FERTILIZERS DO AFFECT POTATO DISEASES

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Central Oregon has been an important potato seed producing area for many years. The growing season is short with frequent June and late August or early September frosts that reduce populations of aphid and insect vectors. The cool summer nights also reduce activity of insect vectors that spread virus diseases. The short growing season is an advantage in reducing aphid population and diseases, but is a disadvantage in reducing yield potential.

The soils are mostly developed from volcanic ash that covered central Oregon when Mt. Mazama (Crater Lake) blew up about 6,000 years ago. This pumice-volcanic ash parent material has low K supplying power, was originally deficient in P and S, and has been acidified with many years' applications of ammonium fertilizers and sulfur. Elemental S was often applied to reduce scab when potato production was started forty years ago in this area.

This combination of soil and environmental conditions has developed a complex, but interesting, set of production problems.

Responses to N, P and S were evident in the first fertilizer demonstrations established; response from application of K on potatoes soon followed. The increased acidity developed on these poorly buffered soils, and the possibility of response from lime on these soils developed under arid environments has been a recent development. Previous experiments with lime and potassium have varied from no response to a lime-K interaction that resulted in 3 to 4 ton increases in yield when both lime and K were applied.

An experiment was started in 1978 to evaluate possible lime responses and whether lime applications might accentuate K deficiencies. Treatments of zero, 2 and 4 T lime/A and 1.5 T of S/A were established; after thorough mixing throughout the surface foot of soil and time to react during 1978 and 1979, these treatments had soil pH values of 4.5, 5.3, 5.9 and 6.3. Potatoes were grown in 1979 with a standard 160-160-160-100 (N-P_2O_5-K_2O-S) fertilizer banded at planting. Yields in 1979 were reduced from added lime, but plant analyses showed higher than normal Mn levels on low pH (S treated) plots and K deficiency was present on all treatments. We assumed that yields would be increased from lime after the K deficiency was corrected in 1980.

The experiment was planted in 1980 with a complete lime X K factorial (0-100-200-400-800 lb. K as KC1/A) on the four replications that had been established. One thousand lbs. of 16-20-0-14s was banded at planting to supply N, P and S. The experiment was irrigated with a solid set sprinkler system and routine weed control practices followed. Petiole samples were taken July 18 and August 5 for analyses.

Yields in 1980 were a surprise. Each increase in soil pH reduced yields (Table 1) even though petiole samples exceeded 600 ppm Mn on plots with soil pH of 4.5. Each increment of KC1 applied, except for the 800 lb. K rate of pH 4.5, increased yields (Fig. 1 and Table 1) and lime did not influence the K response; the lime X potassium interaction was not significant.

K Response

The increase in yield from K zero through 200, or possibly 400 lbs. K/A at high lime, was expected. However, yields were increased from 800 lbs. K/A on all but those S treatments

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with soil pH below 5.0. The K check plot petiole samples started with 5 to 8% K July 18 and had dropped to an average of 3% K August 5 (Fig. 1). However, the high K treatments had 11 to 13% K July 18 and had only dropped to 10-12% K by August 5. We assumed this response from the highest KCl rates applied was not a response from K as a nutrient and looked for explanations. The concentrations of K, Ca and Mg in plant samples were converted to chemically equivalent weights (Fig. 2 and Table 2). The application of KCl decreased concentrations of Ca and Mg, as expected; however, the increase in K was sufficent to result in an increase in the sum of K+Ca+Mg found in the plant.

Lime - Nitrate N - Chloride Relationships

Nitrate N in the petiole was reduced at low pH and with added KCl (Table 1, Figures 1 and 2). This was not surprising since either a pH of 4.5 or a high rate of Cl should reduce nitrification of NH_4-N applied. Also, the high level of Cl should reduce the NO_3-N found in the plant. All of these effects were evident.

Frost Protection

Potassium deficiency symptoms were evident in late August when a frost occurred. By mid-September, vines were dead on the K check plots and on most 100 lb. K treatments. Vines were green with luxuriant growth on high K plots. Reduced frost damage with high KCl applications had been observed in previous experiments. The increased level of total cations (K+Ca+Mg) with the 5 to 7% Cl levels on the high KCl treatments would be expected to increase the osmotic concentration of cell sap and possible reduced frost damage. Potassium deficiency was probably a dominating factor affecting vine death at low K levels, but K deficiency is not a good explanation for reduced damage when the 200, 400, and 800 lb. K treatments are compared. The 400 and 800 lb. K treatments maintained vigorous vine growth through September.

