MT-13F
Final Report
6-22-99

FINAL REPORT

Title: Effect of Boron Fertilization on Alfalfa Production (MT-13F)

Year: 1997

Location: 4 J Farms, east of Ledger, MT.

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Objectives: 1) To predict the response of alfalfa to boron fertilization using soil and/or tissue tests; (2) and prepare a final report at conclusion of the project addressing the above objective.

Summary: Boron (B) at 0, 1, and 2 lbs/a in combination with 0, 40, and 80 lbs phosphorus (P_2O_5)/a was applied to an existing, irrigated, alfalfa stand in 1997 and 1998. Forage yield and selected nutrients were measured. Forage yields averaged 6.1 tons/a in 1997 and 8.6 tons/a in 1998. No significant response to B or P was measured. The lack of yield response to B was attributed to the gradual increase in soil B from 0.4 ppm, in the plow layer, to 1.1 ppm in the 4-5 foot soil depth. In general, B increased the B content of the forage in 1997 but not in 1998. Plant P uptake was mixed also. Phosphorus fertilization increased plant P content in 1998 but not in 1997. Boron and P fertilization did increase the respective soil test levels when measured after the last harvest in 1997. Producers should consider deep sampling for B when planning a B fertilization program.

Procedures: Nine fertilizer treatments and blanket applications of 10 lbs Zn, and 30 lbs K/a were applied to an existing, one year old, alfalfa stand on April 18, 1997. The field plot design was a 3 x 3 factorial (0, 40, and 80 lbs P_2O_5, 0, 1, and 2 lbs B/a) with four replicates. For the second year, P treatments were applied on October 7, 1997; B treatments, 30 lbs K/a, and 10 lbs Zn/a were applied on March 25, 1998. Plot size was 6 x 15 feet. A two-foot wide, flail chopper was used for the first cutting. A three-foot Jari mower was used for all subsequent harvests. After weighing, plot samples were sub-sampled for nutrient and water analysis. Harvest dates for 1997 were June 18 for Cut 1 (1/20th bloom), August 5 for Cut 2 (25 % bloom), and September 24 for Cut 3 (1/10th bloom). Harvest dates for 1998 were June 23 (25 % bloom) for cut one, August 4 (80 % bloom) for cut 2, and September 29 (80 % bloom) for cut 3. Initial soil samples were taken prior to fertilizer application on April 18, 1997. In addition P plots were soil sampled prior to P application on October 7, 1997, and B plots were soil sampled on March 25, 1998 prior to B application. Fertilizer materials were treble super phosphate, potassium chloride, zinc sulfate, and Granubor (14.3 % B). Irrigation water was sampled on July 25, 1997. Initial soil and irrigation water analyses are shown in Table 1.

Results:

Forage Yield:

The 1997 forage yield data are summarized in Table 1, and the average yield for three cuttings was 6.1 tons/a. Forage yield data for 1998 are summarized in Table 2, average yield for three cuttings was 8.60 tons/a. Even though the P and B treatments were based on the initial soil tests and responses were expected, no forage yield response to either P or B was detected. The lack of B response is probably explained by the gradual increase in B from 0.4 ppm, in the plow layer, to 1.1 ppm in the 4 to 5 foot depth. Soil samples deeper than six inches were not analyzed for P, thus the lack of P response cannot be explained by P levels in deeper soil samples. With the relatively high forage yields and a initial P soil test of 13 ppm, a yield response to P fertilization was expected.

Plant Nutrient Content:

Plant nutrient analyses are shown in Tables 3 and 4. In 1997 (Table 3) B fertilization increased B uptake in cuts 1 and 2. Boron also increased P, S, Ca, Mg, and Mn uptake in cut 3, and Zn uptake in cut 2. Phosphorus uptake was unaffected by P fertilization, but P concentration gradually declined from 0.26 to 0.22 % to 0.15 % for cuts 1, 2, and 3, respectively. Zinc concentration declined with the increase in P when measured at cuts 2 and 3. At cut 2, B decreased with increasing P. In 1998 (Table 4) the nutrient concentration responses to P and B were different from 1997. Boron and P fertilization increased N in cut 1, and B increased N in cut 3. Nitrogen was unaffected by B and P in 1997. Phosphorus significantly increased P concentration in all three cuttings. Boron did not affect B uptake as it did in 1997; however, P depressed B uptake in cut 3 rather than cut 2 in 1997. Calcium content was decreased by P in cut 3 and by B in cut 2. Copper levels declined with increasing P in cuts 1 and 2 but were increased by B in cut 2. Iron concentration was increased by B in cut 1 and decreased by B in cut 2. Manganese was increased by B in cut 2. Boron increased Zn and S in cut 1, while P depressed Zn levels in cut 1.

