Effect of Fertilizers on Yield and Quality of Potatoes in the Willamette Valley

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Effect of Fertilizers on Yield and Quality of Potatoes in the Willamette Valley

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ABSTRACT

Data from fertilizer experiments with potatoes in the Willamette Valley from 1961 through 1971 show that responses have been measured from nitrogen, phosphorus, potassium, magnesium, and lime. Responses from these nutrients have been related to soil and/or plant analysis values.

In recent years most of the potato production has moved from hill soil areas to valley floor soils with much of the production following cereal crops with the straw disced or plowed into the soil before planting potatoes. These experiments show that 150 to 200 pounds of nitrogen per acre should be applied for April-planted potatoes following a cereal crop, and this rate should be reduced to 50 to 100 pounds of nitrogen per acre for late May plantings or where potatoes follow a heavily fertilized row crop.

There was a response from band application of phosphorus on all locations. Rates of phosphorus application should be increased from about 80 to about 160 pounds of phosphorus (P_2O_5) per acre when phosphorus soil test values drop below 40 parts per million.

One hundred pounds of potassium (K_2O) per acre should be applied when soil analyses range from 300 to 400 ppm potassium (K). Magnesium fertilizer should be added when soil test values are below 0.8 milliequivalents magnesium per 100 grams of soil. Application of lime the fall before planting should be considered when the soil pH is below 5.5 and soil analysis shows 5 milliequivalents of calcium per 100 grams of soil or less.

INTRODUCTION

Prior to 1960, most Willamette Valley potatoes were grown on well-drained hill soils with production concentrated in Multnomah, Clackamas, and Washington counties. Potatoes frequently followed vegetable crops with a winter cover crop plowed down that gave some carryover of nitrogen. Planting was generally between May 20 and June 15. Vines were frosted or killed in October with digging starting about mid-October. Since most harvesting was by hand, fall rains did not cause the problems that they do with present mechanical harvesting operations. Also, many potatoes were sold for seed, which placed a higher value on small potatoes.

The recent change to mechanical harvesters and the sale of a larger percentage of potatoes to the commercial market altered a number of production practices. Potatoes are being planted earlier, starting about April 1, to give higher yields associated with a longer growing season. Use of mechanical harvesters has encouraged many growers to start harvest in September to avoid fall rains. Also, some commercial acreage has been planted to Norgold variety for early market with harvest starting in early August. Emphasis on higher yields has required sprinkler irrigation and has shifted much production to well-drained valley floor and river bottom soils.

Approximately half of the potatoes are grown following production of a cereal crop. Fall or winter plowing of cereal stubble makes it easier to prepare a seedbed for early planting; these current practices require higher rates of nitrogen than were formerly used.

EXPERIMENTAL METHODS

These data are from experiments carried out between 1960 and 1971. The earlier experiments were located on "hill soils" with relatively late planting dates. Experiments in 1969 and later were on valley floor or river bottom soils with earlier planting dates and following cereal crops.

Soils information. Soil analysis values, soil series, and locations for experiments are given in Table 1.

Fertilizer application. In all experiments except at the North Willamette Experiment Station in 1969, fertilizer materials were banded about 3 inches from the seed at planting time or shortly after planting with an experimental belt applicator. Fertilizers were sidedressed about 6 inches from the seed immediately following planting on the 1969 North Willamette Experiment Station experiment.

Ammonium nitrate and/or ammonium sulfate were used to supply nitrogen. Concentrated superphosphate was used to supply phosphorus, potassium chloride or potassium sulfate was used to supply potassium, and magnesium sulfate was

Table 1. Soil analyses, soil series, and location of experimental sites, Willamette Valley potato fertilizer experiments[1]

				Soil analyses[2]				
Year	Expt. no.	Soil	Location	pH	P (ppm)	K (ppm)	Ca (meq/100g)	Mg (meq/100g)
1961	409	Cascade	J. Rowell farm	5.9	27	210	3.3	.5
1962	129	Cascade	J. Rowell farm	5.4	23	145	4.0	0.8
1962	130	Cascade	J. Rowell farm	5.4	21	215	2.8	0.8
1962	131	Cascade	Red Soils Expt. Sta.	5.5	9	210	4.6	0.9
1968		Powell	Sester Bros. farm	6.2	46	94	3.0	0.7
1969		Cloquato	Crocker farm	5.8	33	385	10.2	4.6
1969	105	Willamette	N. Will. Expt. Sta.	5.7	154	290	5.9	1.4
1970	105	Willamette	N. Will. Expt. Sta.	5.4	152	215	5.1	1.2
1971	111	Willamette	N. Will. Expt. Sta.	5.9	138	351	7.5	1.4

[1] Soil samples were analyzed by the Oregon State University Soil Testing Laboratory with methods as described by S. Roberts, R. V. Vodraska, M. D. Kauffman, and E. H. Gardner in *Methods of soil analysis used in the soil testing laboratory at Oregon State University*, Special Report 321, Agricultural Experiment Station, Oregon State University, Corvallis, April 1971.

[2] ppm equals parts per million; meq/100g equals milliequivalents per 100 grams of soil.

used to supply magnesium. When ammonium nitrate was used as the only source of nitrogen, gypsum was used to supply sulfur. On one experiment, 1962-130, lime was applied in hydrated form and disced into the seedbed eight weeks before planting.

Treatment evaluation. Starting in 1968, petiole samples were chemically analyzed on all experiments.

Yield and grade data have been measured on all experiments. Chip quality, specific gravity, loss of weight during storage, percent of reducing sugars, and susceptibility to bruising were measured on some experiments.

EXPERIMENTAL RESULTS

Statistical analyses were completed on most measurements. Effects that were statistically significant at the 0.05 probability level are discussed. The experiments are discussed in the order in which they were established.

