Northeast Oregon Potato Soil Fertility Studies

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NORTHEAST OREGON POTATO SOIL FERTILITY STUDIES

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During the last 10 years, more than 100,000 acres of sandy desert land in the Columbia Basin of Oregon and Washington have been developed for potato production. About one-third of this acreage is in Oregon. The Basin is blessed with a long growing season and a plentiful supply of water for irrigation, with resulting high yields of potatoes. Total potato production for the region exceeds 2 million tons, with a farm value of more than $100 million. This converts to a processed value exceeding $300 million.

Soil characteristics cause some of the major problems in producing potatoes in this region. The sandy soils are subject to erosion and leaching losses of nutrients during irrigation; cation exchange capacities are low and relatively small amounts of nutrients are retained. Thus, under intensive crop production, the fertility of the soils changes rapidly.

The study consisted of two major components. First, a survey of growers' soil and plant analysis records was conducted to identify soil fertility problems. The results of this survey indicated that potassium fertilization of potato fields required further refinement. Second, field experiments were conducted to obtain information about rates, dates, and kinds of potassium fertilization.

I. Soil Fertility Survey of Potato Fields

A. Objective

To study plant nutrient levels in soils and plants in Columbia Basin potato fields and evaluate the effects of management on soil fertility trends.

B. Procedures

1. Grower yield records for Russet Burbank potatoes were summarized for 47 fields and yield information was evaluated for first, second, third, and fourth potato production years. Potatoes were mostly grown in a two-year rotation involving an annual crop such as wheat. Fields sampled were on Winchester, Quincy, and Ephrata soils.

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2. Grower and commercial laboratory records of plant and soil analyses were summarized and evaluated. Plant analyses, using petiole samples from the youngest fully mature leaves sampled when tubers were about 3/4 inches in diameter, were used to evaluate nutrient concentrations in potato plants. Soil analysis values were based on samples from the 0- to 12-inch depth. Soil testing procedures were based on methods outlined by the Oregon State University Soil Testing Laboratory (1).

C. Results

1. Yield data are summarized in Table 1. The yield of marketable tubers declined from 23.7 to 15.3 tons/acre as the years of potato production increased from 1 to 4. These data clearly illustrate the comparatively high potato yields from new ground. Total yields of tubers did not decline on older fields to the same extent as marketable yields. There was an increased yield of culls on the older fields, as well as a marked tendency toward small tubers. Adequacy of nutrients (Tables 3 and 4) indicates that yield decline on older fields is not primarily caused by declining soil fertility, but probably is caused by other factors such as verticillium wilt and stem soft rot, as well as soil compaction, pH changes, and developing nutrient imbalances.

TABLE 1. EFFECT OF NUMBER OF YEARS FIELDS WERE IN POTATO PRODUCTION ON POTATO YIELDS AND GRADES

No. of Potato Crops	Potato Grade			
	1's & 2's	Over 6 oz.	Culls	Total
	--------	-------- T/A	--------	--------
1	23.7	20.0	3.0	26.7
2	21.7	14.8	3.6	25.3
3	17.4	7.6	8.0	25.4
4	15.3	5.3	8.6	23.9
Means significantly different (P=0.05)	*	*	*	*

2. Concentrations of some plant nutrients in potato petioles varied as the number of years in potato production increased (Table 2). Nitrate, Ca, Mg, and S levels in petioles were higher in older fields. Potassium and B levels did not vary significantly and their was no consistent trend in P and Mn levels in petioles.

   Nitrate levels in petioles tended to be high. Jones and Painter (7) report that mid-season potato petiole NO_3-N concentrations higher than 1.6% are excessive. All the average petiole NO_3-N concentrations in this survey exceeded 2.0%. This level increased on the older fields, indicating excessive N fertilization.

   Average P and K levels in leaf petioles equalled or slightly exceeded the critical levels reported for these nutrients (2, 3, 4), indicating an adequate fertilization program with respect to P and K. Petiole concentrations of Mn and Ca exceeded levels reported by Jackson and Carter (6) for high yielding plots. The average Mg levels in petioles exceeded critical levels reported by Tyler et al. (9) and Dow et al. (3).

   Average Cu concentrations in potato leaf petioles exceeded the critical levels reported by Painter and McDole (8) and Dow et al. (3). Petiole S concentrations were close to concentrations reported by Dow et al. for Washington and Oregon potato fields.

