Improving Alfalfa Production in Wisconsin with Sulfur and Potassium Fertilizer

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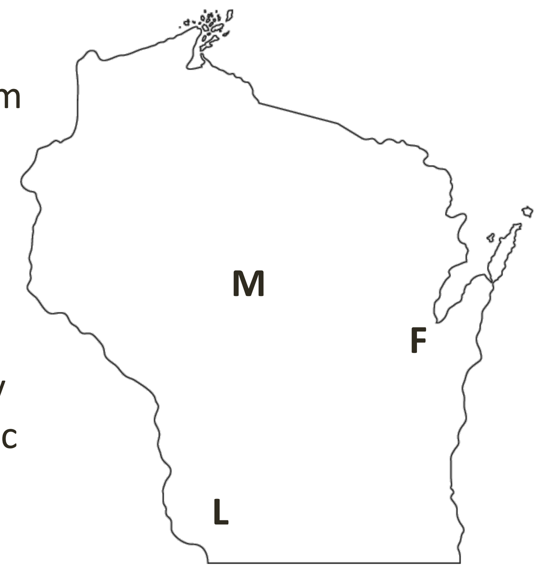
Justification and Objectives

Justification:
The stand longevity and quality of alfalfa are an essential components of Wisconsin's dairy rotations. A recent increase in the number of reports of yellow and/or stunted alfalfa stands indicate potassium (K) and/or sulfur (S) deficiencies may be occurring to a greater extent compared with previous years.

Objectives:
Determine the effect of:
1. S fertilizer rate, timing, and form on alfalfa and milk yield
2. Recommended or no K fertilization on alfalfa and milk yield
3. S and K fertilization on soil test levels in the soil profile

Materials and Methods

Locations:
- Lancaster (L), Dubuque silt loam (Fine-silty, mixed, superactive, mesic Typic Hapludalfs)
- Marshfield (M), Loyal silt loam (Fine-silty, mixed, superactive, frigid Oxyaquic Glossudalfs)
- Freedom (F), Manawa silty clay loam (Fine, mixed, active, mesic Aquollic Hapludalfs)



Treatments:
- Two rates of K (0 or 269 kg K_2O ha^{-1}) were split applied after the first and third cuts, annually
- Each K rate had four S treatments
  - 0 kg S ha^{-1}
  - 84 kg S ha^{-1} as elemental S applied in 2011 only
  - 28 kg S ha^{-1} as gypsum applied annually in spring at green-up
  - 84 kg S ha^{-1} as gypsum applied annually in spring at green-up
- All treatments were applied initially after first cutting (mid-July to August depending on location) in 2011; then according to treatment schedule above
- Four replications in a randomized complete block design
- Plot size: 0.91 or 1.2 m by 7.9 or 8.2 m (depending on location)

Soil Sampling:
- Soil samples were taken in each plot at 0 to 0.15, 0.15 to 0.30, 0.30 to 0.60, and 0.60 to 0.90 m
  - Prior to treatment application in 2011
  - In spring 2014

Alfalfa Harvest:
- Harvested using a flail chopper equipped with a load cell when the crop was at or near first flower
- 2011: one post-treatment harvest at Lancaster; no post-treatment harvest at other locations
- 2012 and 2013: harvested 4 times per season

Alfalfa Sampling:
- Sub-samples in each plot collected to determine:
  - Moisture
  - Whole plant analysis for nutrient composition (all cuttings) and NIR forage quality (2013 cuttings only)
  - Alfalfa nutrient removal was calculated as follows: (dry matter yield) x (K or S concentration)
  - Milk per Mg forage was determined using NIR forage quality analysis and the MILK alfalfa worksheet (Shaver et al., 2000), and was then converted to milk ha^{-1} using forage yield.