Some experiments had a large number of treatment combinations that can be used to compare individual treatment effects. In each experiment, the best combination of treatments to identify a specific response will be listed.

John Rowell farm (Experiment 1961-409)

This experiment was established in 1961 on a Cascade soil on the John Rowell farm near Sandy. The purpose of the experiment was to evaluate response from fertilizers where potatoes followed a processing crop. Potatoes were planted May 29 and harvested October 9. Twenty-six fertilizer treatments were used to evaluate different combinations of nitrogen, phosphorus, potassium, and magnesium. Potatoes were graded and samples saved for measurement of treatment effects on specific gravity, percent of reducing sugars, loss of weight during three months storage, and netting. Yield and quality data for individual treatments are presented in Table 2, and the average nitrogen, phosphorus, and potassium responses are summarized in Table 3.

Data from four treatments that did not affect yield or grade are not reported. One pound of boron per acre was broadcast on two treatments with optimum application of other nutrients; there was no apparent effect from this treatment. Also, potassium chloride was compared with potassium sulfate with fertilizer rates comparable to treatments 5 and 6 in Table 2. Both sources of potassium gave comparable results.

Treatments without nitrogen fertilizer (treatments 1 and 2) averaged 11.04 tons per acre with a large percentage of small potatoes, while higher rates of nitrogen, phosphorus, and potassium yielded 14 to 16 tons per acre with a comparable percentage of number 1 potatoes but fewer small cull potatoes.

The average response from different rates of nitrogen is summarized (Table 3) in treatments A, B, and C. Average yields with 40, 80, and 160 pounds of nitrogen per acre were 13.88, 14.38, and 15.42 tons per acre, respectively. After the initial 40 pounds of nitrogen per acre, grade was not influenced by additional nitrogen fertilizer. These treatments averaged 79.3 percent number ones. There was less "netting" on tubers from those treatments receiving 160 pounds of nitrogen per acre.

The average response from phosphorus is summarized (Table 3) in treatments D, E, and F. Average yields with zero, 80, and 160 pounds of phosphorus (P_2O_5) per acre were 9.51, 12.48, and 14.78 tons per acre, respectively. In ad-

Table 2. Effect of fertilizer treatments on Russet Burbank potatoes (John Rowell farm, Experiment 1961-409)

Treatments[1]						Size			Reducing	
No.	N	P	K	Mg	Yield	No. 1	Small	Specific gravity	Reducing sugars	Storage wt. loss
					T/A	%	%		%	%
1.	0	0	0	0	11.04	75.4	18.6	1.097	.055	4.45
2.	0	2	1	0	11.05	79.5	17.0	1.097	.062	3.34
3.	1	2	1	0	12.70	77.4	10.5	1.095	.085	3.88
4.	1	2	4	0	13.40	82.6	10.8	1.089	.065	3.87
5.	1	2	1	1	14.04	79.9	13.0	1.096	.073	4.02
6.	1	2	4	1	13.70	80.5	12.3	1.095	.068	4.23
7.	2	2	0	1	14.25	79.9	12.0	1.095	.072	3.89
8.	2	2	1	1	14.23	78.8	12.1	1.095	.090	4.77
9.	2	2	2	1	13.35	74.3	15.9	1.095	.060	3.90
10.	2	2	4	1	15.41	82.9	11.8	1.094	.060	3.80
11.	4	2	0	1	14.67	81.5	13.9	1.095	.078	3.90
12.	4	2	1	1	14.42	78.0	12.0	1.096	.058	4.13
13.	4	2	2	1	16.21	75.8	11.8	1.094	.075	4.23
14.	4	2	4	1	16.38	79.6	9.7	1.092	.057	4.25
15.	4	2	1	0	14.92	79.5	12.7	1.098	.062	4.16
16.	4	2	4	0	15.18	79.4	11.2	1.089	.057	3.90
17.	4	2	1	2	13.35	81.4	12.1	1.096	.058	3.73
18.	4	2	4	2	13.54	82.9	10.4	1.094	.075	4.51
19.	2	0	2	1	10.32	81.9	7.2	1.088	.057	4.60
20.	2	1	2	1	12.72	77.3	13.1	1.094	.055	4.44
21.	4	0	2	1	8.70	77.1	11.2	1.090	.055	4.78
22.	4	1	2	1	12.21	80.7	11.5	1.092	......	4.17

[1] Rates of application:
N: 1, 2, 4 = 40, 80, 160 pounds nitrogen per acre as ammonium nitrate.
P: 1, 2 = 80, 160 pounds phosphorus (P_2O_5) per acre as superphosphate.
K: 1, 2, 4 = 40, 80, 160 pounds potassium (K_2O) per acre as potassium sulfate.
Mg: 1, 2 = 20, 40 pounds magnesium per acre as magnesium sulfate.

dition to this increase in yield, application of phosphorus also increased "netting" and color of tubers, an important quality factor for sale of Russet Burbank potatoes.

The average response from potassium is summarized (Table 3) in treatments G, H, I, and J. Average yields with zero, 40, 80, and 160 pounds of potassium (K_2O) per acre were 14.46, 14.48, 14.78, and 15.90 tons per acre, respectively. Although the yield increase from potassium was small, there were a large number of comparisons so the differences between zero and 40 pounds K_2O per acre treatments versus 80 and 160 pounds K_2O per acre were significant.