Plant Disease Relationships

This was the second consecutive potato crop. A concerted effort was made to pick up cull potatoes and pull volunteer plants to reduce virus infection. However, Verticillium dahliae can be identified in all "old" potato fields in central Oregon. Previous research by Huber and others have shown that reduced NO_3-N nutrition and increased NH_4 nutrition reduces Verticillium infections; specific effects of soil pH on the "early dying" complex of disease has not been established.

Summary for 1980 Experiment

This array of treatment effects suggests a complex set of plant nutrition-disease-frost damage interactions that can affect potato production in this area.

Possible effects of KCl in reducing specific gravity of tubers needs to be considered; the use of potassium sulfate has resulted in higher specific gravity of tubers than application of potassium chloride in a number of experiments. However, the 800 lb. K treatments were required to reduce specific gravity with soil pH of 5.3 and 5.9 -- the original lime check and 2 T lime/A plots. The complex set of factors -- maturity, tuber moisture content, level of N nutrition, disease, and starch-sugar translocation -- affect specific gravity.

The marked reduction in NO_3-N concentrations measured in petiole samples as Cl increased must be recognized and "taken into account" by agronomists and other consultants that are using plant analyses to monitor fertilizer programs and recommend N applications.

One experiment is not enough to change recommendations for production practices. However, these results point strongly towards a re-evaluation of plant nutrition-disease relationships. Changes in the NH_4NO_3 nutrition balance with marked shifts in Cl and K ion concentrations in cell sap can have many effects on plant growth and metabolism.

Experiments established near Redmond and Klamath Falls in 1981 where ammonium nitrate, ammonium sulfate, and ammonium chloride were applied in combination with different rates of potassium chloride and potassium sulfate helped to identify these treatment effects.

Results from 1981 Experiment

Results from the 1981 Central Oregon Experiment are summarized in Table 3 for the yield of marketable tubers (#1 and 2); Table 4 for the yield of 10+ oz. tubers; Table 5 for specific gravity effects; Table 6 for effects on stem soft rot.

Yield data summarized in Tables 3 and 4 show there was a marked response from potassium; yields of #1 plus #2 were increased from 11.8 T/A to 20.3 T/A when the three N sources were averaged. The increase in 10+ oz. tubers from 2.91 T/A to 8.77 T/A when the high rate of potassium chloride was added to the ammonium chloride N source was the outstanding yield effect; most of this yield increase was realized when the potassium rate was increased from 200 to 800 lbs. K_2O/A as the chloride source.

It is important to note that yields were decreased when the broadcast N rate was increased from 120 to 240 lbs. N/A at the high potassium rate; this was true for both sulfate and chloride sources of fertilizers.

Two effects of fertilizer treatments on stem soft rot should be noted in Table 6; (1) the level of stem soft rot decreased with the addition of potassium, and (2) this decrease was greater when potassium was combined with the ammonium chloride N source. These effects on disease may be associated with higher osmotic concentrations in the cell sap that are associated with higher rates of potassium and chloride fertilization.

The decrease in specific gravity (Table 5) with the higher potassium, nitrogen, and chloride rates was expected. These effects have been evident on many experiments throughout the Northwest. However, the reduced specific gravity did not reduce the overall quality of the French fries. In fact, higher rates of potassium resulted in fries with a lighter, more uniform, and more desirable color. This might have been the effect of higher potassium rates on starch content, maturity, and/or delayed conversion of starch to sugar. Higher sugar content gives a darker fry color.

Conclusions

We have concluded that we have identified a relationship between plant nutrition and plant disease with potatoes. High rates of potassium chloride undoubtedly has reduced frost damage in both the 1980 and 1981 Central Oregon experiments.

There are undoubtedly a number of plant maturity, plant water relationships, and cell sap osmotic concentration effects involved in these observations. Time of application of potassium, chloride, and nitrogen may be important in potassium, calcium, and magnesium uptake.

Plans for 1982

Experiments will be established in the Hermiston area, Central Oregon, and Klamath County. Potassium, chloride, and nitrogen sources will be compared; treatments will include both time and rate of application. Experimental areas will be fumigated to reduce Verticillium wilt in Klamath and Hermiston area experiments as part of grower practice. The plot area will not be fumigated in Central Oregon.

Plant samples will be taken for disease readings and chemical analyses during the growing season. Measurements will be made on osmotic concentrations of cell sap on selected treatments.

Emphasis will be placed on evaluating effects of time and rate of potassium, chloride, and N source treatments on yield, quality, and nutrient uptake. Possible calcium-heat necrosis relationships will be evaluated in the Hermiston and Central Oregon experiment. Specific gravity measurements will be made on all treatments. French fry quality tests will be run on selected treatments.

