AGRICULTURAL RESEARCH FOUNDATION
FINAL REPORT
FUNDING CYCLE 2014 – 2016

TITLE: Investigating the use of nitrogen, sulfur, and potassium fertilizers to optimize seed production in red clover crops

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SUMMARY: One soil property widely known to be critical in legume seed production is pH, or soil acidity. Clovers and other legumes generally do not tolerate acidic soils. In contrast, very limited information exists for clover nutrient requirements. Nitrogen (N), sulfur (S), and potassium (K) are likely yield limiting nutrients for clover seed production. Many western Oregon clover seed producers focus their management efforts on maintaining adequate soil pH and managing pests but have given minimal attention to the role that soil nutrients play in optimizing seed production. OSU nutrient management recommendations for red clover have been lacking and field-based applied research is needed to assist the industry in determining nutrient requirements.

Upon initiation of this work feedback was provided by leaders in the clover seed industry expressing interest in further evaluating boron (B) fertilizer applications. Soil test K levels were very high at Hyslop Farm and therefore we did not expect to find any response to K. Thus, we replaced initially proposed K treatments with B treatments. Final treatments are identified below.

OBJECTIVES:

1) Determine effect of N, S, and B fertilizers on seed yield, weight and number.
2) Measure plant uptake of N, S, and B applied in the fall and spring to determine when the clover plant uses these nutrients. Evaluate nutrient content of mature seed.
3) Extend results to the growers, industry representatives and others in the clover seed industry via grower meetings, research reports, and field events.
4) Utilize data collected to pursue future funding from other sources.

PROCEDURES: Small research plots were established at Hyslop Research Farm in Corvallis, Oregon to evaluate N, S, and B. At each study site, fertilizer treatments representing various rates and timing options were applied.

Fertilizer treatments at Hyslop Farm will include:

1) Control (no fertilizer application)
2) 40 lb/acre of N applied in fall
3) 40 lb/acre of N applied in spring
3) 30 lb/acre of S applied in fall
4) 30 lb/acre of S applied in spring
5) 2 lb acre of B applied in fall
6) 2 lb acre of B applied in spring
7) 40 lb/acre of N plus 30 lb/acre of S plus 1 lb B applied in fall
8) 40 lb/acre of N plus 30 lb/acre of S plus 1 lb B applied in spring

The trial was arranged in a randomized complete block design with four replications. Plot size was 11 X 50 ft. Soil samples were taken to establish baseline soil nutrient levels and pH. Biomass samples from a 1 ft^2 quadrant in each of the treatment areas were collected, weighed and analyzed for N, C, P, K, Ca, Mg, and B content. These samples were taken at three stages of development during the growing season (prior to stem elongation, flowering, and seed filling) to ascertain the seasonal timing of nutrient uptake in red clover seed crop tissues in relation to seed development and seed yield. Seed number per square meter was calculated. Plots were swathed with a modified John Deere 2280 swather and combined with a Hege 180 plot combine.

SIGNIFICANT ACCOMPLISHMENTS: There was no increase in seed yield, seed weight or percent cleanout measured between the control and N, S, B fertilizer treatments applied in fall or spring in 2014 (Table 1) or 2015 (Table 2).

Table 1. Seed yield, percent cleanout, and seed weight measured after N, S, and B fertilizers were applied to second year red clover in the fall (late-October) and spring (mid-March), 2014.

Treatment		**Timing**	**Yield**	**Cleanout**	**Seed Weight**
			lb a^{-1}	%	mg
Control			681	10.3	1.543
Nitrogen	40 lb/a	Fall	683	11.1	1.550
Nitrogen	40 lb/a	Spring	677	10.8	1.567
Sulfur	30 lb/a	Fall	696	11.2	1.576
Sulfur	30 lb/a	Spring	628	12.0	1.565
Boron	2 lb/a	Fall	668	10.9	1.537
Boron	2 lb/a	Spring	694	10.8	1.538
N + S + B		Fall	669	11.3	1.566
N + S+ B		Spring	652	11.8	1.584

* Means followed by the same letter are not significant at 0.05

Table 2. Seed yield, percent cleanout, and seed weight measured after N, S, and B fertilizers were applied to second year red clover in the fall (late-October) and spring (mid-March), 2015.

Treatment		Timing	Yield	Cleanout	Seed Weight
			lb a^{-1}	%	mg
Control			657	5.9	1.570
Nitrogen	40 lb N/a	Fall	671	5.6	1.539
Nitrogen	40 lb N/a	Spring	568	6.3	1.540
Sulfur	30 lb S/a	Fall	604	6.5	1.543
Sulfur	30 lb S/a	Spring	583	5.9	1.554
Boron	2 lb B/a	Fall	569	5.7	1.575
Boron	2 lb B/a	Spring	587	5.9	1.549
N + S + B		Fall	571	5.4	1.569
N + S + B		Spring	538	6.0	1.541

* Means followed by the same letter are not significant at 0.05

Spring applications of N and S and fall and spring applications of N+S+B increased biomass production prior to silage removal in 2014 (Table 3). There were no biomass effects amongst treatments during the stem elongation period. Sulfur applications (spring and fall) and N (spring only) decreased biomass weights measured during flowering. There was no effect on biomass to any fertilizer treatment in 2015 (data not shown).

Table 3. Mean biomass measurements taken at three timings following N, S, and B fertilizer applications made to first year red clover in 2014.