Application of magnesium increased yields about 0.8 tons per acre (treatments 3 and 4 versus 5 and 6, 15 and

Table 3. Average effect of fertilizer treatments on Russet Burbank potatoes (John Rowell farm, Experiment 1961-409)

Treatments[1]	Yield	Size No. 1	Size Small	Specific gravity	Reducing sugars	Storage wt. loss
	T/A	%	%		%	%
Nitrogen (lb/A)						
A. 40 (Avg. 3-6)	13.88	80.1	11.7	1.094	.073	4.00
B. 80 (Avg. 7-10)	14.38	79.0	13.0	1.095	.075	4.15
C. 160 (Avg. 11-14)	15.42	78.7	11.9	1.094	.067	4.15
Phosphorous (lb/A)						
D. 0 (Avg. 19, 21)	9.51	79.5	9.2	1.089	.050	4.69
E. 80 (Avg. 20, 22)	12.48	79.0	12.3	1.093	.055	4.31
F. 160 (Avg. 9, 13)	14.78	75.1	13.8	1.095	.068	4.07
Potassium (lb/A)						
G. 0 (Avg. 7, 11)	14.46	80.7	13.0	1.095	.075	3.90
H. 40 (Avg. 8, 12)	14.48	78.4	12.1	1.096	.074	4.45
I. 80 (Avg. 9, 13)	14.78	75.1	13.8	1.095	.068	4.07
J. 160 (Avg. 10, 14)	15.90	81.3	10.8	1.093	.059	4.08

[1] Nitrogen, phosphorus, and potassium treatments from Table 2 were averaged. See Table 2 for rates of application.

16 versus 12 and 14 in Table 2), but this effect was not statistically significant. Increasing the application of magnesium to 40 pounds per acre (treatments 17 and 18 in Table 2) decreased yields when compared with lower levels of magnesium (treatments 15 and 16 or 12 and 14). Magnesium deficiency symptoms were apparent in September on plots not receiving magnesium.

The specific gravity averaged about 1.095. There was a reduction in specific gravity from 1.096 to 1.092 from high rates of nitrogen and potassium (treatment 5 versus 14), and there was an increase in specific gravity from 1.088 to 1.095 with the application of phosphorus (treatment 19 versus 9 in Table 2). While the effects of these treatments on specific gravity are typical of many fertilizer experiments, it should be recognized that all samples had relatively high specific gravity values indicating good quality.

One sack of potatoes from each treatment was weighed, placed in storage for 10 weeks, and then reweighed to evaluate any treatment effect on the loss of weight during storage. Average loss in weight was 4 percent, with no significant differences between fertilizer treatments.

The amount of reducing sugars can be used as a measure of chip quality; high concentrations result in a dark brown color. Reducing sugars measured on December 18 varied from 0.055 to 0.090 percent. However, there was considerable variation within any one group of treatments, such as rates of nitrogen, phosphorus, or potassium. These differences between treatments were not statistically significant. Time in storage, storage temperature, and humidity probably had more effect on the amount of reducing sugars than fertilizer treatments did.

A 30-pound sample of potatoes was stored until February 10. After storage, potatoes were washed and graded for netting, color, and firmness or breakdown. As previously discussed, application of phosphorus increased netting and russet color while higher rates of nitrogen and potassium reduced netting and russet color. Differences in firmness and storage breakdown were not associated with fertilizer treatments. There was very little breakdown in storage and samples were all rated "good."

John Rowell farm (Experiments 1962-129 and 130)

Two experiments were established on the John Rowell farm in 1962 on Cascade soils. The first was designed to obtain additional information on responses from nitrogen, phosphorus, and potassium observed in 1961; yield data are given in Table 4. The second was designed to evaluate response from lime and possible effects of lime on potassium and magnesium (Table 5).

Temperatures were cooler in 1962, with 59 days above 80° F as compared to 81 days above 80° F in 1961. This may have been the reason for lower yields in 1962.

Yields were increased (Table 4) from 9.87 tons per acre with no nitrogen (treatments 1 and 2) to 11.01 and 12.61 tons per acre with 40 and 80 pounds of nitrogen per acre, respectively (40 N treatments 10, 16; 80 N treatments 11, 17). However, yield was reduced from 12.61 to 11.58 tons per acre when nitrogen application was increased from 80 to 160 pounds per acre (160 N treatments 12, 18).

Application of phosphorus increased yield from 10.14 to 11.01 tons per acre (treatment 3 versus 10 at 40 pounds of nitrogen). Rates of 120 and 180 pounds of phosphorus per acre were compared at 80 pounds of nitrogen plus 80 or 160 pounds of potassium (treatments 7 and 8 versus 4 and 11). These treatments averaged 11.92 versus 12.51 tons per acre for 120 versus 180 pounds of phosphorus per acre. This difference in yield was not statistically significant, indicating that 120 pounds was adequate for this location.

Response from application of potassium and magnesium can be evaluated by comparing treatments A, B, C, D in Table 4. This table shows the averages for groups of treatments with common potassium and magnesium applications. Average increase from application of potassium was 1.50 tons per acre (treatments A and C versus B and D). This was about the same difference as treatments receiving magnesium (treatments A versus B) and those treatments without magnesium (treatments C and D). In contrast, there was an increase in yield from magnesium when potassium was not applied (treatment B versus D) but no response from magnesium after potassium was applied (treatment A versus C).

Application of sulfur increased the yield from 11.28 to 12.77 tons per acre (treatment 9 versus 17).