Post-Harvest Soil Analysis:

The results of the composite, post-harvest soil sample analysis are shown in Table 5. Both B and P soil test levels increased with increasing fertilizer rates. Soil B levels increased from 0.51 ppm (check treatment) to 0.66 ppm (1 lb B/a treatment) and 0.79 ppm (2 lbs B/a treatment).

Table 1. The Effect of Phosphorus and Boron on Irrigated alfalfa Forage Yield. Western Triangle Ag. Research Center, Conrad, MT. 1997.

Entry	Treatment P_2O_5	Treatment B	Yield[1] 1st Cut	2nd Cut	3rd Cut	Total
	-----(lbs/a)-----		----------(tons/a)----------			
9	80	2	1.58	2.84	1.85	6.26
6	80	1	1.39	2.70	1.89	5.97
3	80	0	1.62	2.68	1.99	6.29
8	40	2	1.33	2.78	1.82	5.94
5	40	1	1.74	2.66	2.03	6.43
2	40	0	1.47	2.66	1.86	5.99
7	0	2	1.52	2.75	1.85	6.13
4	0	1	1.33	2.89	1.87	6.09
1	0	0	1.62	2.71	1.85	6.18
			Summary Statistics			
Experimental Means			1.51	2.74	1.89	6.14
Error Mean Square			0.027	0.061	0.013	0.151
P-value			0.0175	0.8855	0.1738	0.6641
Standard Error			0.165	0.248	0.113	0.389
Standard Error of the Mean			0.083	0.124	0.056	0.195
C.V. 1: (s/mean)*100			10.93	9.03	5.96	6.34
LSD (0.05)			0.24	NS	NS	NS
			Phosphorus Summary			
80			1.53	2.74	1.91	6.17
40			1.51	2.70	1.91	6.12
0			1.49	2.78	1.85	6.13
LSD (0.05)			NS	NS	NS	NS
			Boron Summary			
2			1.48	2.79	1.84	6.11
1			1.49	2.75	1.93	6.16
0			1.57	2.68	1.90	6.15
LSD (0.05)			NS	NS	NS	NS
Interaction P-value			0.003	0.790	0.146	0.264

[1] Yields based on 12% moisture.
Growing season ppt. = Additional moisture from irrigation = 18.0"
Harvest dates for first, second, and third cuttings = June 18, Aug. 5, and Sept. 24, respectively.

Table 1 Continued.

Soil Tests

O.M. = 2.25 %, pH = 8.0

Depth (ft.)	B (ppm)	Cl	NH_4-N	NO_3-N	SO_4-S
		----------lbs/a----------			
0-1	0.35	12.3	13.2	31.7	143.5
1-2	0.38	14.2	7.0	7.8	245.9
2-3	0.42	35.0	15.0	3.3	727.9
3-4	0.78	143.5	7.1	2.6	1293.6
4-5	1.08	410.0	7.6	2.2	4335.2

Element (0-6")	Amount (ppm)
P	13.8
Zn	0.48
Mn	5.85
K	234
Cu	0.9
Fe	6.86
B	0.41

Irrigation Water Analysis

PH = 8.3
EC (mmhos/cm) = 0.65
TDS (mg/L) = 442.0
TSS (mg/L) = 8.0

Element or Ion	Amount (ppm)
B	0.089
Ca	45.0
Cl	4.08
Cu	< 0.01
K	2.8
Mg	34.0
Mn	0.03
Na	38.3
P	0.19
S	45.5
Zn	< 0.01
HCO_3^-	248.0
$CO_c^=$	<1.0

Table 2. The effect of phosphorus and boron on irrigated alfalfa yield. Western Triangle Ag. Research Center, Conrad, MT. 1998.