Treatment	Timing	Biomass		
		g/ft^2		
		May 12	June 10	July 29
Control		32.1 ab*	52.0	105.40 bc**
Nitrogen (40 lb/a)	Fall	31.1 ab	52.3	111.00 c
Nitrogen (40 lb/a)	Spring	39.6 bc	45.5	97.50 abc
Sulfur (30 lb/a)	Fall	33.4 ab	51.0	83.95 a
Sulfur (30 lb/a)	Spring	36.7 bc	60.3	92.35 ab
Boron (2 lb/a)	Fall	25.7 a	53.7	101.30 bc
Boron (2 lb/a)	Spring	34.0 ab	55.2	99.23 bc
N + S + B	Fall	41.0 bc	49.7	106.25 bc
N + S+ B	Spring	50.8 c	47.3	107.40 c

* Means followed by the same letter are not significant at 0.05

** Means followed by the same letter are not significant at 0.10

Tissue was sampled for nutrient concentration analysis at three timings during spring and summer in both 2014 (data not shown) and 2015. There were no effects of fertilizer treatments on percent N, C, P at any sample timings (Table 4). There were varied effects on Ca and Mg on April 30th and on K and B on June 15th. There were no effects on any nutrients on July 15th.

Table 4. Nutrient concentrations measured at three timings on a second-year red clover stand in 2015.

Sampling Date: April 30, 2015

Timing	Treatment	N	C	P	K	Ca	Mg	B
		%	%	%	%	%	%	ppm
	Control	2.85	43.80	0.26	2.33	1.33 c*	0.18 a†	26.8
Fall	Nitrogen 40 lb N/a	2.71	43.70	0.24	2.21	1.13 ab	0.17 a	24.3
Spring	Nitrogen 40 lb N/a	2.54	43.50	0.25	2.37	1.13 ab	0.17 a	23.8
Fall	Sulfur 30 lb S/a	2.83	43.83	0.25	2.16	1.27 bc	0.20 b	25.3
Spring	Sulfur 30 lb S/a	3.04	43.78	0.26	2.46	1.26 bc	0.18 a	26.0
Fall	Boron 2 lb B/a	2.72	43.63	0.25	2.25	1.25 bc	0.17 a	27.8
Spring	Boron 2 lb B/a	2.66	43.55	0.25	2.27	1.19 abc	0.16 a	28.0
Fall	N + S + B	2.46	43.43	0.24	2.40	1.07 a	0.16 a	25.5
Spring	N + S + B	2.58	43.68	0.24	2.24	1.08 a	0.16 a	27.0

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† Means followed by the same letter are not significant at 0.10

Sampling Date: June 15, 2015

Timing	Treatment	N	C	P	K	Ca	Mg	B
		%	%	%	%	%	%	ppm
	Control	3.47	44.03	0.32	2.53 bc†	1.54	0.22	24.5 abc †
Fall	Nitrogen 40 lb N/a	3.38	43.83	0.31	2.58 bc	1.49	0.22	23.5 ab
Spring	Nitrogen 40 lb N/a	3.39	43.68	0.3	2.72 c	1.51	0.21	25.3 bcd
Fall	Sulfur 30 lb S/a	3.61	43.85	0.32	2.46 ab	1.59	0.24	23.8 abc
Spring	Sulfur 30 lb S/a	3.40	43.58	0.28	2.26 a	1.36	0.2	22.5 a
Fall	Boron 2 lb B/a	3.45	43.63	0.32	2.72 c	1.46	0.22	26.3 cd
Spring	Boron 2 lb B/a	3.59	43.90	0.31	2.52 bc	1.53	0.23	26.0 bcd
Fall	N + S + B	3.46	43.80	0.3	2.50 bc	1.55	0.22	25.5 bcd
Spring	N + S + B	3.49	43.75	0.31	2.46 ab	1.56	0.23	27.5 d

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Sampling Date: July 15, 2015

Timing	Treatment		N	C	P	K	Ca	Mg	B
			%	%	%	%	%	%	ppm
	Control		1.73	43.63	0.15	2.21	1.40	0.16	30.5
Fall	Nitrogen	40 lb N/a	1.66	43.50	0.13	2.23	1.39	0.15	30.0
Spring	Nitrogen	40 lb N/a	1.82	43.53	0.14	2.35	1.37	0.15	29.7
Fall	Sulfur	30 lb S/a	1.79	43.78	0.15	2.05	1.37	0.18	29.0
Spring	Sulfur	30 lb S/a	1.60	43.58	0.12	2.32	1.27	0.14	27.3
Fall	Boron	2 lb B/a	1.70	43.20	0.15	2.39	1.37	0.15	33.8
Spring	Boron	2 lb B/a	1.92	43.10	0.15	2.43	1.48	0.17	30.8
Fall	N + S + B		1.73	43.48	0.14	2.23	1.50	0.18	30.0
Spring	N + S + B		1.80	43.40	0.14	2.19	1.60	0.17	33.8

* Means followed by the same letter are not significant at 0.05

BENEFITS & IMPACT:
Boron fertilizer is applied routinely to 90% or more of red clover seed acres in western Oregon and N and S fertilizer applications are also common. Our work shows that a benefit from such applications is not likely to be found and therefore use of such practices is not recommended for maximizing economic seed yield. Data from this study will be utilized in a forthcoming OSU Extension Nutrient Management Guide for Red Clover Grown for Seed.

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Oregon Clover Commission - $11,871

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