The area for the lime experiment (1962-130) was fertilized with 600 pounds of 16-20-0 (ammonium-phosphate-sulfate) per acre banded at planting. Lime, potassium, and magnesium treatments were disced into the seedbed

Table 4. Effect of fertilizer treatments on yield of Russet Burbank potatoes (John Rowell farm, Experiment 1962-129)

Treatments[1] No.	N	P	K	Mg	S	Yield	Treatments[1] No.	N	P	K	Mg	S	Yield
						T/A							T/A
1.	0	0	0	0	0	9.99	13.	1	2	0	1	1	11.97
2.	0	2	2	1	1	9.76	14.	2	2	0	1	1	9.63
3.	1	0	2	1	1	10.14	15.	4	2	0	1	1	10.06
4.	2	2	1	1	1	12.58	B (Avg. 13-15)						10.90
5.	2	2	1	2	1	11.39	16.	1	2	2	0	1	11.01
6.	2	2	2	2	1	13.73	17.	2	2	2	0	1	12.77
7.	2	1	2	1	1	12.37	18.	4	2	2	0	1	11.26
8.	2	1	1	1	1	11.57	C (Avg. 16-18)						11.68
9.	2	2	0	0	0	11.28	19.	1	2	0	0	1	9.26
10.	1	2	2	1	1	11.01	20.	2	2	0	0	1	9.66
11.	2	2	2	1	1	12.45	21.	4	2	0	0	1	9.55
12.	4	2	2	1	1	11.90	D (Avg. 19-21)						9.55
A (Avg. 10-12)						11.79							

[1] Rates of application:
N: 1, 2, 4 = 40, 80, 160 pounds nitrogen per acre as ammonium nitrate.
P: 1, 2 = 120, 160 pounds phosphorus (P_2O_5) per acre as concentrated superphosphate.
K: 1, 2 = 80, 160 pounds potassium (K_2O) per acre as potassium chloride.
Mg: 1, 2 = 10, 20 pounds magnesium per acre as magnesium sulfate.
S: 1 = 20 pounds sulfur per acre as gypsum or magnesium sulfate.

Table 5. Effect of lime, potassium, and magnesium fertilizer treatments on yield of Russet Burbank potatoes (John Rowell farm, Experiment 1962-130)

Lime treatments	Treatments[1] K_0Mg_0	K_1Mg_0	K_0Mg_1	K_1Mg_1	Average yield
	Yield (tons per acre)				T/A
No lime	11.37	14.47	14.10	14.16	13.52
Two tons lime per acre	13.26	14.99	14.86	16.86	14.99

[1] All plots received 600 pounds 16-20-0 per acre as ammonium-phosphate-sulfate.
K_1 = 160 pounds potassium (K_2O) per acre as potassium chloride.
Mg_1 = 10 pounds magnesium per acre as magnesium sulfate.

before planting. It was evident (Table 5) that lime increased potato yields an average of 1.5 tons per acre with the highest yield (16.86 T/A) being produced with complete nitrogen, phosphorus, potassium, magnesium, and lime treatment. There was no evidence of lime inducing scab.

It is important to note that treatments with added potassium or added magnesium increased yields; potassium did not accentuate the magnesium deficiency and magnesium did not accentuate the potassium deficiency. Apparently any one of the three cations added—potassium, calcium, or magnesium—increased yield on this acid soil.

Samples from both experiments (129 and 130) were graded. Both the zero nitrogen and zero phosphorus treatments had a larger percentage of small potatoes. The greatest improvement in grade was realized from application of phosphorus. Effects from application of lime, potassium, and magnesium on grade were not statistically significant.

Red Soils Experiment Station, (Experiment 1962-131)

A third experiment was established in 1962 on a Cascade soil at the Red Soils Experiment Station near Oregon City. The main objective of this experiment was to supplement information obtained from application of nitrogen, phosphorus, potassium, and magnesium on the John Rowell farm. This experiment was established June 15 with the fertilizer banded near the seed piece at planting time. Data from Experiment 131 are presented in Table 6.

Yield was increased from 7.64 to 9.36 tons per acre with 40 pounds of nitrogen per acre (treatment 2 versus 4) and from 6.70 to 9.36 tons per acre with phosphorus at the 40-pound nitrogen rate (treatment 3 versus 4). Yield was increased further with higher rates of nitrogen, phosphorus, and potassium. Yield of 11.12 tons per acre with treatment average B indicates that 80 pounds of nitrogen, 160 pounds of phosphorus, and 80 or 160 pounds of potassium were required for this yield. Increasing phosphorus application to 200 pounds per acre did not result in an additional yield increase (treatment average C versus B). Again, nitrogen and phosphorus improved grade more than any other treatments applied by reducing the percentage of small, cull potatoes.

Treatments with 160 pounds of nitrogen per acre averaged 12.47 tons per acre (treatments 16, 17), while those with 80 pounds of nitrogen per acre (treatments 15, 8) produced a yield of 10.83 tons per acre; phosphorus and potassium were comparable on these treatments. This increase from the higher rate of applied nitrogen was statistically significant.

Application of 160 pounds of potassium per acre increased yield from 9.38 tons per acre (treatment averages D plus E) to 11.66 tons per acre (treatment averages F plus G). A second comparison on rate of potassium application showed that yields were increased from 10.30 tons per acre with 80 pounds of potassium per acre (treatments 5, 7, 9) to 11.44 tons per acre with 160 pounds of potassium per acre (treatments 6, 8, 10). These comparisons indicate a yield increase of more than one ton per acre from each 80-pound increment of potassium on this experiment. Potassium deficiency was not severe enough to have a significant effect on grade.

