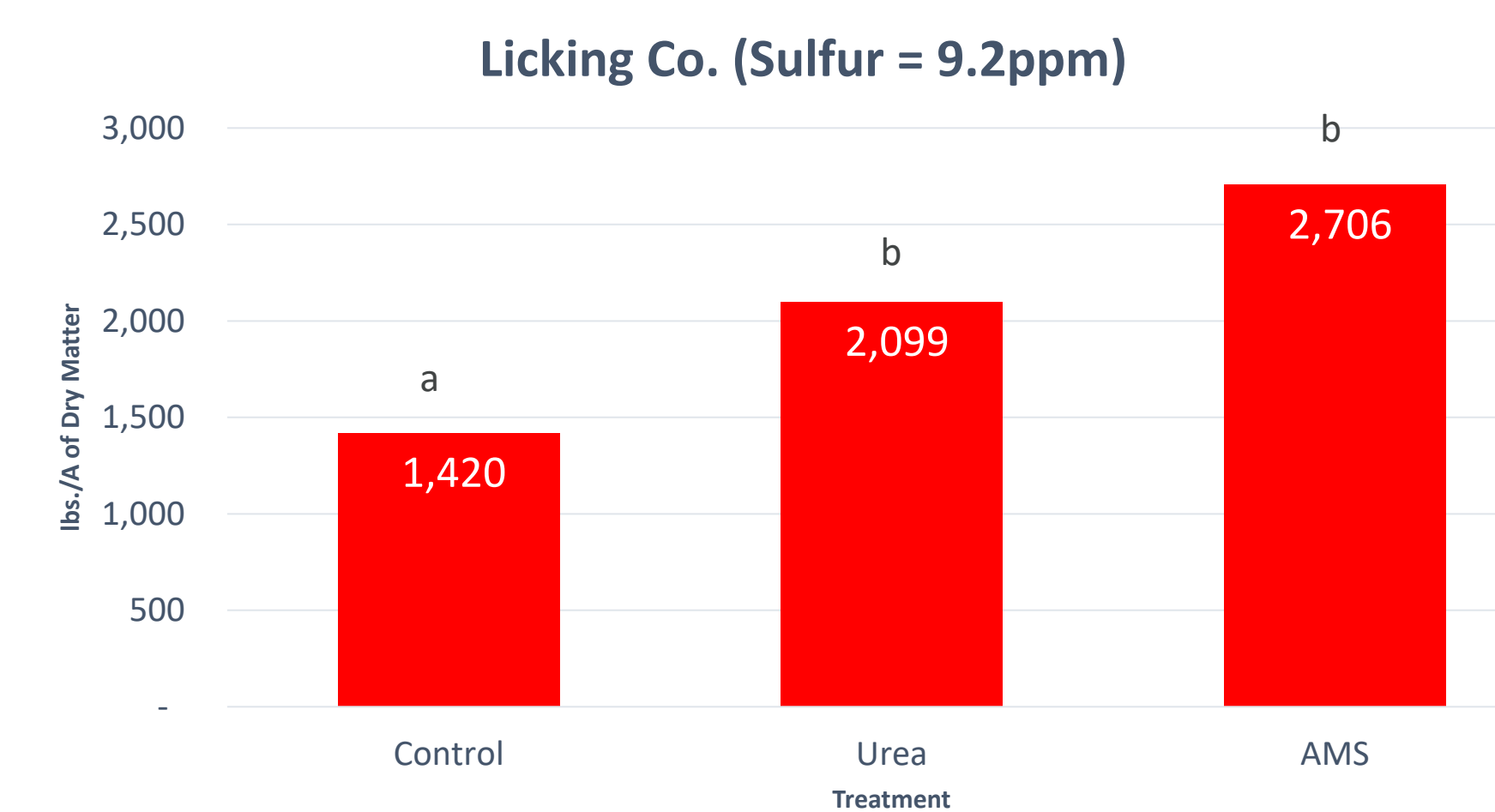
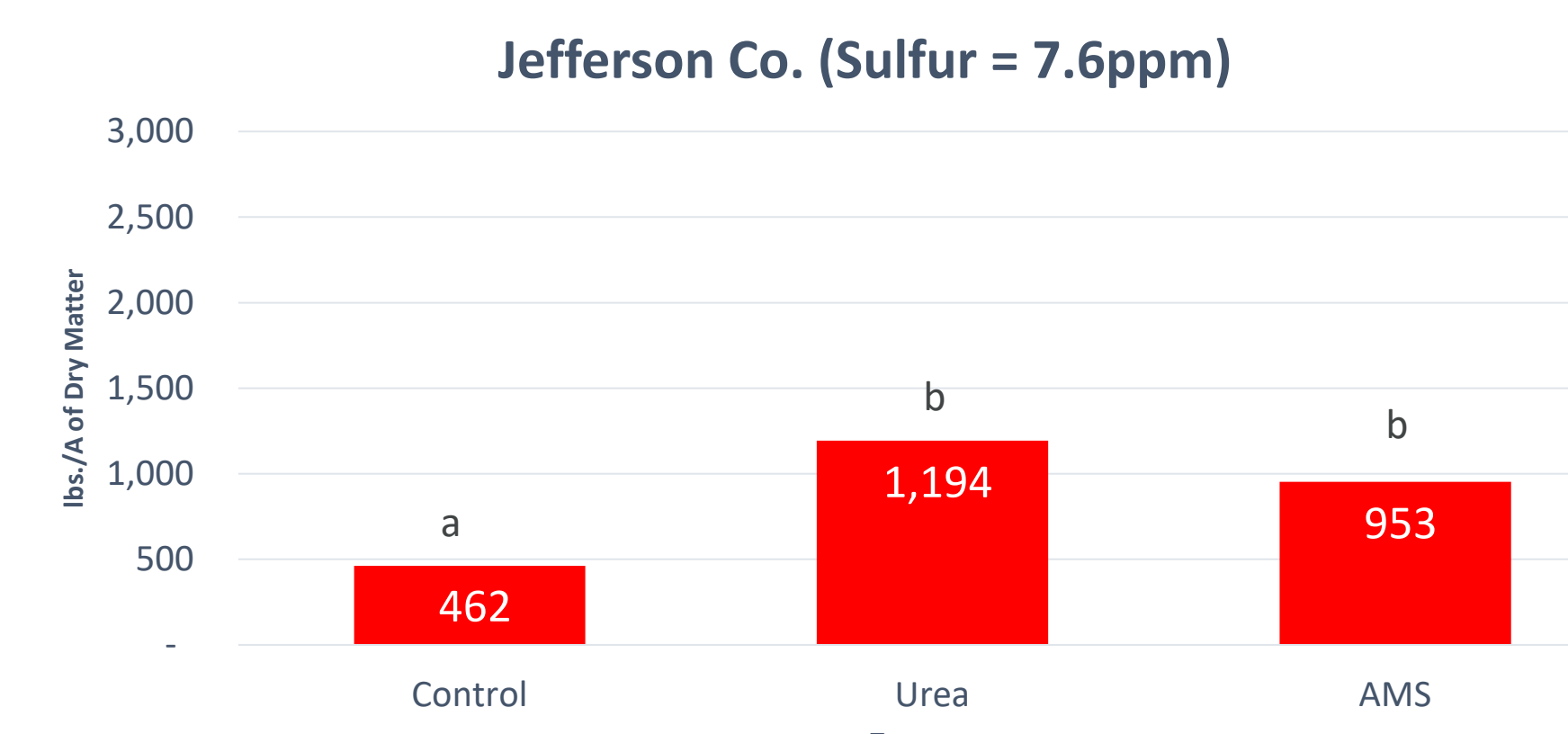
Jefferson County Site



