

# Northern NY Agricultural Development Program 2008-2009 Project Report

**Project Title:** Can sulfur addition increase alfalfa yield and quality in Northern New York?

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**Background:** Alfalfa is an important forage crop in Northern New York (perennial, high protein levels, ability to fix N from the air, deep rooting system that allows continued biomass production in dry periods and reduces risk of leaching losses). Over the past decades, S deposition has decreased substantially from 20-25 lbs S/acre in 1984 to currently as low as 5-6 lbs S/acre in some regions, raising questions about the S status of all field crops but especially alfalfa, a crop with high DM yields and S content. Assuming an average tissue S content of 0.25%, a 4 ton/acre harvest (85% DM) removes about 17 lbs S/acre. If we assume 6 lbs S/acre deposition, 11 lbs S/acre is needed from other sources to match crop removal on an annual basis. Soil organic matter (OM) is a source of additional S but on sandy low OM soils, this S supply might not be sufficient. Manure addition could alleviate a potential S deficiency (about 1 lbs S/1,000 gallons) but applications above 4,000 gallons/acre could pose phosphorus (P) accumulation problems and other management challenges including burn and smothering upon heavier manure applications  
(<http://nmsp.cals.cornell.edu/publications/factsheets/factsheet16.pdf>).

Sulfur deficiency can impact not only yields but also protein quality of alfalfa as S is closely associated with nitrogen in the process of protein and enzyme synthesis, and a constituent of amino acids and vitamins. Deficiencies in these amino acids and vitamins can greatly impact milk production, increase the need for imported feed and hence negatively impact farm N, P, and K balances and increase environmental loss.

Coarse-textured soils that are low in OM are most likely to cause S deficiency in high S consuming crops such as alfalfa. A survey S status of alfalfa fields New York was done in 2007 by sampling 2<sup>nd</sup> year alfalfa fields (top 15 cm of the alfalfa stand at the bud to early bloom stage). This included ten NNY sites several of which showed low S levels (less than

0.25%). Within the Northern New York region, St Lawrence, Lewis and Essex counties have a substantial acreage on such soils. The current S status of alfalfa in Northern NY is, however, unknown most importantly because we lack calibrated tools for determining deficiencies in advance of a yield or quality decline. With combined funding from NNYADP and Federal Formula Funds, our objective was to determine S responsiveness of eight sites including four in NNY.

### **Methods:**

On-farm S response trials were conducted on four NNY sites including two farm sites in St Lawrence County, one farm location in Lewis County and one in Essex County (Willsboro Research Farm). Two of the non-NNY sites were located on the Musgrave and Valatie Research Farms in Cayuga County and Columbia County respectively. The other farm sites were in Steuben County and Wayne County. Initial soil test data for these sites can be found in Table 1. The treatments (four replications) include a no-S control and two S sources ( $\text{CaSO}_4$  and  $\text{K}_2\text{SO}_4\cdot\text{MgSO}_4$ ), both added at a rate of 150 lbs S/acre. These treatments are consistent with work in 1981-1983 conducted by Klausner et al. (1984) allowing for direct comparison with this earlier study. These treatments were applied at each site after 1<sup>st</sup> cutting in 2008. No additional S application took place in 2009. Forage quality samples and yield measurements were taken at 2<sup>nd</sup> and 3<sup>rd</sup> cuttings (and 4<sup>th</sup> at the Cayuga site) in 2008 and at all 3 cuttings in 2009. Soil samples (8 inch depth) were taken after 1<sup>st</sup> cutting prior to applying treatments and after 3<sup>rd</sup> cutting in 2008 and in early spring and after 3<sup>rd</sup> cutting in 2009. Samples from the top 6 inches (15 cm) of the alfalfa were taken at 2<sup>nd</sup> cut in both years for tissue S analysis. In spring of 2009, sites were fertilized with P and K according to Cornell nutrient guidelines (Table 2). Precipitation and temperature data can be found in Tables 3 and 4, respectively. Estimates of milk per ton and milk per acre were calculated using Milk2006 (University of Wisconsin).

### **Results:**

Four sites (Essex, St Lawrence #1, Cayuga and Wayne County sites; grey shaded sites in Table 1) showed a significant yield response to S addition in 2008. In 2009 (no additional sulfur applied) only the Cayuga site had significantly higher total yields in the plots that had received sulfur in 2008 while in the Essex County and St. Lawrence County Site #2 trials, S application in 2008 resulted in increased yields for individual cuts in 2009.

All four tested that were responsive to S below 0.24% S at the start of the experiments (Table 2). A fifth site (Columbia County) tested below 0.25% S, but did not respond to sulfur addition. All but the two non-responsive sites in Northern New York (Lewis and St Lawrence 2) showed a significant tissue S increase upon S addition in 2008 and five of eight sites showed significant differences in tissue S in 2009 as well. The Lewis County site had the highest tissue S levels, reflecting a manure application in 2009.