Application of magnesium (compare treatment averages D and F versus E and G) reduced yield 0.64 tons per

Table 6. Effect of fertilizer treatments on yield of Russet Burbank potatoes (Red Soils Experiment Station, Experiment 1962-131)

Treatments[1] No.	N	P	K	Mg	Yield	Treatments[1] No.	N	P	K	Mg	Yield
					T/A						T/A
1.	0	0	0	0	5.99						
2.	0	2	2	1	7.64	11.	2	2	0	0	8.40
3.	1	0	2	1	6.70	12.	4	2	0	0	10.99
4.	1	2	2	1	9.36	D (Avg. 11, 12)					9.69
5.	2	1	1	1	9.14	13.	2	2	0	1	7.79
6.	2	1	2	1	11.99	14.	4	2	0	1	10.55
A (Avg. 5, 6)					10.52	E (Avg. 13, 14)					9.17
7.	2	2	1	1	11.30	15.	2	2	2	0	10.73
8.	2	2	2	1	10.93	16.	4	2	2	0	13.32
B (Avg. 7, 8)					11.12	F (Avg. 15, 16)					12.03
9.	2	3	1	1	10.47	8.	2	2	2	1	10.93
10.	2	3	2	1	11.40	17.	4	2	2	1	11.62
C (Avg. 8, 9)					10.94	G (Avg. 8, 17)					11.28

[1] Rates of application:
N: 1, 2, 4 = 40, 80, 160 pounds nitrogen per acre as ammonium nitrate.
P: 1, 2, 3 = 120, 160, 200 pounds phosphorus (P_2O_5) per acre as concentrated superphosphate.
K: 1, 2 = 80, 160 pounds potassium (K_2O) per acre as potassium chloride.
Mg: 1, 2 = 10, 20 pounds magnesium per acre as magnesium sulfate.
All plots received a minimum of 20 pounds sulfur per acre as gypsum.

acre. While this small decrease in yield was not statistically significant, the data indicate an adequate level of magnesium in relation to potassium and calcium levels on this soil.

Sester Brothers farm (1968)

An experiment was established on the Sester Brothers farm on June 18, 1968, using Kennebec potatoes on a Powell silt loam soil. Previous crops grown on this field were potatoes in 1966 with barley and red clover in 1967. The red clover was plowed down as a green manure crop in the spring of 1968. Eight fertilizer treatments were sidedressed immediately after planting to evaluate response from nitrogen, phosphorus, potassium, and magnesium. Table 7 shows the arrangement of treatments, effect on yield, and changes in chemical composition of petioles.

The application of nitrogen did not increase yields. This was probably due to the green manure crop and previous fertilization. Petioles from the zero nitrogen plot had 1.73 percent nitrate nitrogen, which indicates a relatively good level of nitrogen nutrition. Petioles were collected on August 19 when the larger tubers were about 0.5 inches in diameter.

The average response from application of phosphorus at 120 pounds of potassium per acre (treatment 3 versus 5) was 1.90 tons per acre. This response from phosphorus fertilization was not re-

Table 7. Effect of fertilizer treatments on yield and chip quality of Kennebec potatoes and chemical composition of petioles. (Sester Brothers farm, 1968)

Treatments[1]						Petiole analyses				Chip quality[3]		
No.	N	P	K	Mg	Yield[2]	NO_3-N	P	K	Mg	Nov. 20	Dec. 11	Feb. 18
					T/A	%	%	%	%			
1.	0	0	0	0	16.05					1.0	1.5	4.0
2.	0	1	1	1	17.00	1.73	.30				3.0	4.2
3.	1	1	1	1	17.00	2.09	.31	10.7	.45	1.0	2.5	4.0
4.	2	1	1	1	16.50	2.16	.28	10.6	.52	1.0	2.5	3.8
5.	1	0	1	1	15.10		.31			1.5	1.2	3.0
6.	1	1	0	1	15.65			9.7		1.0	3.5	4.0
7.	1	1	1	0	16.90				.49	1.8	1.0	3.8
8.	1	1	2	1	16.10	2.23	.31	10.5	.52	1.5	3.2	3.5

[1] Rates of application:

N: 1, 2 = 100, 200 pounds nitrogen per acre as ammonium nitrate, with one half banded at planting and one half on July 26.

P: 1 = 120 pounds phosphorus (P_2O_5) per acre as concentrated superphosphate banded at planting.

K: 1, 2 = 120, 200 pounds potassium (K_2O) per acre as muriate of potassium banded at planting.

Mg: 1 = 200 pounds magnesium per acre as magnesium sulfate banded at planting; sulfur was balanced with gypsum on treatments 1 and 7.

[2] Yield of marketable potatoes.

[3] Chip quality: 5 = light color, good quality chips; 1 = dark brown color from excess reducing sugars.

flected in an increase in the phosphorus content of petioles. The phosphorus soil test value was moderately high (64 ppm).

Application of 120 pounds potassium per acre increased yield from 15.65 to 17.00 tons per acre (treatment 6 versus 3). This yield increase was accompanied by an increase of 1 percent in the potassium content of petioles. The second increment of potassium applied (treatment 8—200 pounds K_2O per acre) decreased yield to 16.1 tons per acre. The potassium soil test value was moderately low (94 ppm). Application of magnesium (treatment 3 versus 7) did not affect yield or magnesium content of petioles; the magnesium soil test value was relatively low (0.7 meq/100g soil).

Evaluation of chip conditioning showed that phosphorus fertilization shortened conditioning time and improved chip quality. The other fertilizer treatments (nitrogen, potassium, and magnesium) did not affect the conditioning time or quality of chips produced.

More than 95 percent of the potatoes were marketable with no significant effect from fertilizer treatments.

Crocker farm (1969)

A Russet Burbank potato experiment was established on a Cloquato river bottom soil in Benton County in 1969. Seed sugar beets had been produced the previous year with heavy nitrogen fertilization and incorporation of a large quantity of crop residue. The experimental area received a uniform application of 100 pounds of nitrogen per acre as anhydrous ammonia before the crop was planted. Fertilizer treatments were banded about 3 inches to one side of seed pieces a few days after planting.