-	Treatment		Yield[1]			
Entry	P_2O_5	B	1st cut	2nd cut	3rd cut	Total
-	(lbs/a)		(tons/a)			
9	80	2	3.69	2.52	2.55	8.63
6	80	1	3.72	2.40	2.43	8.42
3	80	0	3.64	2.62	2.32	8.18
8	40	2	3.61	2.42	2.23	8.10
5	40	1	3.84	2.57	2.30	8.16
2	40	0	3.62	2.25	2.51	8.49
7	0	2	3.54	2.42	2.52	8.50
4	0	1	3.59	2.27	2.67	8.76
1	0	0	3.63	2.45	2.54	8.50
Summary Statistics						
Experimental Means		-	3.65	2.44	2.51	8.60
Error Mean Square		-	0.028	0.058	0.062	0.282
P-value		-	0.49	0.227	0.369	0.204
Standard Error of the Mean			0.048	0.058	0.072	0.153
C.V. 1: (s/mean)*100		-	4.54	2.86	9.89	6.17
LSD (0.05)		-	NS	NS	NS	NS
Phosphorus Summary						
0	-	-	3.68	2.38	2.46	8.43
40	-	-	3.69	2.41	2.45	8.55
80	-	-	3.59	2.51	2.62	8.81
LSD (0.05)	-	-	NS	NS	NS	NS
Boron Summary						
0	-	-	3.63	2.44	2.49	8.56
1	-	-	3.72	2.41	2.48	8.61
2	-	-	3.62	2.45	2.56	8.63
LSD (0.05)	-	-	NS	NS	NS	NS
Interaction P-value		-	0.49	0.227	0.369	0.204

[1] Yields based on 12% moisture.

Harvest dates for first, second, and third cuttings=June 23, Aug.4, and Sept. 29, respectively.

Table 3. Alfalfa nutrient uptake as affected by P and B fertilization. Western Triangle Ag. Research Center, Conrad, MT, 1997.

Entry	Treatment P_2O_5	Treatment B	N 1st Cut	N 2nd Cut	N 3rd Cut	P 1st Cut	P 2nd Cut	P 3rd Cut	B 1st Cut	B 2nd Cut	B 3rd Cut
	-----(lbs/a)-----		----------(%)----------			----------(%)----------			----------(ppm)----------		
9	80	2	2.79	2.64	3.10	0.256	0.225	0.194	57.35	49.05	57.05
6	80	1	2.84	2.69	3.07	0.252	0.219	0.155	57.15	50.45	56.50
3	80	0	3.03	2.72	2.94	0.278	0.240	0.141	56.27	48.90	53.60
8	40	2	2.90	2.80	3.09	0.263	0.219	0.150	58.92	56.12	54.45
5	40	1	3.24	2.76	3.07	0.277	0.217	0.147	56.65	52.80	54.62
2	40	0	2.90	2.66	3.09	0.244	0.225	0.153	52.22	50.47	55.17
7	0	2	2.96	2.84	3.09	0.274	0.221	0.171	61.95	56.27	55.82
4	0	1	2.95	2.61	3.05	0.239	0.216	0.146	53.77	52.75	54.62
1	0	0	2.87	2.74	2.91	0.257	0.196	0.127	55.90	52.67	52.67
						Summary Statistics					
Experimental Means			2.94	2.72	3.04	0.2599	0.2197	0.1536	56.69	52.17	54.95
Error Mean Square			0.055	0.018	0.019	4.53E-04	3.92E-04	9.23E-04	6.13	7.72	18.17
P-value			0.3096	0.2923	0.4224	0.1360	0.2646	0.1810	0.0009	0.0047	0.9005
Standard Error			0.234	0.133	0.138	0.02128	0.0198	0.03038	2.48	2.78	4.26
Standard Error of the Mean			0.117	0.067	0.069	0.011	0.010	0.015	1.24	1.39	2.13
C.V. 1: (s/mean)*100			7.98	4.91	4.52	8.19	9.02	19.79	4.37	5.33	7.76
LSD (0.05)			NS	NS	NS	NS	NS	NS	3.61	4.06	NS
						Phosphorus Summary					
80			2.89	2.68	3.03	0.262	0.228	0.163	56.92	49.47	55.72
40			3.01	2.74	3.08	0.261	0.220	0.150	55.93	53.13	54.75
0			2.93	2.73	3.01	0.257	0.211	0.148	57.21	53.90	54.37
LSD (0.05)			NS	NS	NS	NS	NS	NS	NS	2.34	NS
						Boron Summary					
2			2.88	2.76	3.09	0.264	0.221	0.171	59.41	53.82	55.77
1			3.01	2.69	3.06	0.256	0.217	0.149	55.86	52.00	55.25
0			2.93	2.70	2.98	0.260	0.220	0.140	54.80	50.68	53.82
LSD (0.05)			NS	NS	NS	NS	NS	0.026	2.09	2.34	NS
Interaction P-value			0.1931	0.1651	0.6793	0.0320	0.2279	0.4241	0.0118	0.2482	0.8532