TABLE 2. EFFECT OF NUMBER OF YEARS FIELDS WERE IN POTATO PRODUCTION ON NUTRIENT LEVELS IN PETIOLES

No. of Potato Crops	Concentration of nutrients in petioles[1/]								
	NO_3-N	P	K	Ca	Mg	S	Mn	Cu	B
	%						ppm		
1	2.12	0.28	10.0	0.93	0.42	0.16	77	6.8	26
2	2.07	0.31	10.2	0.98	0.54	0.16	97	7.5	28
3	2.42	0.32	10.2	0.98	0.53	0.17	95	5.8	28
4	2.88	0.24	10.0	1.26	0.72	0.19	52	3.6	26
Means significantly different (P=0.05)	*	*	N.S.	*	*	*	*	N.S.	N.S.

[1/] Fourth petiole from top of plant sampled at early tuber (3/4" diameter) growth stage

3. Trends in plant nutrient soil test levels are reported in Table 3. Phosphorus and Zn soil test levels were higher in older fields compared to K, SO_4-S, and Ca levels which tended to be lower in the older fields. Magnesium and B soil test values tended to be fairly constant in new and older fields. According to soil test interpretations for potatoes in Oregon's Columbia Basin (5), plant nutrient levels would fall into medium low to medium high categories (Table 4).

TABLE 3. EFFECT OF NUMBER OF YEARS FIELDS WERE IN POTATO PRODUCTION ON EXTRACTABLE PLANT NUTRIENT LEVELS IN SOIL

No. of Potato Crops	Extractable nutrients in soil						
	P	K	Ca	Mg	SO_4-S	Zn	B
	ppm						
0	12	240	1150	162	6.7	0.9	0.41
1	18	207	1100	155	9.9	1.4	0.45
2	22	184	850	145	8.6	1.5	0.38
3	23	186	850	144	7.8	1.7	0.41
4	20	186	700	152	5.1	1.9	0.38
Means significantly different (P=0.05)	*	*	*	*	*	*	*

TABLE 4. RATING OF POTATO FIELD SOIL TEST LEVELS

No. of Potato Crops	Nutrient					
	P	K	Ca	Mg	Zn	B
0	M[1/]	M	M	M	M	M
1	M	M	M	M	MH	M
2	MH	ML	ML	M	MH	M
3	MH	ML	ML	M	MH	M
4	MH	ML	ML	M	MH	M

1/ M -- medium H -- high L -- low
Value by comparison with OSU Fertilizer Guide (5) soil test interpretations

D. Summary

A survey of 47 irrigated potato fields in the Boardman-Hermiston area of the Columbia Basin in northeast Oregon showed that marketable yields decreased as the number of years in potato production increased. Chemical analyses of soil samples indicated some changes in plant nutrient concentrations with available P and Zn levels tending to be higher in soils in older fields and Ca and K levels tending to be lower. Plant analyses revealed higher NO_3, S, Mg, and Ca contents in older fields. Phosphorus and Mn levels in plants were variable and B concentrations tended to be constant in newer and older fields. The results indicate that potato production has resulted in soil depletion of some nutrients such as Ca and K and soil enrichment of P and Zn. Future adjustment of the fertilizer program probably will be required to maintain a high level of soil fertility in these potato fields.

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Farms

Simtag Farms

Eastern Oregon Farming Co.

Miracle Potato Co.

U & I Inc. Farm Operations

Eagle Ranch

Western Empire

Sun River Inc.

Processors

J. R. Simplot Co.

Lamb-Weston

Oregon Potato Co.

Gourmet Foods Inc.

Consulting Firms

Agri-Check Inc.

H. R. Consulting Service

Marr Waddoups Inc.

II. Response of Potatoes to Potassium Fertilizers

A. Objectives

To determine the effect of:

1. Rates of K fertilizer application on potato yield and K content of potato plants.

2. Frequency of K fertilizer application on potato yield and uptake of K.

3. Different K fertilizer materials (KCl vs. K_2SO_4) on potato yield and K uptake by potatoes.

B. Procedures

Four potassium fertilizer experiments with circle irrigated Russet Burbank potatoes were conducted on Winchester loamy sand soil on the Simtag Farm in Morrow County in 1980. The potassium fertilizer treatments consisted of:

1. Three rates of application

   Zero, recommended rate, and double the recommended rate. The recommended rate is based on the soil test K value and the resulting rate recommended in OSU Fertilizer Guide No. 57.

2. Two sources of K fertilizer

   KCl and K_2SO_4.