Table 8 gives yield and chemical analyses of petioles collected when tubers were 2 to 3 inches long, which is a more advanced stage of maturity than is generally used. The initial 100 pounds per acre application of nitrogen (treatment 1) provided an adequate level of nitrogen fertilization and maintained a high level of nitrate nitrogen in petioles, especially when the late date of sampling is considered.

Application of phosphorus increased yield 2.05 tons per acre (treatment 2 versus 4) and phosphorus content of plant samples from 0.10 to 0.15 percent. Phosphorus levels in petioles were low because of the late sampling date, but phosphorus application resulted in a marked increase in the phosphorus content. Also, the phosphorus soil test value was moderately low (33 ppm).

The response from potassium fertilizer was variable with yields of 15.50, 14.95, 19.30, and 15.15 with zero, 100, 200, and 300 pounds of potassium per acre, respectively. All plant samples had a

Table 8. Effect of fertilizers on yield of Russet Burbank potatoes and chemical composition of petioles (Crocker farm, Benton County, 1969)

Treatments[1]					Analyses of petiole samples[3]		
No.	N	P	K	Yield[2]	NO_3-N	Phosphorus	Potassium
				T/A	%	%	%
1.	1	2	2	18.55	1.61	.13	About 13
2.	2	2	2	19.30	2.05	.15	About 13
3.	3	2	2	18.15	2.33	.16	About 13
4.	2	0	2	17.25		.10	About 13
5.	2	1	2	19.65		.12	About 13
6.	2	2	0	15.50		.17	About 13
7.	2	2	1	14.95		.19	About 13
8.	3	2	3	15.15	2.40	.15	About 13

[1] Rates of application:

N: 1, 2, 3 = 0, 100, 200 pounds per acre of added nitrogen as ammonium nitrate. All plots received 100 pounds of nitrogen per acre as anhydrous ammonia before planting.

P: 1, 2 = 100, 200 pounds phosphorus (P_2O_5) per acre as concentrated superphosphate.

K: 1, 2, 3 = 100, 200, 300 pounds potassium (K_2O) per acre as muriate of potassium.

[2] Yield figures are the sum of U. S. No. 1 plus 2 grades.

[3] Petioles were taken late (tubers were 2 to 3 inches long); this accounts for the low N and P analyses when compared with plant samples taken when tubers are about 0.75 inches in diameter.

minimum of 13 percent potassium, which should be an adequate level; the potassium soil test value was fairly high (385 ppm).

NORTH WILLAMETTE STATION EXPERIMENTS

In 1969, a series of experiments was started at the North Willamette Experiment Station. These experiments were continued through 1971, using the Kennebec variety for the major comparisons. A limited number of treatments were included on Norchip, Norgold, and Russet Burbank varieties in 1970 and 1971 to obtain a relative measure of response from nitrogen fertilizer. Each experiment was established on a field that had produced about 100 bushels per acre of wheat the previous year. All straw was disced and plowed into the seedbed for each experiment. This approximates practices being followed by many growers in the area. Potatoes were planted in late April each year.

The first petioles were taken each year as the tubers were about 0.75 inches in diameter. Petioles from the most recently matured leaves were sampled. This generally resulted in sampling the third petiole from the top of the plant on Kennebec potatoes and the fourth petiole on Norgold and Russet Burbank varieties. Tuber samples from the Kennebec variety were saved for evaluation of chip quality each year. Yield data are presented in Table 9. Plants were hilled when the largest tubers were about 2 inches in diameter, which could have reduced total yields.

Application of nitrogen increased yields from 11.0 to 16.6, 18.4, 19.8, and 20.5 tons per acre with 50, 100, 150, and 200 pounds of nitrogen per acre, respectively (compare treatments 2, 4, 5, 7, and 9); most of this increase in yield was produced with the first 100 pounds per acre of nitrogen applied (treatment 5). Nitrate nitrogen content of petioles was 1.52 percent for treatment 9 on the first sampling date. This treatment produced maximum yield. It is important to note the marked decrease in petiole nitrate nitrogen with each sampling date. On the last sample, taken August 28, nitrate nitrogen dropped to 0.09 percent on the 200-pound nitrogen treatment and had disappeared from all other treatments.

There was essentially no response from application of phosphorus on this experiment (compare treatments 10, 11, and 5). Phosphorus content of petioles was relatively high, with 0.40 percent phosphorus for zero phosphorus treatment (treatment 10); this is higher than critical levels of 0.30 to 0.35 percent suggested for this stage of growth. The soil test value for phosphorus was high.

Application of 100 and 200 pounds of potassium per acre increased yield from 18.0 to 18.4 and 18.8 tons per acre, respectively (treatments 13 versus 5 and 14) when potassium was applied in combination with 100 pounds of nitrogen per acre. Petioles from zero potassium treatments (12, 13) were relatively high (10.6 and 10.1 percent) in potassium. This relatively small increase in yield and the high petiole analysis values suggest that response from potassium was questionable. There was little effect from either phosphorus or potassium on chip quality for the first chip date. However, after several months storage, application of both phosphorus and potassium improved chip quality, particularly at higher levels of nitrogen.