Table 3. Continued:

Entry	Treatment P_2O_5	Treatment B	Ca 1st Cut	Ca 2nd Cut	Ca 3rd Cut	S 1st Cut	S 2nd Cut	S 3rd Cut	K 1st Cut	K 2nd Cut	K 3rd Cut
	-----(lbs/a)-----		----------(%)----------			----------(%)----------			----------(%)----------		
9	80	2	1.66	1.36	1.43	0.329	0.332	0.331	2.83	2.61	2.60
6	80	1	1.69	1.42	1.14	0.333	0.346	0.278	2.79	2.71	2.59
3	80	0	1.82	1.49	0.94	0.348	0.347	0.220	2.84	2.56	2.51
8	40	2	1.74	1.49	1.11	0.353	0.361	0.261	2.80	2.61	2.66
5	40	1	1.70	1.41	1.08	0.350	0.335	0.267	2.93	2.67	2.51
2	40	0	1.56	1.39	1.13	0.309	0.339	0.261	2.89	2.77	2.67
7	0	2	1.78	1.54	1.35	0.370	0.366	0.328	2.99	2.62	2.64
4	0	1	1.64	1.56	1.21	0.313	0.352	0.286	2.68	2.52	2.54
1	0	0	1.69	1.43	0.95	0.339	0.344	0.233	3.00	2.72	2.60
						Summary Statistics					
Experimental Means			1.70	1.45	1.15	0.338	0.347	0.274	2.86	2.64	2.59
Error Mean Square			0.017	0.022	0.073	8.09E-04	1.47E-03	4.32E-03	0.037	0.049	0.026
P-value			0.2679	0.5767	0.2208	0.1130	0.9336	0.2857	0.3825	0.8106	0.7528
Standard Error			0.132	0.149	0.270	0.028	0.038	0.066	0.191	0.222	0.160
Standard Error of the Mean			0.066	0.075	0.135	0.014	0.019	0.033	0.096	0.111	0.080
C.V. 1: (s/mean)*100			7.76	10.26	23.54	8.41	11.04	24.01	6.68	8.41	6.19
LSD (0.05)			NS	NS	NS	NS	NS	NS	NS	NS	NS
						Phosphorus Summary					
80			1.72	1.42	1.17	0.336	0.342	0.276	2.82	2.63	2.56
40			1.67	1.43	1.11	0.337	0.345	0.263	2.87	2.68	2.61
0			1.70	1.51	1.17	0.341	0.354	0.282	2.89	2.62	2.59
LSD (0.05)			NS	NS	NS	NS	NS	NS	NS	NS	NS
						Boron Summary					
2			1.72	1.47	1.30	0.350	0.353	0.307	2.87	2.61	2.63
1			1.68	1.46	1.14	0.332	0.344	0.277	2.80	2.63	2.54
0			1.69	1.43	1.01	0.332	0.343	0.238	2.91	2.68	2.59
LSD (0.05)			NS	NS	0.23	NS	NS	0.055	NS	NS	NS
Interaction P-value			0.0949	0.4475	0.3831	0.0461	0.7994	0.5194	0.2227	0.5496	0.6493

Table 3. Continued:

Entry	Treatment P_2O_5	Treatment B	Cu 1st Cut	Cu 2nd Cut	Cu 3rd Cut	Fe 1st Cut	Fe 2nd Cut	Fe 3rd Cut	Zn 1st Cut	Zn 2nd Cut	Zn 3rd Cut
	-----(lbs/a)-----		----------(ppm)----------			----------(ppm)----------			----------(ppm)----------		
9	80	2	6.69	6.09	6.91	102.0	70.40	71.05	15.07	14.15	14.32
6	80	1	6.65	6.64	6.86	117.3	79.10	59.60	17.55	14.85	15.32
3	80	0	6.43	6.12	6.77	103.1	75.55	44.65	17.60	13.97	14.87
8	40	2	6.81	6.91	7.05	137.6	74.50	50.50	16.40	15.88	14.97
5	40	1	6.65	6.47	7.22	138.8	72.62	55.67	17.65	14.57	15.00
2	40	0	6.48	6.62	6.90	99.10	73.70	54.72	17.42	14.85	14.22
7	0	2	6.80	7.12	7.38	124.6	82.85	66.67	18.77	17.35	16.82
4	0	1	6.24	6.33	7.25	157.0	75.02	61.20	16.15	14.82	16.45
1	0	0	6.45	6.80	6.94	97.97	72.55	50.32	16.20	14.80	15.62
						Summary Statistics					
Experimental Means			6.58	6.57	7.03	119.7	75.14	57.16	16.98	15.03	15.29
Error Mean Square			0.191	0.367	0.268	2333	88.19	278.30	4.33	1.00	1.31
P-value			0.6554	0.2733	0.7346	0.6316	0.7348	0.4555	0.3761	0.0030	0.0474
Standard Error			0.437	0.606	0.518	48.30	9.39	16.68	2.08	1.00	1.14
Standard Error of the Mean			0.219	0.303	0.259	24.15	4.70	8.34	1.04	0.500	0.571
C.V. 1: (s/mean)*100			6.65	9.22	7.37	40.35	12.50	29.19	12.26	6.65	7.47
LSD (0.05)			NS	NS	NS	NS	NS	NS	NS	1.46	NS
						Phosphorus Summary					
80			6.59	6.28	6.84	107.5	75.02	58.43	16.74	14.32	14.84
40			6.65	6.66	7.05	125.2	73.61	53.63	17.16	15.10	14.73
0			6.50	6.75	7.19	126.5	76.81	59.40	17.04	15.66	16.30
LSD (0.05)			NS	NS	NS	NS	NS	NS	NS	0.84	0.96
						Boron Summary					
2			6.76	6.71	7.11	121.4	75.92	62.74	16.75	15.79	15.37
1			6.51	6.48	7.11	137.7	75.58	58.83	17.12	14.75	15.59
0			6.45	6.51	6.87	100.0	73.93	49.90	17.07	14.54	14.91
LSD (0.05)			NS	NS	NS	NS	NS	NS	NS	0.84	NS
Interaction P-value			0.7645	0.2606	0.9505	0.8534	0.4107	0.4918	0.1054	0.0398	0.6008

Table 3. Continued.

Entry	Treatment P_2O_5	Treatment B	Mg 1st Cut	Mg 2nd Cut	Mg 3rd Cut	Mn 1st Cut	Mn 2nd Cut	Mn 3rd Cut	Na 1st Cut	Na 2nd Cut	Na 3rd Cut
	-----(lbs/a)-----		----------(%)----------			----------(ppm)----------			----------(ppm)----------		
9	80	2	0.467	0.311	0.283	27.73	21.75	22.43	997.8	764.5	1320.0
6	80	1	0.442	0.325	0.215	29.13	20.60	18.13	1009.0	940.0	1063.0
3	80	0	0.472	0.332	0.194	30.28	22.98	14.28	1003.0	900.3	1279.0
8	40	2	0.477	0.340	0.222	30.13	21.80	16.95	961.3	988.3	1277.0
5	40	1	0.459	0.322	0.215	30.70	21.23	17.18	824.0	948.3	1180.0
2	40	0	0.432	0.312	0.216	26.33	21.95	17.35	958.8	786.8	1130.0
7	0	2	0.470	0.321	0.259	32.65	25.08	22.05	939.8	812.3	1358.0
4	0	1	0.445	0.333	0.224	27.03	22.45	17.13	998.5	1125.0	1265.0
1	0	0	0.449	0.313	0.190	27.85	19.78	14.10	869.3	1005.0	1283.0
						Summary Statistics					
Experimental Means			0.457	0.323	0.224	29.09	21.96	17.73	951.1	918.9	1239.0
Error Mean Square			2.34E-03	1.08E-03	2.38E-03	10.08	10.82	17.95	3.85E+04	4.55E+04	1.01E+05
P-value			0.8981	0.9108	0.2250	0.1658	0.5761	0.1113	0.8883	0.3406	0.9313
Standard Error			0.048	0.033	0.049	3.18	3.29	4.24	196.3	213.3	318.3
Standard Error of the Mean			0.024	0.016	0.024	1.59	1.64	2.12	98.15	106.6	159.2
C.V. 1: (s/mean)*100			10.58	10.15	21.74	10.91	14.98	23.9	20.64	23.21	25.69
LSD (0.05)			NS	NS	NS	NS	NS	NS	NS	NS	NS
						Phosphorus Summary					
80			0.460	0.323	0.231	29.04	21.78	18.28	1003.0	868.3	1221.0
40			0.456	0.325	0.218	29.05	21.66	17.16	914.7	907.8	1195.0
0			0.455	0.322	0.224	29.18	22.43	17.76	935.8	980.8	1302.0
LSD (0.05)			NS	NS	NS	NS	NS	NS	NS	NS	NS
						Boron Summary					
2			0.471	0.324	0.254	30.17	22.88	20.48	966.3	855.0	1318.0
1			0.449	0.327	0.218	28.95	21.43	17.48	943.7	1004.0	1169.0
0			0.451	0.319	0.200	28.15	21.57	15.24	943.5	897.4	1231.0
LSD (0.05)			NS	NS	0.041	NS	NS	3.57	NS	NS	NS
Interaction P-value			0.7937	0.5968	0.4954	0.0572	0.3238	0.2822	0.7273	0.3423	0.9338