Licking County Site

Results: Pounds of Dry Matter in Sulfur Plots

Red graphs bars indicate soil test low sulfur conditions while grey indicates adequate soil test sulfur conditions.



Dry matter production results for the years 2023 and 2025 were averaged by location. Location and year did not have a significant interaction. Location and treatment were significant.

- There was a nitrogen fertilizer response both years at all locations.
- The response magnitude was different by location.
- There were no significant yield responses to sulfur application by AMS in either the high or low sulfur soil conditions.

Table 2. Relative increase in dry production from fertilizer type

Location	% Increase in Yield Relative to Control	
	Urea: 46-0-0-0 S	AMS: 21-0-0-22 S
Jefferson Co.	159%	107%
Licking Co.	48%	91%
Muskingum Co.	41%	74%

Conclusions and Discussion

Under the conditions experienced over 6 sites and 2 years in this experiment, the addition of sulfur did not improve pounds of dry matter, CP%, ADF%, or TDN% over the addition of nitrogen alone. This study supports the use of nitrogen to increase production. Addition of nitrogen in the form of either urea or AMS led to similar increases in dry matter production over control plots regardless of soil sulfur test designated as low or high in both years 2023 and 2025.



Licking County Site

Both years at the Jefferson location, a rain shower followed shortly after the fertilizer application. This is the only location where urea consistently out-yields AMS. At the Licking location, there was a trend toward higher yields with the AMS application compared with urea. Urea fertilizer has a greater risk of nitrogen loss from volatilization than AMS. Urea can hydrolyze, especially at warm temperatures, high pH, and low moisture, releasing NH₃ gas. The utilization of urease inhibitors can reduce volatilization risks. AMS contains ammonium nitrogen, which is less likely to be subject to volatilization risk.

Future research in the area is still needed to determine if there is any difference when nitrogen rates are increased to the point that no additional nitrogen applications increase yield; these results may change.

Forage quality testing was blocked by location and year to control forage testing costs, rather than testing each replication within a location. There was a significant effect of block (location) in the quality testing. The Licking location had lower CP and higher ADF than the other locations.

As environmental sulfur deposition continues to vary across the country, sulfur fertilization should remain under study. The utilization of urea or AMS and various nitrogen rates can make excellent on-farm research projects, as the history of farm practices on pastures can greatly affect mineral nitrogen release. Multiple forage quality analyses for each treatment at a location may detect increases in crude protein that our trial design was unable to detect.

Special thanks to the Ohio Forage Grasslands Council for supporting this project.