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Effect of Magnesium and Sulfur Fertilization of Alfalfa

K.L. Wells and J.E. Dollarhide

In response to concerns that high yields of alfalfa need to be fertilized with sulfur (S) because of soil depletion of S and less S entering the soil from atmospheric fallout, studies were conducted during 1998-1999, to test for S response by alfalfa. Additionally, alfalfa was tested for magnesium (Mg) response because previous hay analysis from the study site had shown very low levels of Mg.

STUDIES CONDUCTED

The study site was on the Eldon Calebs farm in Meade County, Kentucky, and was located on a deep, well-drained soil, which, although mapped as Crider silt loam, more closely resembled a Memphis silt loam, and occurred on 2-6% slopes. Two studies were conducted, as follows.

Study 1 – This study was initiated on an excellent 1-year old stand of alfalfa (var. Multistar) which showed promise of producing high yields. At the time of study initiation on May 26, 1998, the first harvest had been made. Hay analysis results from 1997 showed very low levels of Mg (0.12%). A fertilizer study was designed to test no fertilizer, Mg at 55 lbs/A topdressed as MgO, S at 90 lbs/A topdressed as elemental S, and a combination of the Mg and S treatments. A 4 x 4 Latin Square design was used, with individual plots being 25 ft x 25 ft. Each plot was soil sampled to a depth of 0-4 inches before applying fertilizer. Average soil test values for these initial 16 samples were: pH 7.4; and P 70; K 487; Ca 4891; Mg 319; Zn 8.3, lbs/A. After soil sampling,

plots were topdressed with the appropriate treatment, and then harvested 5 additional times for hay during 1998. Hay yields were measured by weighing the growth from a 11 ft length of an 8 ft 7 in wide mower swath from the center of each plot, and taking a grab sample for moisture and nutrient determination. Hay yield of the 5^{th} and 6^{th} harvests was reduced because of dry weather. Each plot was soil sampled at the end of the 1998 season (November), beginning of the 1999 season (April), the end of the 1999 season (October), and in February, 2000. All soil samples were analyzed in the University of Kentucky's Soil Testing Laboratory, with Mehlich-3 extractant. Fertilizer treatments were topdressed over the appropriate plots again on April 8, 1999, after plots were soil sampled. Yield measurements were taken for 3 harvests, as previously described. A severe drought in 1999 caused insufficient growth for any further yield measurements.

Study 2 – Another fertilizer study was conducted during 1999, on a 6-year old stand of alfalfa (var. Alfagraze) in an adjacent field on the same soil type, with the objective of testing for a yield response to potassium (K) and S. Four fertilizer treatments were tested: 275 lbs of K_2O/A as muriate of potash (KCl) with no S; 275 lbs of K_2O/A as KCl plus 100 lbs S/A as gypsum ($CaSO_4$); 275 lbs K_2O/A and 100 lbs S/A as sulfate of potash (K_2SO_4); 100 lbs S/A as gypsum, with no K. A 4 x 4 Latin Square design with plots of 25 ft x 25 ft size was used. Each plot was soil sampled to a depth of 0-4 inches before applying fertilizer (4-8-99). Average initial soil test values for these 16 plots were: pH 7.3; and P 102; K 179; Ca 4260; Mg 204; Zn 7.8 lbs/A. Hay yields were measured from 3 harvests, as explained above, after which there was insufficient growth for making hay

because of severe drought. Each plot was soil sampled at the end of the season (October), and again in February, 2000.

RESULTS

Study 1 – There was no effect of Mg topdressed as MgO, and S fertilization, topdressed as elemental S, on alfalfa yields, either in 1998 or 1999 (Table 1), despite high levels of production. Average yield of all treatments for the 5 harvests made in 1998 was 5.6 T/A, which, when added to the 1.7 T/A yield obtained by the producer from the first harvest, resulted in a yield of 7.3 T/A from 6 clippings, the last two of which were limited by a drought. Despite severe drought limiting 1999 production to only 3 harvests, the average yield of all treatments was 5.2 T/A. The Mg concentration of the hay (0.13-0.20%) was unaffected by Mg fertilizer (data not shown), and neither was total Mg uptake (Table 1). While S fertilization increased plant concentration of S (from 0.30% to 0.40%, data not shown) and total uptake of S, it did not increase yields (Table 1).

Analysis of hay quality for the second harvest in 1998, (Table 2) showed that it was very close to the 20-30-40 %, respectively for crude protein (CP), acid detergent fiber (ADF), and neutral detergent fiber (NDF) which dairymen consider to be ideal. The relative feed value (RFV) was calculated to be 158, indicative of excellent quality. Neither S nor Mg fertilization had an effect on these quality factors.

The effect of Mg fertilization on soil test levels of Mg (STMg) is shown in Table 3. The 55 lbs Mg/A topdressed as MgO after the first soil samples were taken in 1998, had little effect on STMg levels measured 5 months later, in November, and showed no effect on samples taken the following April (1999), just prior to applying the 1999 dose. However, STMg levels were significantly higher on samples taken in October, 1999, and

February, 2000, as a result of the total 110 lbs Mg/A which had been applied during the previous 18 months. It is possible that the lack of Mg application on STMg following the first application (5-98) was due to MgO not being as soluble as some other Mg sources. As noted, however, STMg levels were increased following the second application of Mg (4-99). Despite higher STMg levels in 1999, Mg concentration in the hay was not increased.

