Optimizing Boron Maintenance Fertilization for Alfalfa (*Medicago sativa* L.) in Montana

A. Sapkota[1], D.M. Staudenmeyer[1], R.N. Stougaard[2], E.C. Glunk[1], and J.A. Torrion[2]

[1]Department of Animal and Range Sciences, Montana State University, MT and [2]Northwestern Agricultural Research Center, Montana State University, Kalispell, MT

IMPACT STATEMENT

Boron application rate, timing, and adequate soil moisture can influence alfalfa yield and performance. This research identifies the benefits of boron application on yield and forage quality of alfalfa. The results of this research will help farmers and ranchers grow high-quality, high-producing alfalfa.

SUMMARY

This research was designed to determine an optimum rate for boron (B) application in alfalfa while assessing its effect on yield and forage quality. Five different B treatments were applied to alfalfa, consisting of: a) 0.0 lb B per acre, b) 0.25 lb B per acre at the beginning and 0.25 lb B per acre applied mid-season, c) 0.50 lb B per acre at the beginning of season and 0.50 lb B per acre applied mid-season, d) 1 lb B per acre at the beginning and 1 lb B per acre applied mid-season, and e) 2 lb B per acre applied at the beginning of the season. The effect of B application on yield observed at the Dillon site was promising for an overall effect of B application on alfalfa performance. Severe drought at Creston and our inability to provide sufficient supplemental irrigation to meet crop demands above non-stressed conditions resulted in no yield differences. These results illustrate the importance of soil water availability to B accessibility by the plant. A second year of research is warranted to investigate the impact of B on alfalfa production as well as the impact of water availability on B uptake.

INTRODUCTION

Alfalfa (*Medicago sativa)* is a perennial flowering plant of the pea family *Fabaceae* and is cultivated in many countries around the world. Alfalfa ranks as the fifth highest crop in production in the United States (NASS, 2015). Quality factors such as high protein, vitamins, energy, and digestibility contribute to producers commonly referring to alfalfa as "Queen of Forages." (Burton, 1972). Alfalfa is adapted to grow in a wide range of environments (Iannucci et al., 2002) and contributes to 72% of total hay production in Montana.

Alfalfa has one of the highest B demands among many crops (Rathore, 2015). B deficiency limits growth, productivity, and yield of crops causing impairment of metabolic and physiological processes (Herrera-Rodríguez et al., 2010). To address B deficiency, regular supply of B during the growing season is essential (Malhi & Karamanos, 2013). However, specific B fertilization recommendations for alfalfa have not been evaluated under Montana conditions. Therefore, this project was designed to evaluate the impacts of increasing B fertilization rates on alfalfa production. The specific objectives of this project were to evaluate how different application rates of B fertilization affect the yield and quality of alfalfa. We hypothesize that increasing supplementation of soil B will increase alfalfa yield and quality.

PROCEDURES

Research was conducted at the NWARC in Creston and at a private producer's farm in Dillon, MT. The project was conducted in established, two year-old stands of alfalfa where the soil types were a fine sandy loam and silt loam, respectively. The Creston soil had lower soil water holding capacity than Dillon soils. The research was laid out in a Randomized Complete Block Design with five treatments and four replications. The treatments were a) 0.0 lb B per acre, b) 0.25 lb B per acre at the beginning and 0.25 lb B per acre applied after first harvest, c) 0.50 lb B per acre at the beginning of season and 0.50 lb B per acre applied after first harvest, d) 1 lb B per acre at the beginning and 1 lb B per acre applied after first harvest, and e) 2 lb B per acre applied at the beginning of the season. Liquid B fertilizer (10% B AgriSolutions^{TM}) was used for the purpose of B application. Yield and quality samples were collected at 10% bloom at each site. Three harvests were taken at the Creston site, and two harvests were taken at the Dillon site. Plant tissues were analyzed for B and other nutrient concentrations.

RESULTS AND DISCUSSION

Creston site

No significant differences were observed for height or yield at Creston (Table 1). The initial soil test for B in spring was low, but the average initial B tissue test was near or at sufficiency levels for low B application. The one exception was the pre-bud tissue test where a slight increase in B was observed with increasing B application rate. We associate this result with the confounding effect of water-depleted soils due to drought, and insufficient irrigation.

No consistent hay quality trend was observed amongst the treatments (Table 2). All samples had nutrient values within expected ranges. Future response of alfalfa to B application at Creston will consider irrigation as an additional factor to B uptake and hay quality. We hypothesize that alfalfa response in Creston was influenced by drought and our inability to meet crop water demands with irrigation. The Creston site had a full soil profile beginning in spring as rainfall received in the fall and early spring was above average. From green-up to the last cutting (April to September, 2015) only 3.5 inches of rain was received and irrigation amounts were insufficient. Based on the soil depletion pattern, the Creston site had a longer water stress period compared to the Dillon site.

Dillon site

Yields at Dillon did show a response to B during second cutting (Table 3; P =0.049). Though total yields for the season were not significantly different among treatments, the incremental yield increase with increasing levels of B application is worthy of further investigation. No consistent trend in hay quality was observed. However, protein levels were higher than expected which may have been caused by the high S tissue content.