3. Three frequencies of application of KCl

   1, 3, and 5 applications. The K rate for each application equals the total K application rate divided by the number of applications.

TABLE 5. K FERTILIZER TREATMENTS

Treat. No.	No. of Applic.	Dates of[1/] K Applic.	K Source	Total rate of K application Experiment[2/] 1	2	3	4
				----------K_2O lbs/A---------			
1	1		KCl	205	164	155	77
2	3	5-1,7-1	KCl	205	164	155	77
3	5	5-1,6-15,8-1,9-15	KCl	205	164	155	77
4	1		KCl	410	328	310	154
5	3	5-1,7-1	KCl	410	328	310	154
6	5	5-1,6-15,8-1,9-15	KCl	410	328	310	154
7	1		K_2SO_4	205	164	155	77
8	1		K_2SO_4	410	328	310	154
9	0		-0-	-0-	-0-	-0-	-0-
		K Soil Test (ppm)		195	236	245	323

1/ These dates do not include the initial application which was made immediately after the planting in each case.

2/ Experiments 1 and 2 were in new circles not previously cropped to potatoes; Experiments 3 and 4 were in old circles with a history of at least 5 crops of potatoes.

The initial K fertilizer treatments were banded 2 to 3 inches to the side of the seed immediately after planting and the subsequent K applications were banded on the soil surface 3 inches to the side of the rows. Petiole samples for K analysis were removed on June 15, July 15, and August 15. Petioles were taken from the youngest fully expanded leaves.

C. Results

1. Yield of Tubers

Total and marketable yields of tubers were highest on fields which had been least often cropped to potatoes (Experiments 1 and 2) and the newer fields had the highest percentage of grades 1 + 2 tubers (Tables 6 and 7). The mean marketable yields of tubers were 26.1 and 14.4 T/A for the newer and older fields, respectively.

Significant yield responses to K fertilizer were not recorded at most locations (Tables 6 and 7). Split applications of K fertilizer failed to increase yields over single applications, and K_2SO_4 and KCl did not produce significantly different yields although there is some indication that KCl gave higher yields on the older fields.

Marketable yields of tubers on the zero K plots (Treatment 9) tended to decrease as K soil test values increased (Tables 5 and 7). This trend probably relates to higher K soil test values resulting from high grower K fertilizer applications to the lower yielding older fields.

TABLE 6. TOTAL YIELDS OF TUBERS

No. of Treat.	Fert.	No.of Applic.[1/] x Rate	Experiment 1	2	3	4	Ave.
			T/A				
1	KCl	1 x 1	36.3	32.7	25.2	22.6	29.2
2	KCl	1 x 3	35.5	29.0	23.7	23.7	28.0
3	KCl	1 x 5	34.2	29.6	24.4	21.0	27.3
4	KCl	2 x 1	34.1	27.4	25.2	23.1	27.4
5	KCl	2 x 3	34.5	27.6	23.1	23.6	27.2
6	KCl	2 x 5	33.3	31.4	24.6	19.7	27.2
7	K_2SO_4	1 x 1	35.3	32.7	24.1	20.4	28.1
8	K_2SO_4	2 x 1	36.9	32.9	23.1	23.5	29.1
9	-0-	---	36.9	33.7	23.0	23.3	29.2
	Ave.		35.2	30.8	24.0	22.3	
	$L.S.D._{.05}$		N.S.	3.4	N.S.	N.S.	

TABLE 7. YIELDS OF GRADE 1 + GRADE 2 TUBERS

No. of Treat.	Fert.	No.of Applic.[1/] x Rate	Experiment 1	2	3	4	Ave.
			T/A				
1	KCl	1 x 1	31.2	23.4	15.9	15.5	21.5
2	KCl	1 x 3	30.8	20.4	13.5	14.5	19.8
3	KCl	1 x 5	29.5	20.4	14.3	11.3	18.9
4	KCl	2 x 1	28.8	20.1	16.8	15.7	20.3
5	KCl	2 x 3	27.9	19.5	14.8	15.7	19.5
6	KCl	2 x 5	27.2	22.1	14.8	12.5	19.1
7	K_2SO_4	1 x 1	31.1	24.9	13.4	11.5	20.2
8	K_2SO_4	2 x 1	32.5	25.3	14.6	15.0	21.8
9	-0-	---	31.5	24.4	13.2	16.4	21.4
	Ave.		30.0	22.3	14.6	14.2	
	$L.S.D._{.05}$		N.S.	N.S.	2.87	N.S.	

