THE EFFECT OF pH AND POTASSIUM ON THE YIELD AND QUALITY OF ALFALFA HAY

FINAL REPORT

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ABSTRACT

An experiment to study the effects of soil pH and potassium (K) on potatoes, winter wheat, and alfalfa was begun in 1979 at Powell Butte, Oregon. A wide range of soil pH levels was created by the addition of lime or elemental sulphur; five K levels were created by the addition of potassium chloride. The trial area was seeded with Pioneer 532 alfalfa in 1984. One cutting was taken in 1984, three cuttings were taken each year in 1985 and 1986, and 1987.

In each of the four years of the study, hay yields increased as the soil pH increased. When the pH level dropped below 6.5 (the highest pH observed in the study), yields decreased. Also, in each year, as the soil pH level dropped below 6.5, the percent crude protein dropped. Higher pH levels were also advantageous in stand establishment and nodule formation.

The soil K level had less effect on yield and quality of alfalfa hay than soil pH levels. As soil K increased, hay yields trended slightly higher.

INTRODUCTION

Hay is one of Oregon's principal farm commodities, ranking third in total value of production, behind cattle/calves, and greenhouse/nursery products in 1987 (1). Approximately 52,000 acres of hay are grown annually in Deschutes, Crook, Jefferson, and northern Klamath counties. A soil fertility survey conducted in 1980 on central Oregon alfalfa fields indicated 42 percent of the fields were below a pH critical level of 6.5, and five percent of the fields were below the soil K critical level of 150 ppm (2). Fertilizing alfalfa

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with K was not practiced in central Oregon for many years because soil K levels were very high (800-1200 ppm) when lands were converted from rangeland to cropland. In 1980, surveyed fields averaged 367 ppm of K and many were lower, hence a downward trend in K fertility has developed in central Oregon alfalfa fields.

An experiment to study the effects of soil pH and K on potatoes was begun in 1979 at Powell Butte, Oregon. A wide range of soil pH and K levels was created by the addition of lime or elemental sulphur and potassium chloride. After completion of the potato studies in 1983, the trial was seeded to alfalfa in 1984. The alfalfa experiment was designed to determine critical pH and soil K levels and aid in the fertilizer recommendations of lime and K.

MATERIALS AND METHODS

A relatively uniform Deschutes sandy loam site with a pH of 5.5 and soil K level of 168 ppm at the Powell Butte site of Central Oregon Experiment Station was chosen for the experiment in 1979. The experiment consisted of 20 treatments arranged in a completely random design replicated four times. Plots were sized 20 feet x 30 feet to facilitate tillage and reduce edge effects. Four different pH levels were artificially created on March 19, 1979, by four application levels of: four tons/acre of lime, two tons/acre of lime, no amendment, and one and one-half tons/acre of elemental sulphur. These treatments were allowed to stabilize for one year with a crop of potatoes.

Five K levels were created within each pH level in May, 1980, by the application of 0, 100, 200, 400, and 800 pounds/acre of K as muriate of potash. The K treatments were repeated in April 1982, and May 1986.

The trial area was cropped as follows:

1979:	Potatoes
1980:	Potatoes
1981:	Winter Wheat
1982:	Potatoes
1983:	Winter Wheat
1984:	Alfalfa
1985:	Alfalfa
1986:	Alfalfa
1987:	Alfalfa

The trial was seeded June 6, 1984, with 17 pounds/acre of Pioneer 532 alfalfa. The plots were treated with three pints/acre of Eptam 7-E before planting and two quarts/acre of 2,4-DB was applied July 5, 1984, after the plants had

three trifoliate leaves. The trial was fertilized with 650 pounds/acre of 0-10-0-13 in 1984 and 1985; 455 pounds/acre of 0-10-0-13 was applied in 1986, and 490 pounds/acre of 0-10-0-13 was broadcast in 1987.

One cutting of hay was taken in 1984 on August 30. A 20-foot x 44-inch swath was harvested from each plot and a one-pound sample was taken from each plot for moisture determination and plant analysis. Three cuttings of hay were taken in 1985, 1986, and 1987. Protein and plant nutrients were determined from the first cutting in 1984 (only cutting), the second cutting in 1985, the third cutting in 1986, and the second cutting in 1987.