Table 4. The effect of phosphorus and boron on nutrient uptake of alfalfa. Western Triangle Ag. Research Center, Conrad, MT. 1998.

Entry	Treatment		N			P			K		
-	P_2O_5	B	Cut 1	Cut 2	Cut 3	Cut 1	Cut 2	Cut 3	Cut 1	Cut 2	Cut 3
-	------ (lbs/a) ------		---------- (%) ----------			---------- (%) ----------			---------- (%) ----------		
1	0	0	2.59	2.75	2.60	0.161	0.211	0.157	2.15	2.31	2.28
2	40	0	2.74	2.92	2.70	0.185	0.246	0.179	2.10	2.41	2.35
3	80	0	2.72	2.88	2.72	0.204	0.256	0.182	2.04	2.36	2.16
4	0	1	2.67	2.89	2.76	0.170	0.224	0.162	2.03	2.16	2.25
5	40	1	2.83	2.86	2.77	0.197	0.243	0.179	2.14	2.35	2.38
6	80	1	2.84	2.87	2.69	0.198	0.254	0.192	2.04	2.22	2.29
7	0	2	2.65	2.85	2.68	0.169	0.223	0.164	2.05	2.31	2.23
8	40	2	2.81	2.85	2.70	0.193	0.241	0.171	2.02	2.23	2.24
9	80	2	2.75	2.87	2.66	0.198	0.252	0.196	2.12	2.31	2.26

Summary Statistics

Experimental Means	2.73	2.86	2.70	0.186	0.239	0.176	2.08	2.30	2.27
Error Mean Square	0.01208	0.009488	0.005116	0.127E-3	0.283E-3	0.989E-4	0.0423	0.03266	0.02028
P-value	0.0425	0.5079	0.0935	0.0000	0.0065	0.0000	0.9822	06683	0.5649
Standard Error of the Mean	0.05495	0.0487	0.0487	0.563E-2	0.842E-2	0.497E-2	0.1028	0.09035	0.07121
C.V. 1: (s/mean)*100	4.025	3.407	2.653	6.056	7.049	5.661	9.912	7.875	6.276
LSD (0.05)	0.16	NS	NS	0.016	0.025	0.015	NS	NS	NS

Phosphorus Summary

0	2.64	2.83	2.68	0.167	0.219	0.161	2.08	2.26	2.25
40	2.79	2.88	2.72	0.192	0.243	0.196	2.09	2.33	2.32
80	2.77	2.87	2.69	0.200	0.254	0.190	2.06	2.30	2.24
LSD (0.05)	0.08	NS	NS	0.011	0.015	0.009	NS	NS	NS

Boron Summary

0	2.68	2.85	2.67	0.183	0.238	0.173	2.09	2.36	2.26
1	2.78	2.87	2.74	0.188	0.240	0.178	2.07	2.24	2.31
2	2.74	2.86	2.68	0.187	0.0239	0.177	2.06	2.29	2.24
LSD (0.05)	0.08	NS	0.06	NS	NS	NS	NS	NS	NS
Interaction P-value	0.9380	0.0871	0.1817	0.5438	0.7936	0.4095	0.8028	0.6495	0.4401

Table 4. continued:

Entry	Treatment		B			Ca			Cu		
-	P_2O_5	B	Cut 1	Cut 2	Cut 3	Cut 1	Cut 2	Cut 3	Cut 1	Cut 2	Cut 3
-	------ (lbs/a) ------		---------- (ppm) ----------			---------- (%) ----------			---------- (ppm) ----------		
1	0	0	47.1	44.0	52.1	1.50	1.30	1.54	5.4	8.8	8.2
2	40	0	45.3	47.2	51.4	1.35	1.29	1.51	5.4	8.2	6.8
3	80	0	50.2	42.5	51.7	1.56	1.37	1.62	5.2	8.0	7.2
4	0	1	48.3	48.4	55.8	1.71	1.39	1.69	5.7	8.5	7.7
5	40	1	49.7	45.5	51.9	1.49	1.30	1.52	5.5	8.1	7.0
6	80	1	48.9	45.9	54.6	1.51	1.36	1.59	5.1	8.2	8.4
7	0	2	52.1	47.9	55.7	1.44	1.38	1.57	6.1	9.6	8.4
8	40	2	50.3	47.7	51.6	1.49	1.28	1.54	5.7	8.8	7.5
9	80	2	49.5	45.5	52.1	1.44	1.30	1.57	5.3	7.8	6.5

Summary Statistics

Experimental Means	49.0	46.1	53.1	1.50	1.33	1.57	5.5	8.4	7.5
Error Mean Square	14.40	10.73	8.814	0.0176	0.0087	0.0090	0.1665	0.3869	1.418
P-value	0.4072	0.2354	0.2128	0.0616	0.5610	0.2198	0.0643	0.0117	0.2300
Standard Error of the Mean	1.897	1.638	1.484	0.06633	0.04652	0.04739	0.2040	0.3110	0.5955
C.V. 1: (s/mean)*100	7.742	7.110	5.593	8.858	6.999	6.025	7.465	7.400	15.87
LSD (0.05)	NS	NS	NS	0.19	NS	NS	0.6	0.9	NS

Phosphorus Summary

0	49.2	46.8	54.8	1.55	1.36	1.60	5.7	8.9	8.1
40	48.4	46.8	51.6	1.44	1.29	1.52	5.5	8.3	7.1
80	49.5	44.6	52.8	1.50	1.34	1.59	5.2	8.0	7.4
LSD (0.05)	NS	NS	2.5	NS	NS	0.07	0.4	0.6	NS

Boron Summary

0	47.5	44.6	52.0	1.47	1.32	1.56	5.3	8.3	7.4
1	48.9	46.6	54.1	1.57	1.35	1.60	5.4	8.2	7.7
2	50.6	47.0	53.1	1.45	1.32	1.56	5.7	8.7	7.4
LSD (0.05)	NS	NS	NS	0.11	NS	NS	NS	NS	NS
Interaction P-value	0.4573	0.4406	0.7619	0.0988	0.6090	0.1992	0.7436	0.3181	0.2469

Table 4. continued:

Entry	Treatment		Fe			Mg			Mn		
-	P_2O_5	B	Cut 1	Cut 2	Cut 3	Cut 1	Cut 2	Cut 3	Cut 1	Cut 2	Cut 3
-	------ (lbs/a) ------		---------- (ppm) ----------			---------- (%) ----------			---------- (ppm) ----------		
1	0	0	51.8	93.2	63.0	0.337	0.340	0.325	17.8	20.9	20.3
2	40	0	60.2	104.8	62.7	0.338	0.352	0.332	18.2	23.6	23.0
3	80	0	57.0	114.5	63.8	0.369	0.378	0.363	20.6	24.6	23.3
4	0	1	66.7	106.1	62.4	0.369	0.361	0.369	20.5	22.3	24.1
5	40	1	60.4	89.3	61.8	0.342	0.332	0.343	20.1	20.9	22.3
6	80	1	65.8	85.2	72.4	0.347	0.350	0.335	19.7	22.7	21.5
7	0	2	72.2	100.7	62.2	0.338	0.349	0.346	20.7	26.0	26.4
8	40	2	73.4	99.6	63.8	0.364	0.356	0.353	19.1	23.2	20.9
9	80	2	55.1	92.0	61.9	0.361	0.366	0.357	19.5	22.9	23.3

Summary Statistics

Experimental Means	62.5	98.4	63.8	0.352	0.354	0.347	19.6	23.0	22.8
Error Mean Square	106.2	134.3	79.7	0.218E-2	0.851E-3	0.694E-3	5.447	4.380	7.527
P-value	0.0674	0.0310	0.8203	0.7812	0.5609	0.3192	0.6160	0.0402	0.1207
Standard Error of the Mean	5.153	5.795	4.463	0.0179	0.0146	0.0132	1.167	1.046	1.372
C.V. 1: (s/mean)*100	16.49	11.78	14.00	10.20	8.251	7.596	11.93	9.102	12.05
LSD (0.05)	15.0	16.9	NS	NS	NS	NS	NS	3.1	NS