Table 1. Effects of Potassium and Lime (or S) Treatments on Yield and Nutrient Concentration in Potato Petioles. Central Oregon Exp. Sta. 1980.

Lime	POTASSIUM TREATMENTS, lb K/A					
or S	0	100	200	400	800	Avg.
	Total Yield, T/A					
S	14.50	16.28	17.60	18.90	18.75	17.20
0	11.34	14.53	14.48	16.88	18.33	15.11
2 T/A	9.49	13.68	14.91	16.43	17.27	14.35
4 T/A	10.09	11.89	13.63	14.67	15.34	13.12
Avg.	11.35	14.09	15.15	16.72	17.42	
	Yield of #1 plus #2, T/A					
S	8.99	10.58	12.28	13.81	13.08	11.75
0	5.18	7.86	9.64	11.05	12.46	9.24
2 T/A	3.72	7.57	9.83	11.09	11.24	8.69
4 T/A	4.44	6.23	7.69	9.29	10.11	7.55
Avg.	5.58	8.06	9.86	11.31	11.72	
	% Nitrate (NO_3)-N, sampled 8-5-80					
S	2.02	1.69	1.68	1.51	1.43	1.67
0	2.29	2.07	1.80	1.77	1.63	1.91
2 T/A	2.43	2.22	2.07	1.85	1.75	2.06
4 T/A	2.44	2.44	2.15	1.98	1.84	2.17
Avg.	2.30	2.11	1.93	1.78	1.66	
	% Chloride (Cl), sampled 8-5-80					
S	1.7	3.5	4.3	5.6	6.9	4.4
0	1.6	2.6	3.6	4.3	5.7	3.6
2 T/A	1.3	2.4	2.8	3.8	5.1	3.1
4 T/A	1.1	2.0	2.4	3.3	4.4	2.6
Avg.	1.4	2.6	3.3	4.3	5.5	
	ppm Mn (Manganese), sampled 7-18-80					
S	560	661	510	598	464	559
0	109	108	153	135	169	135
2 T/A	62	78	73	90	75	76
4 T/A	64	66	67	72	73	68
	ppm Zn (Zinc), sampled 7-18-80					
S	67	89	70	90	76	78
0	47	48	55	50	57	51
2 T/A	39	41	43	47	61	46
4 T/A	35	36	40	41	44	39

Table 2. Effects of Potassium and Lime (or S) Treatments on Potassium (K), Calcium (Ca), and Magnesium (Mg) Concentration of Petioles at two Sample Dates. Central Oregon Exp. Sta. 1980.

Lime or S	POTASSIUM TREATMENTS, lb K/A 0	100	200	400	800	Avg.
	---------% Potassium (K), sampled 7-18-80---------------					
S	8.1	10.4	10.7	12.1	12.8	10.8
0	6.2	7.8	9.5	10.5	11.9	9.2
2 T/A	5.5	7.3	8.5	9.6	11.4	8.5
4 T/A	5.6	6.4	8.2	9.6	11.1	8.2
Avg.	6.4	8.0	9.2	10.5	11.8	
	------------% Calcium (Ca), sampled 7-18-80-------------					
S	.79	.64	.71	.57	.68	.68
0	1.40	1.22	1.04	.99	.96	1.12
2 T/A	1.61	1.44	1.39	1.12	.96	1.30
4 T/A	1.59	1.64	1.42	1.30	1.04	1.40
Avg.	1.35	1.24	1.14	1.00	.91	
	---------% Magnesium (Mg), sampled 7-18-80-------------					
S	1.49	1.14	1.00	.81	.83	1.05
0	1.77	1.47	1.19	1.00	.80	1.25
2 T/A	1.79	1.50	1.32	1.02	.75	1.28
4 T/A	1.67	1.58	1.28	1.06	.77	1.27
Avg.	1.68	1.42	1.20	.97	.79	

Lime or S	POTASSIUM TRTS.	CATIONS IN PETIOLE K	Ca	Mg	Total
		sampled 8-5-80			
	--lb K/A--	-----------meq/100 g-----------			
S	0	114	47	155	316
	100	166	39	131	336
	200	215	42	110	367
	400	258	36	86	380
	800	312	37	71	420
0	0	77	67	174	318
	100	122	67	150	339
	200	149	62	128	339
	400	192	60	113	365
	800	284	47	66	397
2 T/A	0	54	76	180	310
	100	100	79	162	341
	200	128	74	136	338
	400	195	66	108	369
	800	259	56	72	387
4 T/A	0	64	85	178	327
	100	89	84	165	338
	200	117	80	148	345
	400	168	75	113	356
	800	248	62	75	385