Study 2 – Results for hay yield and nutrient uptake from this one-year study are shown in Table 4. Although 100 lbs S/A either as gypsum or potassium sulfate equally increased alfalfa concentation of S (data not shown) and total uptake of S (Table 4), it did not increase alfalfa hay yield. Topdressing 275 lbs K_2O/A either as muriate or sulfate of potash nearly doubled K uptake by alfalfa and significantly increased hay yields on this low-K soil, as compared to no K. Despite K uptake of 213 lbs/A (256 lbs K_2O, av. of K plots, Table 4), STK increased from an average of 180 lbs/A before fertilization (April) to 345 lbs K/A at the end of the season (October) and it remained about that level 4 months later, in February. With no K fertilizer, and with 116 lbs K (139 lbs K_2O) uptake by alfalfa (Table 4), STK had changed very little by the end of the season, and even increased slightly by the following February (Table 5).

CONCLUSIONS

1- After 2 years topdressing with Mg (a total of 110 lbs Mg/A) soil test levels of Mg had increased, but plant concentration and uptake, and hay yield did not increase.

2- Two years of S topdressing (a total of 180 lbs S/A) increased plant content and total S uptake, but hay yield was not increased.

3- Fertilization with Mg and/or S did not improve hay quality.

4- One year's application of S increased plant content and total uptake of S, with gypsum and sulfate of potash being equally effective, but did not increase hay yield.

5- Topdressing a low-K soil (STK of 180 lbs/A) with 275 lbs of K_2O/A either as muriate or sulfate of potash significantly increased hay yield, with both K-sources being equally effective.

Table 1. Effect of Mg and S on Alfalfa Yield and Nutrient Uptake.

			Uptake (lbs/A)[4/]					
	Hay Yield (T/A)[1/]		K		Mg		S	
Treatment	1998[2/]	1999[3/]	1998[2/]	1999[3/]	1998[2/]	1999[3/]	1998[2/]	1999[3/]
0	5.40a	5.17a	250a	179a	16.2a	19a	28c	24b
Mg	5.46a	5.24a	268a	189a	15.5a	19a	29bc	24b
Mg + S	5.71a	5.03a	283a	196a	15.8a	18a	33a	31a
S	5.82a	5.21a	286a	202a	15.5a	17a	33ab	30a
L.S.D. (.05)	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	4	5

All data are av. of 4 reps/tmt. Treatment averages followed by the same letter are not significantly different (P = .05).

[1/] Tons hay at 12% moisture.

[2/] Yield and nutrient uptake for cuttings 2-6; Yield from 1st harvest was measured by producer as 1.69 T/A.

[3/] Yield and nutrient uptake from 3 clippings.

[4/] Dry matter basis.

Table 2. The Effect of Mg and S Fertilization on Alfalfa Hay Quality (2nd harvest, 1998).

Treatment	% Crude Protein	% ADF[1/]	% NDF[2/]
0	20.9	29.3	39.7
Mg	21.0	29.2	39.2
Mg + S	21.7	28.6	38.8
S	21.0	28.6	38.8

[1/] Acid detergent fiber
[2/] Neutral detergent fiber

Table 3. Effect of Mg Fertilization on Soil Test Mg Levels

	Soil Test Mg (lbs/A) at Dates Shown				
Treatment	5-98	11-98	4-99	10-99	2-2000
0	320a	337a	298a	295c	300b
Mg	329a	344a	309a	391a	409a
Mg + S	323a	338a	301a	337b	362a
S	305a	314a	279a	286c	294b
L.S.D. (.05)	NS	NS	NS	41	48

All data are av. of 4 reps/tmt. Treatment averages followed by the same letter are not significantly different (P = .05).

Table 4. Effect of K and S on Alfalfa Yield.

Treatment[1/]	Hay Yield (T/A)[2/]	Uptake (lbs/A)[3/] K	Uptake (lbs/A)[3/] S
KCl, no S	4.74a	218a	21b
KCl + S	4.78a	215a	25a
K_2SO_4	4.54a	205a	28a
S, no K	4.15b	116b	26a
L.S.D. (.05)	0.52	36	4

All data are av. of 4 reps/tmt. Treatment averages followed by the same letter are not significantly different (P = .05).

[1/] K rate was 275 lbs K_2O/A for all K tmts.; S rate was 100 lbs S/A applied as $CaSO_4$ or K_2SO_4.

[2/] Tons hay at 12% moisture.

[3/] Dry matter basis.

Table 5. Effect of K Application on Soil Test K Levels

	Soil Test K Levels (lbs K/A)		
Treatment[1/]	April 1999	October 1999	February 2000
KCl, no S	189a	348a	337a
KCl + S	171a	325a	343a
K_2SO_4	180a	363a	376a
S, no K	177a	187b	200b
L.S.D. (.05)	N.S	77	93

All data are av. of 4 reps/tmt. Treatment averages followed by the same letter are not significantly different (P = .05).

[1/] Potassium was applied at 275 lbs K_2O/A immediately after taking soil samples in April, 1999.