Results

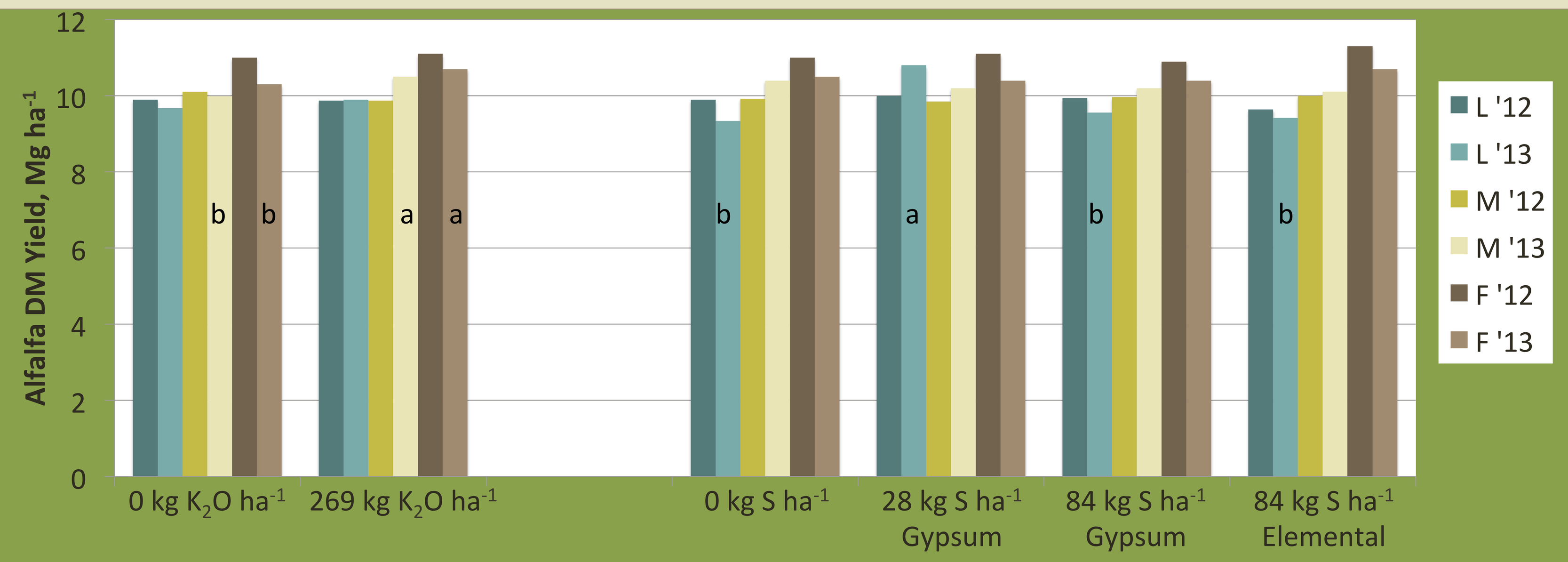


Figure 1. Potassium and sulfur fertilizer treatment effects on cumulative alfalfa dry matter (DM) yield at Lancaster, Marshfield, and Freedom in 2012 and 2013. Means with different letters indicate significant (α = 0.10) differences between K or S fertilizer treatment rates for a given location and year.