Table 3. Potassium, chloride, and nitrogen source effects on yields of #1 and #2 tubers. Central Oregon Exp. Sta. (Powell Butte), 1981

Potassium treatment	#1+#2 tuber yield, Nitrogen Treatment N_1n	N_1s	N_1cl	Average
	----------Tons/Acre----------			
K_0	11.9	10.6	13.0	11.8
K_1s	13.3	15.5	16.7	15.2
K_1cl	12.1	15.2	17.5	14.9
K_2cl	17.1	13.1	15.5	15.2
K_4s	17.0	20.1	15.2	17.4
K_4cl	19.5	18.8	22.7	20.3
Average	15.2	15.6	16.8	
	N_1cl K_2s	N_2s K_4s	N_2cl K_4cl	
	16.1	15.0	18.5	

LSD .05 individual treatments = 4.71

Average for three treatments = 3.46

All plots received 200 lb/A 16-20-0-14S plus 200 lb/A superphosphate (45% P_2O_5) banded at planting. Added N and K were broadcast and disced before planting. Nn = ammonium nitrate, Ns = ammonium sulfate, Ncl = ammonium chloride. Ks = potassium sulfate, Kcl - potassium chloride. N_1, N_2 = 120 or 240 lb N/A added; K_1, K_2, K_4 = 200, 400, 800 lb K_2O/A.

Table 4. Potassium, chloride, and nitrogen source effects on yields of 10+ oz. tubers. Central Oregon Exp. Sta. (Powell Butte), 1981.

Potassium treatment	10+ oz tuber yield, Nitrogen Treatment N_1n	N_1s	N_1cl	Average
	----------Tons/Acre----------			
K_0	1.27	1.21	2.91	1.80
K_1s	2.95	2.53	4.16	3.21
K_1cl	1.84	3.14	4.45	3.14
K_2cl	4.12	2.85	4.97	3.98
K_4s	4.02	4.38	4.37	4.26
K_4cl	5.88	6.44	8.77	7.09
Average	3.34	3.44	4.94	
	N_1cl K_2s	N_2s K_4s	N_2cl K_4cl	
	3.06	2.29	6.61	

LSD .05 individual treatments = 2.73

Average for three treatments = 1.77

All plots received 200 lb/A 16-20-0-14S plus 200 lb/A superphosphate (45% P_2O_5 banded at planting. Added N and K were broadcast and disced before planting. Nn - ammonium nitrate, Ns = ammonium sulfate, Ncl = ammonium chloride. Ks - potassium sulfate, Kcl = potassium chloride. N_1, N_2 = 120 or 240 lb N/A added; K_1, K_2, K_4 = 200, 400, 800 lb K_2O/A.

Table 5. Potassium, chloride, and nitrogen source effects on specific gravity. Central Oregon Exp. Sta. (Powell Butte), 1981.

Potassium treatment	Nitrogen Treatment N_1n	N_1s	N_1cl	Average
K_0	1.085	1.087	1.082	1.085
K_1s	1.083	1.089	1.085	1.086
K_1cl	1.081	1.085	1.087	1.084
K_2cl	1.083	1.079	1.076	1.079
K_4s	1.084	1.085	1.080	1.083
K_4cl	1.080	1.079	1.080	1.080
Average	1.083	1.084	1.082	
	N_1cl K_2s	N_2s K_4s	N_2cl K_4cl	
	1.079	1.081	1.075	

All plots received 200 lb/A 16-20-0-14S plus 200 lb/A superphosphate (45% P_2O_5) banded at planting. Added N and K were broadcast and disced before planting. Nn = ammonium nitrate, Ns = ammonium sulfate, Ncl = ammonium chloride. Ks = potassium sulfate, Kcl = potassium chloride. N_1, N_2 = 120 or 240 lb N/A added; K_1, K_2, K_4 = 200, 400, 800 lb K_2O/A.

Table 6. Potassium, chloride, and nitrogen source effects on stem soft rot (Erwina cartovora) Central Oregon Exp. Sta. (Powell Butte), 1981.

