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

PRELIMINARY 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 and K levels was created by the addition of lime or elemental sulphur and 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. The trial will be continued for one more year (1987).

The preliminary results after three years suggest that soil pH levels below 6.0 are detrimental to hay yield and quality. The pH treatments below 6.0 had lower yields, fewer nodules, and lower percent crude protein than plots with a pH above 6.0.

Soil K levels had less effect on yield and quality of alfalfa hay than soil pH levels. Increasing the soil K levels slightly increased hay yield but slightly decreased percent crude protein.

The production of hay is one of Oregon's principal farm commodity enterprises, ranking second in total value of production behind cattle/calves in 1985 (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 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.

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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 an application 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

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.

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 both 1985 and 1986. Protein and plant nutrients were evaluated from the first cutting in 1984 (only cutting), the second cutting in 1985, and the third cutting in 1986.

The soil was sampled August 30, 1984, May 2, 1985, and September 11, 1986. 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 including 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, and Table 3 for 1984, 1985, and 1986, 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. Increasing the pH 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 also significantly increased by increasing the pH and soil K levels. 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. Hay yields increased as pH and soil K levels increased. The effect of higher soil K levels producing greater hay yields noted in 1985 was not observed in 1984 with seedling alfalfa. The three cuttings of hay taken in 1985 perhaps removed more K from the soil thus producing the yield response to increased soil K levels.

The effect of pH on percent crude protein was similar to the effect seen in 1984 except the 18.3 percent 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. Increasing the soil pH increased total hay yield, percent crude protein, and percent acid detergent fiber (ADF). These effects have been consistent in each of the three years. Increasing the soil K levels also increased yields except for the highest level of K (336 ppm). Percent crude protein decreased as soil K levels increased.

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. Also, in each year higher soil K levels increased the uptake of K and decreased plant Mg. Soil K had no effect on plant P, Ca, Zn, and Mn except in 1986 when high K levels decreased the amount of Zn in the plant.

SUMMARY

The preliminary results after three years suggest that soil pH levels below 6.0 are detrimental to hay yield and quality. The pH treatments below 6.0 had lower yields, fewer nodules, and lower percent crude protein than plots with a pH above 6.0.

Soil K levels had less effect on yield and quality of alfalfa hay than soil pH levels. Increasing the soil K levels slightly increased hay yield but slightly decreased percent crude protein.

LITERATURE CITED

(1) Williamson, P.M., R.A. Ledbury. 1985. 1984-85 Oregon Agricultural Statistics. USDA Statistical Reporting Service and Oregon Department of Agriculture.

(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					Plant					
							pH	P	K	Ca	Mg	P	K	Ca	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 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	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