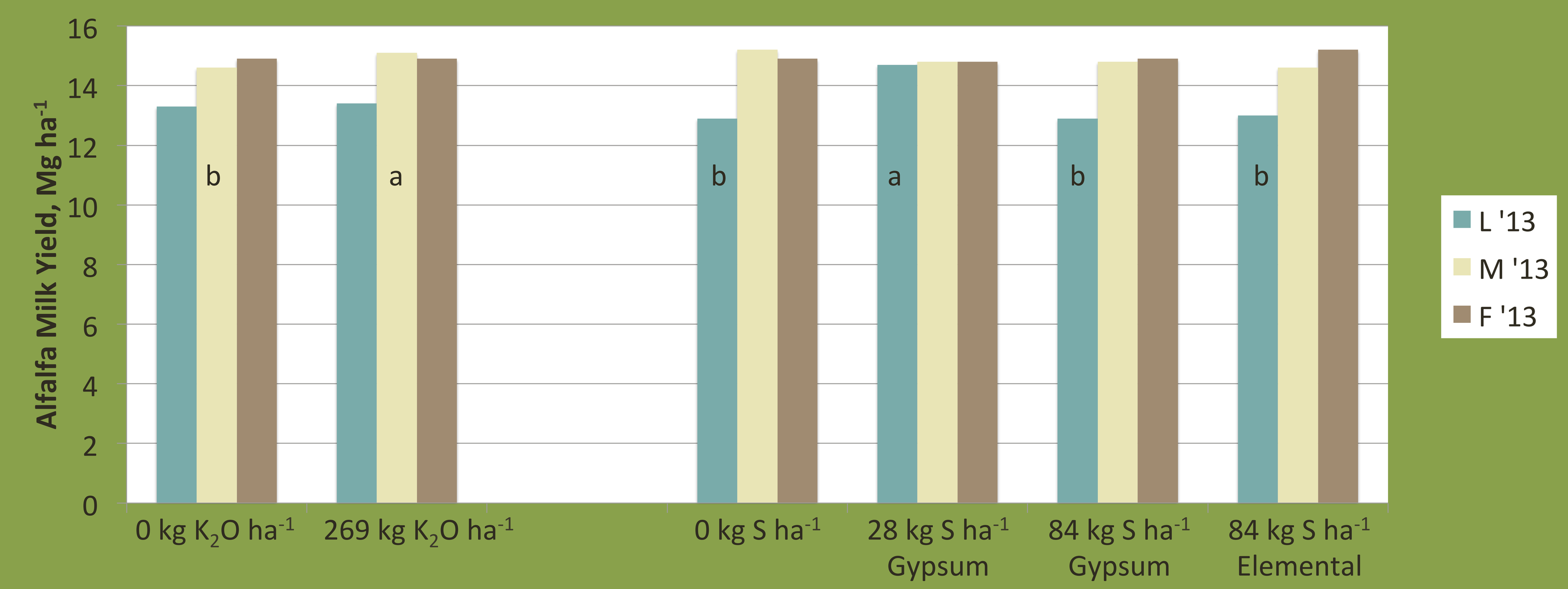


Figure 2. Potassium and sulfur fertilizer treatment effects on cumulative milk yield at Lancaster, Marshfield, and Freedom in 2012 and 2013. Means with different letters indicate significant (α = 0.10) differences between K or S fertilizer treatment rates for a given location and year.

Table 1. Potassium and sulfur fertilizer treatment effects soil test K and SO_4-S at several soil depth increments in early spring 2014 compared with pretreatment values in spring 2011 (n=32) at Lancaster, Marshfield and Freedom for the main effect of soil test K (n=16) and for soil test SO_4 (n=8).

Location & Date	Treatment	Soil test K, Soil depth, m				Soil test S, Soil depth, m			
		0-0.15	0.15-0.3	0.3-0.6	0.6-0.9	0-0.15	0.15-0.3	0.3-0.6	0.6-0.9
		ppm							
Lancaster									
Spring 2011	All	122	71	88	97	3.5	3.4	3.3	3.8
	Potassium (kg K_2O ha^{-1}):								
	0	86 b*†	63*	83*	94	4.8*	5.1*	4.9*	5.2*
	269	114 a	62*	83*	94*	4.8*	5.0*	5.0*	5.1*
	Sulfur (kg S ha^{-1}):								
	0	98*	62*	81 b*	94	4.6 b*	4.5 b*	4.6 b*	5.1*
	28 (annual gypsum)	103*	63*	80 b*	93	4.8 b*	4.8 b*	4.8 b*	5.1*
	84 (annual gypsum)	93*	61*	87 a	94	5.2 a*	6.3 a*	5.9 a*	5.5*
	84 (one time elemental)	105	65	84 ab	94	4.7 b*	4.6 b*	4.6 b*	5.0*
Marshfield									
Spring 2011	All	98	88	121	116	2.8	6.2	7.7	9.0
	Potassium (kg K_2O ha^{-1}):								
	0	80 b*	67 b*	113*	110	4.7*	4.8*	6.7	9.5
	269	151 a*	80 a	116*	115	4.8*	4.7*	7.1	8.3
	Sulfur (kg S ha^{-1}):								
	0	124 a*	78 a	126	117	4.5 b*	4.5*	5.5 bc*	8.7
	28 (annual gypsum)	106 b	68 b*	111 *	129	4.5 b*	4.7*	7.3 ab	8.0
	84 (annual gypsum)	111 b	66 b	106*	96*	5.3 a*	5.0*	8.4 a*	10.7*
	84 (one time elemental)	121 ab*	81 a	116*	107	4.8 ab*	4.8*	6.5 b*	8.0
Freedom									
Spring 2011	All	98	63	35	37	2.7	4.1	5.2	8.4
	Potassium (kg K_2O ha^{-1}):								
	0	93 b*	72*	55*	52*	4.5*	4.4*	5.3	9.3
	269	135 a*	74*	59*	53*	4.5*	4.4	5.0	8.2
	Sulfur (kg S ha^{-1}):								
	0	109*	72*	54*	49*	4.5*	4.4*	4.5 b*	6.3 b
	28 (annual gypsum)	101*	73*	56*	49*	4.5*	4.4*	4.4 b*	8.1 b
	84 (annual gypsum)	116*	73*	58*	57*	4.5*	4.5	7.2 a*	12.7 a*
	84 (one time elemental)	121*	74*	61*	54*	4.5*	4.4	4.9 b*	8.0 b