Potassium treatment	Nitrogen Treatment N_1n	N_1s	N_1cl	Average
	------% infected stems-------			
K_0	35.0	52.5	22.5	36.7
K_1s	10.0	5.0	10.0	8.3
K_1cl	22.5	7.5	12.5	14.2
K_2cl	7.5	2.5	7.5	5.8
K_4s	12.5	12.5	2.5	9.2
K_4cl	2.5	12.5	2.5	5.8
Average	15.0	15.4	9.6	
	N_1cl K_2s	N_2s K_4s	N_2cl K_4cl	
	27.6	5.0	7.5	

All plots received 200 lb/A 16-20-0-14S plus 200 lb/A superphosphate (45% P_2O_5) banded at planting. Added N and K were broadcast and disced before planting. Nn = ammonium nitrate, Ns = ammonium sulfate, Ncl = ammonium chloride. Ks = potassium sulfate, Kcl = potassium chloride. N_1, N_2 = 120 or 240 lb N/A added; K_1, K_2, K_4 = 200, 400, 800 lb K_2O/A.

Figure 1. Relationship between Tuber Yield, #1 plus #2--T/A, and Nitrate-N, Chloride, and Potassium Concentration of Potato Petioles.

LIME AND POTASSIUM CHLORIDE EFFECTS ON YIELD
AND CHEMICAL COMPOSITION OF POTATO PETIOLES.
Central Oregon -- 1980

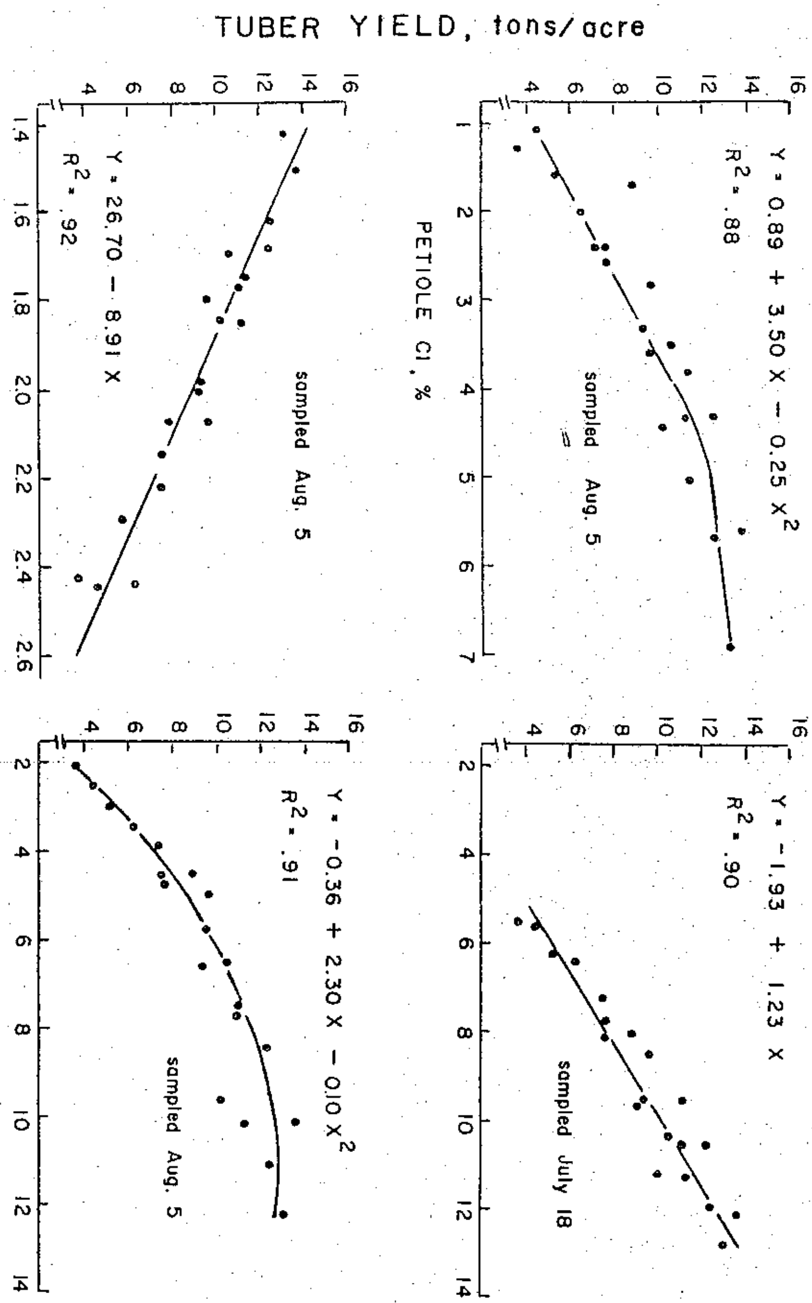

Figure 2. Potassium chloride effects on nutrient concentrations in petiole samples. Central Oregon 1980. Concentrations expressed in chemical equivalents.