Magnesium application probably had little effect on yield or chip quality;

Table 9. Effect of fertilizer treatments on yield, chip quality, and chemical composition of petioles for Kennebec potatoes (North Willamette Experiment Station, Experiment 1969-105)

Treatments[1]						Chip quality[2]		Petiole analyses[3]						
								Nitrate-N						
						Dec. 17, 1969	Feb. 5, 1970	Sample date[4]				P	K	Mg
No.	N	P	K	Mg	Yield			1	2	3	4	(from sample 1)		
					T/A			%	%	%	%	%	%	%
1.	0	0	0	0	9.9	3.4	2.4							
2.	0	2	1	1	11.0	3.6	3.5	0.12	0.0	0.02	0.00	.50	10.4	.20
3.	1	1	1	1	16.5	3.5	2.9	0.69				.43	11.5	.18
4.	1	2	1	1	16.6	3.4	2.5	0.31	0.0	0.00	0.00	.51	11.5	.19
5.	2	2	1	1	18.4	4.0	3.5	0.72	0.23	0.07	0.00	.42	11.2	.18
6.	2	2	1	0	19.2	4.4	3.1	0.88				.47	11.5	.19
7.	3	2	1	1	19.8	4.2	3.3	1.15	0.60	0.21	0.00	.43	11.6	.21
8.	3	3	1	1	19.3	4.2	3.2	1.14				.45	11.3	.23
9.	4	2	1	1	20.5	3.8	4.0	1.52	1.10	0.88	0.09	.43	11.1	.25
10.	2	0	1	1	19.2	4.0	3.4	1.10				.40	10.8	.18
11.	2	1	1	1	19.2	4.1	3.5	0.82				.49	11.6	.19
12.	1	2	0	1	16.1	3.9	3.5	0.49				.45	10.6	.18
13.	2	2	0	1	18.0	4.4	2.6	1.05				.41	10.1	.20
14.	2	2	2	1	18.8	4.1	3.2	1.07				.44	11.8	.18
15.	1	2	2	1	16.4	4.4	3.0	0.37				.50	11.7	.17
16.	2	2	2	0	19.1	4.2	3.6	0.77				.43	12.3	.17

[1] Rates of application:

N: 1, 2, 3, 4 = 50, 100, 150, 200 pounds nitrogen per acre as ammonium nitrate.

P: 1, 2, 3 = 80, 160, 240 pounds phosphorus (P_2O_5) per acre as concentrated superphosphate.

K: 1, 2 = 100, 200 pounds potassium (K_2O) per acre as potassium chloride.

Mg: 1 = 15 pounds magnesium per acre as magnesium sulfate; sulfur was balanced with gypsum on treatments 1, 6, 16.

[2] Chip quality: 1 = dark chips; 5 = light-colored chips; 2, 3, and 4 are intermediate ratings.

[3] Calcium analyses varied from .59 to .89 percent Ca but there were no consistent treatment effects. Zinc analyses varied from 45 to 70 ppm, well above any suggested critical levels. Manganese analyses varied from 105 to 220 ppm, above suggested critical levels but not high enough to cause toxicity.

[4] The first petioles were taken when the larger tubers were 0.50 to 0.75 inches in diameter; second and third samples were taken two and four weeks later; fourth sample was taken the day before vine kill.

yield may have been decreased from magnesium (treatment 6 versus 5 and 16 versus 14). Magnesium application did not significantly affect the magnesium content of petioles.

North Willamette Experiment Station (Experiment 1970-105)

This experiment was modified (Table 10) to include higher nitrogen rates plus a limited evaluation of the relative re-

Table 10. Effect of fertilizer treatments on yield, chip quality, and chemical composition of petioles for Kennebec potatoes (North Willamette Experiment Station, Experiment 1970-105)

Treatments[1]					Yield		Chip quality[2]		Petiole analyses[3]					
									Nitrate-N (Sample date)					
No.	N	P	K	Mg	Total	Percent No. 1	Dec. 21, 1970	Mar. 16, 1971	1	2	P	K	Mg	Ca
					T/A	%			%	%	%	%	%	%
1.	0	0	0	0	12.26	45	3.0	3.9	0.06	0.00	.28	9.0	.20	1.13
2.	0	1	2	0	11.75	40			0.08	0.07	.25	11.2	.35	1.28
3.	1	1	2	0	20.99	37	4.0	4.3	0.81	0.11				
4.	2	1	2	0	25.79	36	4.1	4.5	1.18	0.56	.29	10.6	.44	.90
5.	3	1	2	0	25.93	20	3.8	4.4	2.38	1.51	.34	9.9	.56	.94
6.	4	1	2	0	26.84	16	3.8	3.9	2.43	1.89	.28	10.7	.60	1.22
7.	5	1	2	0	24.69	17	4.3	4.4	2.46	2.23				
8.	3	0	2	0	24.29	26	3.9	4.5	2.14	1.20	.19	11.8	.47	1.07
9.	3	2	2	0	26.72	17	2.9	4.3	2.02	1.32	.26	10.7	.58	1.39
10.	2	1	0	0	22.88	35			1.60	0.42	.24	9.7	.47	.85
11.	2	1	1	0	24.01	32			1.07	0.35	.29	10.4	.39	.83
12.	3	1	0	0	25.51	24	2.7	4.1	1.37	1.54	.25	9.4	.61	1.16
13.	3	1	2	0	27.80	22			1.74	1.18	.37	9.9	.37	0.79
14.	3	1	1	1	26.41	22			2.04	1.18				
15.	2	1	2	1	27.74	24			2.08	1.33	.25	10.8	.57	1.29
16.	4	1	1	0	27.23	17			2.60	1.94				

[1] Rates of application.

N: 1, 2, 3, 4, 5 = 50, 100, 200, 300, 400 pounds nitrogen per acre; 50 and 100 banded, rates above 100 broadcast; treatments 1 and 2 as $(NH_4)_2SO_4$.

P: 1, 2 = 80, 160 pounds phosphorus (P_2O_5) per acre as concentrated superphosphate.

K: 1, 2 = 150, 300 pounds potassium (K_2O) per acre as muriate of potassium.

Mg: 1 = 15 pounds magnesium per acre as $MgSO_4$.

[2] Chip quality: 1 = dark chips; 5 = light-colored chips; 2, 3, and 4 are intermediate ratings.