The soil was sampled August 30, 1984, May 2, 1985, and September 11, 1986, and July 17, 1987. Eight cores at a sampling depth of 0-8 inches were taken from each plot and analyzed for pH, phosphorus, potassium, calcium, and magnesium.

Ten plants with their entire root systems were removed from the center of each plot immediately after the first cutting was taken in 1984. The samples were refrigerated overnight and carefully washed the following day. The number of pink or presumably functioning nodules was recorded for each plant. Nodulation samples were not taken in 1985 and 1986.

RESULTS

Yield, soil analyses, plant analyses, and hay quality results are shown in Table 1, Table 2, Table 3, and Table 4 for 1984, 1985, and 1986, and 1987, respectively.

1984. Soil pH levels ranged from 5.2 to 6.5 in 1984. Hay yields from the first cutting of the new stand significantly increased for each increase in soil pH. Soil K had no effect on hay yield.

Soil pH also affected hay quality; pH levels over 6.0 increased percent crude protein significantly over pH levels under 6.0. Higher soil pH levels increased acid detergent fiber and total digestible nutrients, but decreased relative feed value. Soil K levels had little effect on hay quality in 1984.

Nodulation was increased nearly threefold when the pH level was greater than 6.0 as compared with pH levels less than 6.0. A soil K level of 321 ppm also significantly increased nodulation over a soil K level of 116.

1985. Soil pH levels were lower in 1985 than the other years tested. Generally, the soil pH is lower in the spring after fertilizer application than later in the year. The

soil was sampled May 2, 1985; soil samples were taken later in the year in each of the three additional years of the study. Hay yields increased as soil pH and K levels increased. At a pH less than 5.4, hay yields were significantly lower than treatments with a pH of 5.4 or higher. As soil K levels increased, yields corresponding increased.

Crude protein increased as soil pH increased except the 18.3 percent crude protein observed at the lowest pH level was surprisingly high and equal to the percent protein at the two higher pH levels. Soil K levels of 160 and 162 ppm produced the highest protein levels in 1985.

1986. As soil pH increased, total hay yields, percent crude protein, and percent acid detergent fiber (ADF) increased. Increasing soil K levels also increased yields except for the highest level of K (336 ppm). Percent crude protein decreased as soil K levels increased.

1987. As soil pH levels increased, hay yield, and percent crude protein increased. At a pH of 6.4, hay yields averaged nearly one half a ton per acre higher and tested two percent higher in crude protein than hay yields and percent crude protein harvested from plots with a pH of 5.3. Hay yields also trended higher as soil K levels increased; soil K had no effect on percent crude protein.

Plant Analysis. In each year of the study, as pH levels increased, plant K, Mg, Zn, and Mn decreased. The soil pH had no effect on plant P and Ca, except in 1987 when plant Ca levels increased as soil pH increased. Also, in each year higher soil K levels increased the uptake of K and decreased plant Mg. Soil K had no effect on plant Zn and Mn except in 1986 when high K levels decreased the amount of Zn in the plant. Higher soil K levels tended to decrease plant P and Ca.

SUMMARY

In each of the four years of the study, hay yields increased as the soil pH increased. When the pH level dropped below 6.5 (the highest pH observed in the study), yields decreased. Also, in each year, as the soil pH level dropped below 6.5, the percent crude protein dropped. Higher pH levels were also advantageous in stand establishment and nodule formation.

The soil K level had less effect on yield and quality of alfalfa hay than soil pH levels. As soil K increased, hay yields trended slightly higher.

LITERATURE CITED

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(2) Rogers, W.R., H. Gardner, W.S. Reid, R. Rizzio. 1980. Results of a Soil Fertility Survey of Oregon Alfalfa Fields. OSU Department of Soil Science, unpublished manuscript.