* 2014 mean for a given treatment is significantly (α = 0.10) different than 2011 mean before treatment application.
† Means with different letters indicate significant (α = 0.10) differences between rates of K or S fertilizer for a given location and year.

Summary

Failure to apply K to alfalfa resulted in soil test K levels decreasing throughout the soil profile even when yield did not significantly increase with K application (e.g. Lancaster) and suggests that K deficiency may be a problem in crops following alfalfa under this management.
- In 2013, 269 kg K_2O ha^{-1} significantly increased cumulative alfalfa yield at all locations except Lancaster (Figure 1), likely due to higher initial soil test K levels that occurred in the 0- to 0.15-m depth compared to the other sites (Table 1).
- Application of K significantly increased cumulative milk production at Marshfield in 2013 (Figure 2).
- Spring 2014 soil test K levels in the 0- to 0.15-m depth at all locations and the 0.15- to 0.3-m depth at Marshfield were significantly greater where 269 kg K_2O ha^{-1} was applied annually compared to where no K was applied (Table 1).
- Annual applications of potash significantly increased soil test K in the 0- to 0.15-m depth in spring 2014 compared to spring 2011 at Marshfield and Freedom (Table 1).
- At all locations, 0- to 0.15-m soil test K levels, decreased significantly where no K was applied (Table 1).
- At Lancaster and Marshfield, soil test K levels declined during the study to a depth of 0.6 m when no K was applied (Table 1).

Application of gypsum at rates greater than crop removal of S resulted in soil test S levels increasing deeper in the soil profile.
- Alfalfa DM and milk yield did not respond to S fertilizer rates, timings or forms, except at Lancaster in 2013 where 28 kg S ha^{-1} was applied as gypsum (Figures 1 and 2).
- Gypsum applied annually at 84 kg S ha^{-1} significantly increased spring 2014 soil test S deeper within the soil profile, to 0.6 m at Lancaster and Marshfield and to 0.9 m at Freedom, but did not result in greater yield than where 28 kg S ha^{-1}, approximately crop removal, was annually applied as gypsum (Table 1).

Weather influenced crop growth
- Stand establishment was slow at Marshfield and Freedom because average April through June temperatures were 1.2 and 2.7°C, respectively, below normal.
- Depending on location, moderate to extreme drought conditions were observed in 2012.

Acknowledgements

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Literature Cited

Shaver, R.D., D. Undersander, E. Schwab, P. Hoffman, J. Lauer, D. Combs, and J. Coors. 2000. Milk: Combining Yield and Quality into a Single Term. University of Wisconsin-Extension. http://www.uwex.edu/ces/forage/pubs/milk2000.htm (accessed 21 October 2014).