Forage analyses (2008 only) showed very few differences in neutral detergent fiber (NDF), 30 hour neutral detergent fiber digestibility (NDFD, and acid detergent fiber (ADF). Crude protein (CP) increased with S addition for the Essex and Cayuga County sites, both sites responded in yield to S application and showed low S tissue levels in 2008. Neutral detergent fiber bound protein (NDFCP) and starch did not show major changes upon S addition. Milk per ton estimates were not impacted by S addition at any of the locations. Differences in milk per acre were due to yield increases upon S addition.

Table 1: Effect of sulfur (S) application on yield of alfalfa in 2008 and 2009. Sulfur was applied after 1<sup>st</sup> cutting in 2008. No S was applied in 2009

-----DM yield (Tons/acre) -----								
	2008			2009				
Essex County								
Treatment	2 <sup>nd</sup> Cut	3 <sup>rd</sup> Cut	Total	1 <sup>st</sup> Cut	2 <sup>nd</sup> Cut	3 <sup>rd</sup> Cut	Total	
Control	1.00 b	0.37 a	1.37 b	1.62 a	1.05 b	0.48 a	3.15 a	
Plus S	1.37 a	0.35 a	1.72 a	1.91 a	1.19 a	0.44 a	3.54 a	
St. Lawrence County # 1 (2 data points missing)								
Control	1.39 a	0.71 b	2.07 b	1.47 a	0.54 a	0.96 a	2.97 a	
Plus S	1.53 a	0.89 a	2.41 a	1.46 a	0.53 a	1.04 a	3.04 a	
Lewis County								
Control	1.40 a	1.32 a	2.72 a	1.29 a	1.39 a	1.28 a	3.95 a	
Plus S	1.33 a	1.30 a	2.63 a	1.12 a	1.63 a	1.26 a	4.00 a	
St. Lawrence County # 2								
Control	1.59 a	0.91 a	2.50 a	1.33 a	0.85 a	1.03 b	3.21 a	
Plus S	1.51 a	1.04 a	2.55 a	1.43 a	0.92 a	1.14 a	3.49 a	
Cayuga County								
Treatment	2 <sup>nd</sup> Cut	3 <sup>rd</sup> Cut	4 <sup>th</sup> Cut	Total	1 <sup>st</sup> Cut	2 <sup>nd</sup> Cut	3 <sup>rd</sup> Cut	Total
Control	1.77 a	1.56 a	0.46 b	3.79 b	3.36 a	1.41 b	0.91 b	5.68 b
Plus S	2.02 a	1.77 a	0.64 a	4.44 a	3.53 a	2.06 a	1.49 a	7.08 a
Columbia County								
Control	2.34 a	0.68 a	3.02 a	2.05 a	1.38 a	1.01 a	4.44 a	
Plus S	2.13 a	0.73 a	2.86 a	2.08 a	1.43 a	1.08 a	4.44 a	
Steuben County								
Control	1.49 a	0.79 a	2.29 a	0.62 a	0.67 a	0.50 a	1.80 a	
Plus S	1.66 a	0.77 a	2.44 a	0.64 a	0.67 a	0.46 a	1.76 a	
Wayne County								
Control	2.02 a	0.66 b	2.67 b	1.94 a	0.33 a	.	2.26 a	
Plus S	2.19 a	0.78 a	2.97 a	1.83 a	0.31 a	.	2.14 a	

\*Average values with different letters (a,b,c) are statistically different ( $\alpha = 0.05$ ).

Table 2: Effect of sulfur (S) application alfalfa tissue S levels as measured in top 6 inches. Sulfur was applied after 1<sup>st</sup> cutting in 2008. No S was applied in 2009.

S content of (% in top 6 inches)								
2008								
	Essex	St Law 1	Lewis	St Law 2	Cayuga	Columbia	Steuben	Wayne
Control	0.16 b	0.24 b	0.29 a	0.30 a	0.20 b	0.20 b	0.28 b	0.22 b
Plus S	0.29 a	0.35 a	0.32 a	0.35 a	0.26 a	0.28 a	0.43 a	0.35 a
2009								
Control	0.10 a	0.13 b	0.24 a	0.20 b	0.12 b	0.18 a	0.16 b	0.14 b
Plus S	0.11 a	0.17 a	0.22 a	0.22 a	0.21 a	0.20 a	0.23 a	0.20 a

†Average values with different letters (a,b,c) are statistically different ( $\alpha = 0.05$ ).