Table 1. The effect of four pH treatments and five potassium treatments on the yield, quality, nodulation, and soil and plant nutrient levels of establishment year (1984) alfalfa grown at Powell Butte, OR

Treatment	Yield	Nodules /plant	Crude protein	ADF	TDN	RFV	Soil pH	Soil P	Soil K	Soil Ca	Soil Mg	Plant P	Plant K	Plant Ca	Plant Mg	Zn	Mn
	ton/A	no.	%	%				ppm	ppm	meq	meq	%	%	%	%	ppm	ppm
pH-1	1.43	1.38	13.0	31.5	54.7	140	5.2	41.6	196	8.1	3.2	.27	2.3	1.4	.37	27.9	168
pH-2	1.69	1.38	13.3	32.3	54.7	137	5.8	35.1	184	8.5	4.1	.27	2.0	1.4	.33	23.0	69
pH-3	2.00	3.38	15.4	33.5	56.0	133	6.2	31.1	185	10.7	3.8	.27	2.1	1.4	.31	21.1	53
pH-4	2.22	3.96	15.4	33.9	55.8	132	6.5	32.2	168	12.0	3.6	.27	2.0	1.4	.27	18.5	45
LSD 5%	0.14	1.05	0.9	1.2	.8	4	0.1	3.0	21	0.3	.2	NS	.1	NS	.02	1.9	13
K-0	1.86	1.88	-14.2	33.1	55.2	135	6.0	32.5	116	9.8	3.6	.27	1.7	1.4	.37	21.7	73
K-100	1.94	2.50	14.3	33.3	55.2	134	6.0	34.1	131	9.9	3.5	.27	1.9	1.4	.34	23.6	89
K-200	1.77	2.11	14.3	32.9	55.3	136	5.9	34.3	166	10.3	3.9	.27	2.1	1.4	.33	23.1	88
K-400	1.89	2.56	13.9	32.9	55.0	135	5.9	34.8	182	9.9	3.6	.27	2.2	1.4	.29	21.3	79
K-800	1.71	3.57	14.7	31.9	55.9	139	5.9	39.3	321	10.4	3.8	.27	2.6	1.3	.28	23.3	89
LSD 5%	NS	1.18	NS	1.3	NS	4	NS	3.4	24	0.4	.3	NS	.1	NS	.03	NS	14

Table 2. The effect of four pH treatments and five Potassium treatments on the yield, quality, and soil and plant nutrient levels of second year (1985) alfalfa grown at Powell Butte, OR

Treatment	Yield*	Crude protein	ADF	TDN	RFV	Soil pH	Soil P	Soil K	Soil Ca	Soil Mg	Plant P	Plant K	Plant Ca	Plant Mg	Plant Zn	Plant Mn
	ton/A	%	%				ppm	ppm	meq	meq	%	%	%	%	ppm	ppm
pH-1	5.7	18.3	36.0	57.3	125	4.78	39.3	169	8.9	4.1	0.37	2.5	0.9	0.41	11.6	92
pH-2	6.0	17.1	37.9	55.9	118	5.43	31.9	176	10.9	4.0	0.36	2.4	1.0	0.39	13.9	52
pH-3	6.0	18.4	37.6	56.9	119	5.73	25.0	183	12.2	3.2	0.34	2.2	1.0	0.38	12.7	41
pH-4	6.1	18.5	39.1	56.6	113	6.11	28.8	164	13.0	3.5	0.34	2.0	1.0	0.36	12.3	34
LSD 5%	0.3	1.0	1.1	.9	4	0.12	5.8	19	0.8	0.7	NS	0.2	NS	0.02	NS	13
K-0	5.7	17.6	37.7	56.3	119	5.65	29.2	147	11.1	3.9	0.35	2.0	1.0	0.42	13.7	55
K-100	5.9	18.9	36.7	57.5	122	5.57	32.0	160	11.0	3.8	0.34	1.9	1.0	0.42	13.2	48
K-200	5.9	19.0	37.9	57.3	118	5.44	28.1	162	10.9	4.0	0.36	2.2	1.0	0.40	12.2	59
K-400	6.1	17.4	38.2	56.1	117	5.41	31.8	168	11.4	3.3	0.36	2.4	0.9	0.38	11.6	51
K-800	6.2	17.4	37.8	56.1	118	5.50	35.1	229	11.8	3.3	0.34	3.0	0.9	0.31	12.5	62
LSD 5%	0.3	1.1	1.2	1.0	4	0.14	6.5	21	0.9	NS	NS	0.2	NS	0.03	NS	NS

* Total of three cuttings

Table 3. The effect of four pH treatments and five Potassium treatments on the yield, quality, and soil and plant nutrient levels of third year (1986) alfalfa grown at Powell Butte, OR