[1/] 1 x 1 means recommended rate of K in 1 application; 2 x 3 means a total of double the recommended rate of K in 3 equal applications

2. Potassium Concentration in Leaf Petioles

Statistical analyses revealed significant differences between K fertilizer treatments and K concentrations in potato leaf petioles (Table 8). Average values for the 4 experiments show that potassium fertilization increased petiole K concentrations over the check (zero K) treatment (Figures 1, 2, 3) and split K applications resulted in higher K petiole levels on the latest sampling date (8-15). These higher K petiole levels, however, were not reflected in higher tuber yields (Tables 2 and 3).

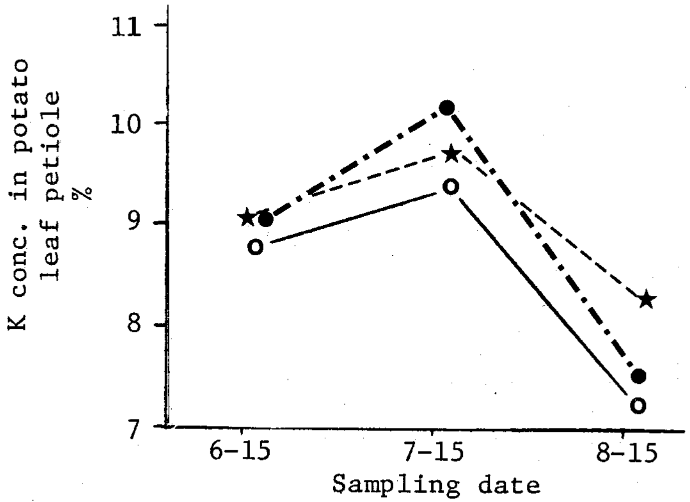
Potato petiole K levels were highest for the mid-season (7-15) sampling date compared to the early (6-15) and late (8-15) sample dates (Table 8 and Figures 1, 2, 3). Petiole K concentrations were highest at the top yielding location (Experiment 1).

Potassium soil test levels and leaf petiole K concentrations were not positively related. Leaf petiole K levels for potatoes on non-K fertilized plots (Treatment 9) tended to be lower for locations with higher K soil test values compared to lower K soil test sites (Experiment 2 vs. Experiment 1). As previously mentioned, higher K soil test levels occurred in older, lower yielding fields apparently as a result of high K fertilizer applications.

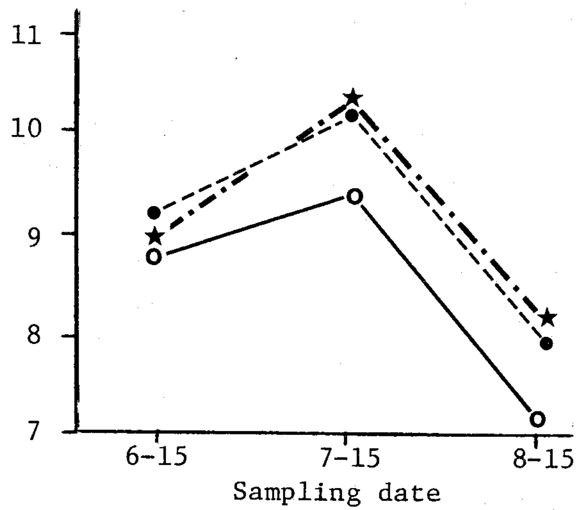
TABLE 8. POTASSIUM CONCENTRATIONS IN POTATO LEAF PETIOLES FOR DIFFERENT K FERTILIZER TREATMENTS AND SAMPLING DATES