In the second year of the project, we propose that water regime be included as an additional treatment factor of B response in alfalfa. At the Creston site, we will add a second set of plots in a seedling stand of alfalfa with the same set of B treatments, but with three moisture regimes (100ET, 50ET and rain-fed) as the whole plot factor and five B levels as the sub-plot factor. The current Creston and Dillon B research plots will continue for another year and be irrigated in the same manner as 2015. Expanding the scope of this project will help to provide better recommendations to Montana producers and ranchers.

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Table 1. Height and yield with B treatments, Creston, MT

	1st Harvest - Jun 10		2nd Harvest -Jul 14		3rd Harvest - Oct 2		Harvest Total
	HT	YLD	HT	YLD	HT	YLD	YLD
Treatment	in	T/A	in	T/A	in	T/A	T/A
0 lb B	27	3.0	22	1.9	21	1.6	6.5
0.25 lb B begin + mid-season	28	3.1	22	1.7	21	1.5	6.2
0.5 lb B begin + mid-season	27	2.9	21	1.7	23	1.4	6.0
1 lb B begin + mid-season	29	3.0	21	1.6	21	1.4	6.0
2 lb B begin season	28	3.0	20	1.6	20	1.3	5.9
Mean	28	3.0	21	1.7	21	1.4	6.1
CV	8	11	10	9	17	13	8
LSD	ns	ns	ns	ns	ns	ns	ns
Pr>F	0.5978	0.9730	0.5875	0.0855	0.8307	0.3720	0.4408

HT: height, YLD: yield, ns: nonsignificant, B: Boron (amount applied begin season same as mid-season)

Table 2. Plant tissue test and hay quality, Creston, MT

Treatment	CP %	ADF %	NDF %	TDN %	RFV %	B ppm	S %
	1st Harvest - Jun 10						
0 lb B	25.6	30.0	44.1	66.3	138	25	0.25
0.25 lb B begin + mid-season	25.7	27.7	38.8	68.8	161	34	0.27
0.5 lb B begin + mid-season	27.7	28.6	36.0	67.8	172	30	0.26
1 lb B begin + mid-season	22.9	33.0	38.5	63.1	153	30	0.27
2 lb B begin season	28.9	30.4	34.7	65.9	175	38	0.30
	2nd Harvest - Jul 14						
0 lb B	22.7	35.0	40.3	60.9	142	25	0.33
0.25 lb B begin + mid-season	22.4	36.3	42.5	59.5	133	33	0.29
0.5 lb B begin + mid-season	22.8	37.8	45.7	57.9	121	34	0.28
1 lb B begin + mid-season	28.3	28.2	31.9	68.2	195	30	0.30
2 lb B begin season	25.6	34.5	40.2	61.5	144	38	0.31
	3rd Harvest - Oct 2						
0 lb B	25.6	22.1	29.1	74.8	229	32	0.25
0.25 lb B begin + mid-season	27.4	24.3	29.0	72.5	224	41	0.24
0.5 lb B begin + mid-season	25.0	25.7	31.0	71.0	207	32	0.21
1 lb B begin + mid-season	24.7	22.9	30.4	74.0	217	43	0.28
2 lb B begin season	25.1	25.8	29.7	70.8	215	40	0.25

CP: crude protein, ADF: acid detergent fiber, NDF: neutral detergent fiber, TDN: total digestible nutrients, RFV: relative feed value, B: Boron (amount applied begin season same as mid-season)

Table 3. Yield with boron treatments, Dillon, MT

Treatment	YLD 1 T/A	YLD 2 T/A	Total YLD T/A
0 lb B	2.4	1.7[b]	4.1
0.25 lb B begin + mid-season	2.3	1.9[a]	4.2
0.5 lb B begin + mid-season	2.5	2.0[a]	4.4
1 lb B begin + mid-season	2.6	2.0[a]	4.6
2 lb B begin season	2.4	2.1[a]	4.5
Mean	2.4	1.9	4.3
CV	13	8	7
LSD	0.47	0.24	0.48
Pr>F	0.7047	0.0499	0.2017

YLD: yield, B: Boron (amount applied begin season same as mid-season)

Table 4. Plant tissue test and hay quality, Dillon, MT

Treatment	B ppm	CP %	ADF %	NDF %	TDN %	RFV %	B ppm	S %
	1st Harvest - Jul 26	2nd Harvest - Aug 11						
0 lb B	53	30.8	27.8	35.3	68.7	177.0	58	0.39
0.25 lb B begin + mid-season	54	28.7	33.8	34.2	62.2	170.0	43	0.34
0.5 lb B begin + mid-season	58	29.8	27.7	35.3	68.8	177.0	49	0.36
1 lb begin + mid-season	55	30.3	28.9	40.5	67.5	152.0	48	0.36
2 lb B begin season	53	29.9	28.5	31.3	67.9	198.0	50	0.38

CP: crude protein, ADF: acid detergent fiber, NDF: neutral detergent fiber, TDN: total digestible nutrients, RFV: relative feed value, B: Boron