Treatment	Yield*	Crude protein	ADF	TDN	RFV	Soil					Plant					
						pH	P	K	Ca	Mg	P	K	Ca	Mg	Zn	Mn
	ton/A	%	%				ppm	ppm	meq	meq	%	%	%	%	ppm	ppm
pH-1	4.2	21.2	28.7	61.6	150	5.35	44.1	187	8.2	3.1	0.34	2.5	1.3	0.37	22.8	104
pH-2	4.7	21.4	31.2	61.1	141	5.85	33.3	177	9.6	3.8	0.35	2.6	1.3	0.35	21.7	58
pH-3	5.0	21.8	30.8	61.4	142	6.14	31.4	190	10.4	3.5	0.34	2.4	1.4	0.33	19.6	41
pH-4	5.2	22.2	30.7	61.8	143	6.41	30.8	186	11.8	3.3	0.34	2.2	1.5	0.33	21.8	35
LSD 5%	0.3	0.7	1.2	NS	4	0.08	3.6	NS	.5	.2	NS	0.2	NS	0.02	2.2	13
K-0	4.7	22.2	29.2	62.2	149	6.01	34.6	96	9.9	3.4	0.37	1.7	1.5	0.42	23.4	56
K-100	4.8	22.0	"30.5	61.7	143	5.93	33.6	124	9.8	3.3	0.35	2.0	1.4	0.38	21.3	54
K-200	4.6	22.3	29.2	62.3	148	5.91	36.0	172	10.2	3.6	0.33	2.4	1.4	0.35	22.1	68
K-400	5.0	21.2	31.1	60.9	141	5.93	33.2	197	9.8	3.3	0.34	2.8	1.3	0.33	19.8	55
K-800	4.7	20.5	31.8	60.2	138	5.89	37.0	336	10.3	3.5	0.32	3.2	1.2	0.27	20.7	64
LSD 5%	0.3	0.8	1.3	0.9	5	0.09	NS	29	NS	NS	0.02	0.2	NS	0.02	2.5	NS

* Total of three cuttings

Table 4. The effect of four pH treatments and five Potassium treatments on the yield, quality, and soil and plant nutrient levels of fourth year (1987) alfalfa grown at Powell Butte, OR

Treatment	Yield*	Crude protein	ADF	TDN	RFV	Soil					Plant					
						pH	P	K	Ca	Mg	P	K	Ca	Mg	Zn	Mn
	ton/A	%	%				ppm	ppm	meq	meq	%	%	%	%	ppm	ppm
pH-1	6.2	15.9	32.4	56.6	137	5.25	43.0	157	8.5	3.1	0.29	1.8	1.4	0.38	19.0	103
pH-2	6.3	16.1	33.8	56.4	131	5.87	34.1	162	10.0	3.7	0.29	1.7	1.5	0.37	18.8	65
pH-3	6.3	16.8	34.3	56.7	130	6.14	30.3	171	10.9	3.5	0.29	1.7	1.5	0.34	17.7	52
pH-4	6.6	17.7	33.6	57.5	132	6.36	28.6	145	12.2	3.3	0.29	1.5	1.7	0.33	17.1	43
LSD 5%	0.3	0.8	1.2	.9	5	0.10	3.3	NS	0.5	0.2	NS	0.2	0.1	0.02	1.0	6
K-0	6.2	16.5	32.9	56.9	135	6.06	32.8	94	10.5	3.5	0.31	1.2	1.7	0.42	18.3	71
K-100	6.4	17.0	32.6	57.4	136	5.91	32.8	106	10.1	3.3	0.30	1.4	1.6	0.39	18.4	67
K-200	6.4	16.4	34.9	56.1	127	5.83	33.4	127	10.4	3.5	0.29	1.6	1.5	0.36	18.1	62
K-400	6.4	16.5	33.8	56.7	131	5.88	34.6	165	10.1	3.3	0.28	1.8	1.5	0.33	17.6	62
K-800	6.5	16.7	33.4	56.9	133	5.84	36.3	303	10.8	3.5	0.28	2.4	1.4	0.29	18.1	67
LSD 5%	0.3	NS	1.4	1.0	5	0.11	NS	36	0.6	NS	0.01	0.2	0.1	0.03	NS	7

* Total of three cuttings