		Treatment[1/]									
Expt.	Date	KCl 1x1	KCl 1x3	KCl 1x5	KCl 2x1	KCl 2x3	KCl 2x5	K_2SO_4 1x1	K_2SO_4 2x1	0	Ave.
		%K									
1	6-15	8.4	8.9	8.9	8.7	8.8	9.2	8.4	8.2	8.4	8.6
	7-15	11.3	10.6	10.4	10.9	11.5	11.5	10.7	10.4	9.9	10.8
	8-15	8.7	8.5	9.5	9.3	9.7	9.0	8.5	9.6	8.1	9.0
	Ave.	9.5	9.3	9.6	9.6	10.0	9.9	9.2	9.4	8.8	9.5
2	6-15	10.5	7.2	8.2	9.8	9.2	8.2	8.2	8.6	9.2	8.8
	7-15	9.4	9.1	8.2	9.7	9.1	8.8	8.0	8.8	8.9	8.9
	8-15	7.3	9.0	7.8	7.9	8.0	8.0	7.6	7.9	7.3	7.9
	Ave.	9.1	8.4	8.1	9.1	8.8	8.3	7.9	8.4	8.5	8.5
3	6-15	9.2	9.7	9.3	9.4	9.2	9.0	8.8	9.0	9.1	9.2
	7-15	11.0	10.1	11.2	10.2	10.9	10.4	10.0	10.6	9.4	10.4
	8-15	7.3	7.5	7.8	7.3	7.6	8.0	7.5	7.2	6.7	7.4
	Ave.	9.2	9.1	9.4	9.0	9.2	9.1	8.8	8.9	8.4	9.0
4	6-15	8.5	8.7	8.9	8.9	8.5	9.4	7.7	8.8	8.1	8.6
	7-15	9.6	9.1	9.3	9.3	9.6	9.6	9.0	10.9	9.3	9.5
	8-15	7.0	7.5	8.1	7.1	7.7	7.4	7.7	6.9	6.8	7.3
	Ave.	8.4	8.4	8.8	8.4	8.6	8.8	8.1	8.9	8.1	8.5

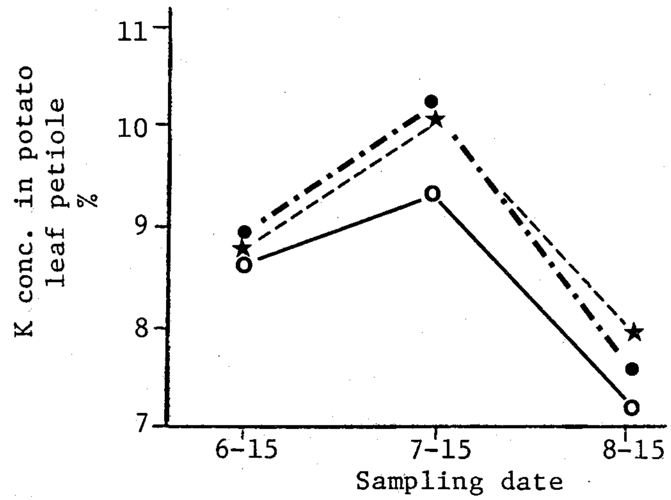
1/ Planting date 4-12 to 4-20. At first sampling date (6-15) plants were in early tuber (<1/2") growth stage.



<u>Fig 1:</u> Effect of zero K (o) and single (•), and 5 applications (★) totalling the recommended rate of K fertilizer on the concentration of K in potato petioles at different sampling dates.



<u>Fig 2:</u> Effect of zero K (o) and single (•), and 5 applications (★) totalling twice the recommended rate of K fertilizer on the concentration of K in potato petioles at different sampling dates.



<u>Fig 3:</u> Effect of zero K (o) and single applications equalling the recommended (•) and twice the recommended rate (★) of K fertilizer on the concentration of K in potato petioles at different sampling dates.

3. Specific Gravity

Fertilizer K treatments did not result in significantly different tuber specific gravity values at any of the 4 experimental locations. Mean specific gravity values for Experiments 1, 2, 3, and 4 were 1.084, 1.096, 1.083, and 1.083, respectively. The highest specific gravity was for tubers from Experiment 2, which was in a new field. Experiment 1, however, which also was in a new field, did not produce tubers with a higher specific gravity than did Experiments 3 and 4, which were in older fields.

4. Hollow Heart

Fertilizer K treatments did not result in significant differences of hollow heart incidence at any of the experimental locations. Mean percentages of tubers with hollow heart were 10.9, 8.3, 9.7, and 2.7 for Experiments 1, 2, 3, and 4, respectively. The lowest incidence of hollow heart occurred in Experiment 4, which was the lowest yielding experiment and was in an older field.

D. Summary

Yields of marketable potato tubers were lower in experiments in older potato fields compared to new potato fields.

K fertilizer failed to increase yields of marketable tubers and split applications of K did not increase yields over single applications. The two sources of K (KCl vs. K_2SO_4) gave similar potato yields.

Potassium fertilization resulted in increased concentrations of K in potato leaf petioles, but there was little difference in K petiole levels among the different K fertilizer treatments. Splitting K fertilizer treatments did result in higher K petiole levels on the last sampling date. K petiole concentrations were highest at the mid-season sampling compared to the early and late season samples.

Potassium fertilization did not affect tuber specific gravity and did not reduce the incidence of hollow heart.

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