Phosphorus Summary

0	63.6	100.0	62.5	0.348	0.350	0.347	19.7	23.1	23.6
40	64.7	97.9	32.8	0.348	0.346	0.343	19.1	22.5	22.1
80	59.3	97.2	66.0	0.359	0.364	0.352	19.9	23.4	22.7
LSD (0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS

Boron Summary

0	56.3	104.2	63.1	0.348	0.356	0.340	18.8	23.0	22.1
1	64.3	93.5	65.5	0.352	0.348	0.349	20.1	22.0	22.6
2	66.9	97.4	62.6	0.354	0.357	0.352	19.8	24.0	23.6
LSD (0.05)	9.6	8.8	NS	NS	NS	NS	NS	2.0	NS
Interaction P-value	0.1786	0.0116	0.6636	0.4635	0.4354	0.0330	0.4000	0.0716	0.0677

Table 4. continued:

Entry	Treatment		Na			S			Zn		
-	P_2O_5	B	Cut 1	Cut 2	Cut 3	Cut 1	Cut 2	Cut 3	Cut 1	Cut 2	Cut 3
-	------ (lbs/a) ------		---------- (%) ----------			---------- (%) ----------			---------- (ppm) ----------		
1	0	0	0.102	0.081	0.135	0.272	0.331	0.359	14.7	17.2	9.7
2	40	0	0.118	0.074	0.127	0.268	0.340	0.355	14.2	16.1	10.3
3	80	0	0.127	0.087	0.179	0.281	0.349	0.374	13.4	12.6	11.9
4	0	1	0.103	0.085	0.145	0.295	0.354	0.399	16.0	19.0	12.6
5	40	1	0.108	0.089	0.161	0.286	0.330	0.353	13.9	15.8	9.9
6	80	1	0.114	0.077	0.132	0.288	0.348	0.359	15.1	23.9	11.0
7	0	2	0.106	0.075	0.136	0.280	0.360	0.389	17.9	18.0	23.6
8	40	2	0.130	0.076	0.156	0.283	0.333	0.361	16.5	18.0	8.8
9	80	2	0.104	0.082	0.149	0.292	0.335	0.354	13.7	13.2	8.8

Summary Statistics

Experimental Means	0.112	0.081	0.147	0.283	0.342	0.367	15.0	17.1	11.8
Error Mean Square	0.923E-3	0.483E-3	0.159E-2	0.197E-3	0.733E-3	0.291E-3	1.770	27.35	15.89
P-value	0.8724	0.9827	0.7140	0.1925	0.7582	0.0039	0.0009	0.1612	0.0007
Standard Error of the Mean	0.015	0.011	0.020	0.702E-2	0.135E-1	0.853E-2	0.6651	2.615	1.993
C.V. 1: (s/mean)*100	27.17	27.22	27.17	4.967	7.910	4.647	8.850	30.62	33.69
LSD (0.05)	NS	NS	NS	NS	NS	0.025	1.9	NS	5.8

Phosphorus Summary

0	0.104	0.081	0.139	0.282	0.348	0.392	16.2	18.1	15.3
40	0.119	0.080	0.148	0.279	0.334	0.356	14.9	16.6	9.6
80	0.115	0.082	0.153	0.287	0.344	0.362	14.0	16.6	10.6
LSD (0.05)	NS	NS	NS	NS	NS	0.017	1.2	NS	3.9

Boron Summary

0	0.116	0.081	0.147	0.274	0.340	0.363	14.1	15.3	10.6
1	0.108	0.084	0.146	0.290	0.344	0.370	15.0	19.6	11.1
2	0.113	0.078	0.147	0.285	0.343	0.368	16.0	16.4	13.8
LSD (0.05)	NS	NS	NS	0.014	NS	NS	1.2	NS	NS
Interaction P-value	0.6017	0.4884	0.1552	0.7942	0.5836	0.0656	0.0696	0.1500	0.0115

Table 5. Soil test for P and B separated by fertilizer rates for 0 to 6" depth. Western Triangle Ag. Research Center, Conrad, MT. 1998.

Treatment		Soil Test[1]	
P_2O_5	B	P	B
---------- (lbs/a) ----------		---------- (ppm) ----------	
0	0	9.5	0.51
40	1	16.9	0.66
80	2	18.0	0.79

[1] Soil sampled for P on October 7, 1997 and for B on March 25, 1998.