Soil test data explained much of the response seen in the yield and tissue S data. The two non-responsive sites in Northern New York showed soil test S levels above 15 lbs/acre S at the first sampling in 2008. Four sites with soil test S levels below 15 lbs/acre at the start of the experiments were responsive to S, indicating S deficiency. The remaining two sites in Columbia and Steuben County had low soil test S levels but at these two sites, the soil pH was around 6, suboptimal for alfalfa production and explaining a lack of a response to S addition.

Table 3: Soil SrCl<sub>2</sub> extractable sulfur (S) levels over 4 sampling rounds as impacted by sulfur application using two sulfur sources. Sulfur was applied after 1<sup>st</sup> cutting in 2008.

----- S (lbs/acre) -----																
Treatment	2008				2009				2008				2009			
	Initial		3 <sup>rd</sup> Cut		Spring		3 <sup>rd</sup> Cut		Initial		3 <sup>rd</sup> Cut		Spring		3 <sup>rd</sup> Cut	
	Essex County								Cayuga County							
Control	6	a	6	b	5	b	6	a	11	a	9	b	11	a	13	a
CaSO <sub>4</sub>	9	a	14	a	8	a	8	a	10	a	49	a	13	a	12	a
K <sub>2</sub> Mg <sub>2</sub> (SO <sub>4</sub> ) <sub>3</sub>	7	a	7	b	5	b	6	a	11	a	57	a	13	a	16	a
	St. Lawrence County # 1								Columbia County (low pH)							
Control	9	a	8	a	5	a	5	a	10	a	8	c	6	a	8	b
CaSO <sub>4</sub>	8	a	29	a	11	a	7	a	9	b	21	a	7	a	10	a
K <sub>2</sub> Mg <sub>2</sub> (SO <sub>4</sub> ) <sub>3</sub>	9	a	27	a	11	ab	7	a	9	b	15	b	6	a	9	ab
	Lewis County								Steuben County (low pH)							
Control	43	a	37	b	18	a	42	a	10	a	9	b	6	a	12	b
CaSO <sub>4</sub>	54	a	131	a	19	a	43	a	11	a	112	a	14	a	21	a
K <sub>2</sub> Mg <sub>2</sub> (SO <sub>4</sub> ) <sub>3</sub>	48	a	112	a	18	a	37	a	12	a	43	ab	14	a	17	ab
	St. Lawrence County # 2								Wayne County							
Control	19	a	10	b	10	b	12	a	11	a	11	b	9	a	12	b
CaSO <sub>4</sub>	19	a	76	a	17	a	11	a	12	a	98	a	16	a	15	a
K <sub>2</sub> Mg <sub>2</sub> (SO <sub>4</sub> ) <sub>3</sub>	18	a	48	a	13	ab	10	a	11	a	29	ab	20	a	15	a

† Average values with different letters (a,b,c) are statistically different ( $\alpha = 0.05$ ).

The results also indicate that there is limited carryover of S applied in 2008 into the 2009 growing season, indicating that repeated annual applications may be needed for low S sites (as opposed to the application of larger amounts once in 2-3 years). Sulfur levels increased in 2009 at the Lewis County site due to application of 5,000 gallons of manure. The results of this site suggest that fields that receive manure will not be S deficient.

### Conclusions/Outcomes/Impacts:

The results of this study suggest:

- (1) There is a potential for a yield response upon S addition to alfalfa in New York.
- (2) Manured fields are not likely to be S responsive; light textured soils low in organic matter are most likely to show a sulfur deficiency.
- (3) Tissue testing (top 6 inches at 3<sup>rd</sup> cutting) is effective in identifying S deficient sites; tissues tests <0.25% S indicate the potential for a response to S addition.
- (4) Additional research is needed but the 2008-2009 research suggests that soil testing can be used to determine the likeliness of a yield or tissue S response to S addition; soil samples should be taken at greenup or after 1<sup>st</sup> cutting (0-8 inch depth) and analyzed for 0.01 M CaCl<sub>2</sub> extractable S. Soil test >15 lbs/acre indicates no lack of S while <20 lbs/acre indicates the probability of a response to S addition.

### Outreach:







The project was discussed at winter meetings and field crop retreats in 2009 and will be presented in 2010 winter meetings. We are working on journal articles on the soil testing and field trial components of the project, to be submitted in early 2010, once the 2009 yield quality analyses have been received. A “What’s Cropping Up?” extension article on the work will be published in March/April of 2010.

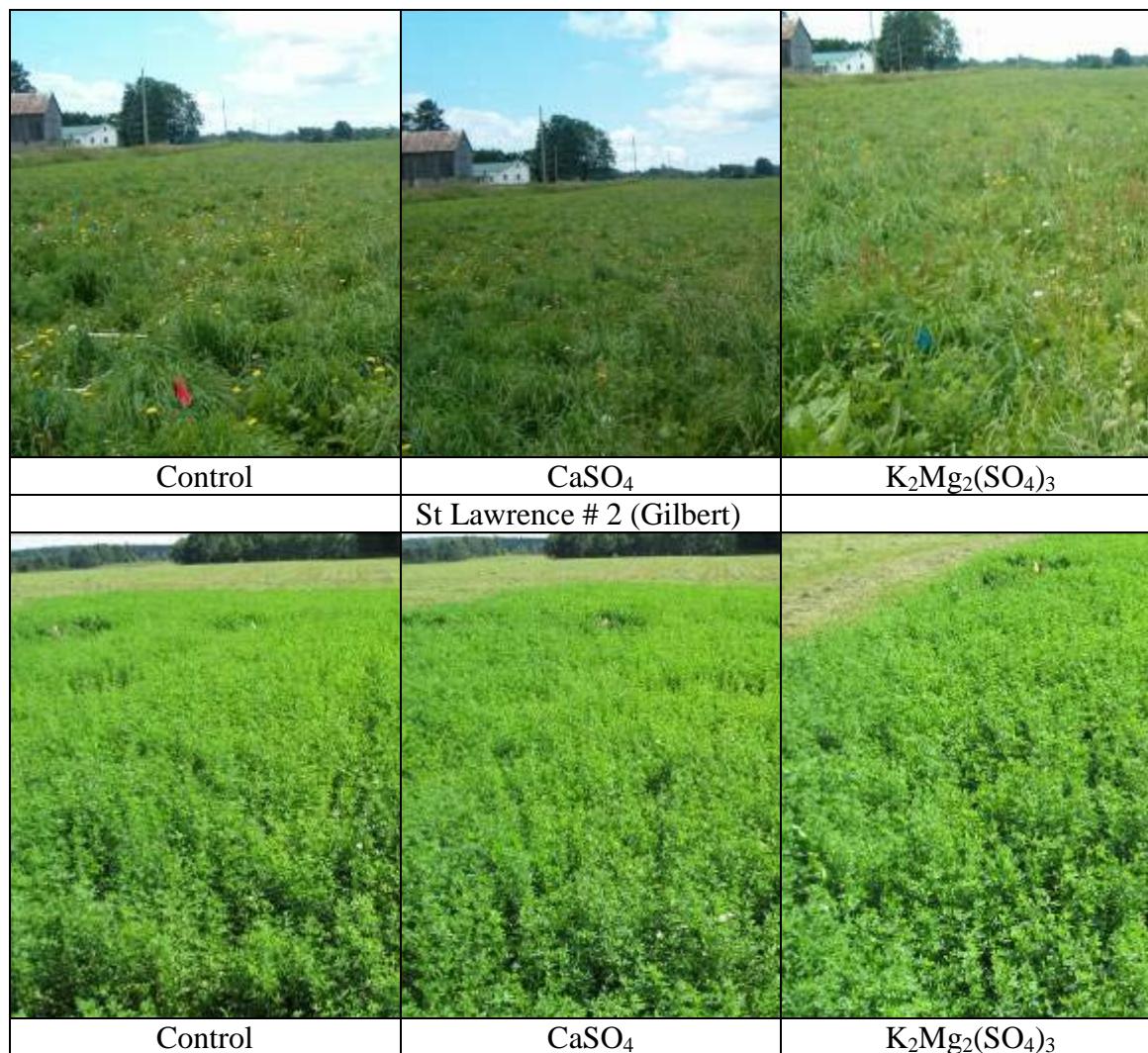
**Next steps if results suggest continued work is needed in the areas of research, demonstration and/or education.**

In 2010, with federal formula funds, we plan to focus on the effects of S addition on forage quality (protein profiles) and testing of fields with manure or compost history. a should be done.

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**Photos**

Essex County (Willsboro) 3 <sup>rd</sup> Cutting		
		
Control	CaSO <sub>4</sub>	K <sub>2</sub> Mg <sub>2</sub> (SO <sub>4</sub> ) <sub>3</sub>
St Lawrence #1 (Cook)		
		
Control	CaSO <sub>4</sub>	K <sub>2</sub> Mg <sub>2</sub> (SO <sub>4</sub> ) <sub>3</sub>
	Lewis County (Hanno)	



**Reports and/or articles in which the results of this project have already been published.**

The initial results of the soil testing component were presented at the Northeastern Branch of ASA/SSSA/CSSA and national ASA/SSSA/CSSA meetings in 2009. They were shared with the extension educators during retreats and other extension meetings. A sulfur factsheet was developed (<http://nmsp.cals.cornell.edu>) and extension summaries of the field trials will be available shortly (waiting for final laboratory results).

**Person(s) to contact for more information:**

For more information, contact Quirine Ketterings, Nutrient Management Spear Program, 323 Morrison Hall, Department of Animal Science, Cornell University ([qmk2@cornell.edu](mailto:qmk2@cornell.edu) or 607 255 3061).