[3] First petiole samples were taken when larger tubers were 0.75 inches in diameter; second sample was taken two weeks later.

sponse from nitrogen on Norchip, Norgold, and Russet Burbank varieties planted in a block adjacent to the main experiment.

The largest yield increase resulted from nitrogen. Yield was increased from 11.75 to 20.99, 25.79, 25.93, and 26.84 tons per acre with application of 50, 100 200, and 300 pounds of nitrogen per acre, respectively (treatment 2 versus 3, 4, 5, and 6). The combination of higher rates of nitrogen, phosphorus, and potassium (treatments 9, 13, and 14) increased yields above that measured with 100 pounds of nitrogen per acre in treatment 4. This indicates that a petiole nitrate nitrogen content approaching 2 percent on the first sampling date should be optimum for these conditions.

Each 80 pound per acre increment of phosphorus applied increased yield from 24.29 to 25.93 and 26.72 tons per acre (treatment 8 versus 5 and 9). Phosphorus content of petioles from zero phosphorus treatment was 0.19 percent, well below the suggested critical levels. The phosphorus soil test value was high (152 ppm).

Yield was increased from 22.88 to 24.01 and 25.79 tons per acre with 150 and 300 pounds of potassium per acre, respectively, at the 100 pound per acre nitrogen rate (treatment 10 versus 11 and 4). Yield increases (25.51 to 26.41 and 27.80 tons per acre) from potassium were comparable with 200 pounds per acre of nitrogen. Yield was increased with each increment of potassium applied; increase from the second increment (150 versus 300 pounds K_2O per acre) averaged 1.55 tons per acre. Potassium content of petioles was increased to 10.6 and 9.9 percent for the 300-pound potassium treatment with 100 and 200 pounds of nitrogen, respectively. These comparisons suggest that petiole potassium levels for the Kennebec variety should be 10 percent or slightly higher. The potassium soil test value was moderate (215 ppm).

Chip quality evaluations were conducted on selected treatments of Kennebec on December 21, 1970, and March 16, 1971. Chip quality improved with storage on all treatments evaluated. The first increment of nitrogen improved chip quality on both dates; there was very little change from higher rates of nitrogen. It is interesting to note that the highest rate of nitrogen produced chips with as good or better color than any other treatment.

Phosphorus application (treatment 8 versus 5 versus 9) reduced chip quality on the first chipping date but had essentially no effect on the second date. Potassium application (treatment 12 versus 5) may have improved chip color. In evaluating effects of phosphorus and potassium on chip color, it is important to note that the effect of both treatments were high, indicating the soil had a relatively good supply of both nutrients.

Nitrogen rate comparisons (treatments 4, 5, and 6) were repeated with the Norchip, Norgold, and Russet Burbank varieties. These data (Table 11) indicate a consistent yield increase from increasing nitrogen application from 100 to 200 pounds per acre for each variety. Kennebec and Russet Burbank varieties yielded more than Norchip and Norgold varieties.

North Willamette Experiment Station (Experiment 1971-111)

Nitrogen application (Table 12) increased yields of Kennebec variety from 8.4 to 17.1, 21.4, 22.9, and 26.8 with 50, 100, 200, and 300 pounds of nitrogen per acre, respectively (treatment 1 versus

Table 11. Effect of nitrogen on yield, chip quality, and chemical composition of petioles for four potato varieties (North Willamette Experiment Station, Experiment 1970-105)

Treatments[1]				Yield		Chip quality[2]		Petiole analyses[3]					
								Nitrate-N (Sample date)					
No.	N	P	K	Total	Per-cent No. 1	Dec. 21, 1970	Mar. 16, 1971	1	2	P	K	Mg	Ca
				T/A	*%*			*%*	*%*	*%*	*%*	*%*	*%*
					Kennebec variety								
4.	2	1	2	25.79	36	4.1	4.5	1.18	0.56	.29	10.6	.44	.90
5.	3	1	2	25.93	20	3.8	4.4	2.38	1.51	.34	9.9	.56	.94
6.	4	1	2	26.84	16	3.8	3.9	2.43	1.89	.28	10.7	.60	1.22
					Norchip variety								
4.	2	1	2	20.59	33			1.10	0.45				
5.	3	1	2	21.15	30			1.87	1.63	.40	10.2	.51	0.70
6.	4	1	2	22.05	29			1.95	1.72				
					Norgold variety								
4.	2	1	2	19.58	35			0.72	0.15				
5.	3	1	2	22.83	34			1.66	0.98	.21	10.6	.46	1.07
6.	4	1	2	23.06	29			2.10	1.58				
					Russet Burbank variety								
4.	2	1	2	22.16	29			1.36	0.52				
5.	3	1	2	24.08	25			1.91	1.28	.23	10.0	.53	1.38
6.	4	1	2	26.55	29			2.37	1.64				

[1] Rates of application:

N: 2, 3, 4 = 100, 200, 300 pounds nitrogen per acre; 100 banded as $(NH_4)_2SO_4$, remainder broadcast.

P: 1 = 80 pounds phosphorus (P_2O_5) per acre as concentrated superphosphate.

K: 2 = 300 pounds potassium (K_2O) per acre as muriate of potassium.

[2] Chip quality: 1 = dark chips; 5 = light-colored chips; 2, 3, and 4 are intermediate ratings.

[3] First petiole samples were taken when the larger tubers were 0.75 inches in diameter; second sample was taken two weeks later.

2, 8, 10). Also, yield was increased a minimum of 2.4 tons per acre in the Norchip, Norgold, and Russet Burbank variety comparisons by increasing nitrogen application from 100 to 200 pounds per acre.

Potassium application increased yield from 19.1 to 21.4 and 22.6 tons per acre at the 100-pound nitrogen rate and from 21.7 to 22.9 and 24.2 at the 200-pound nitrogen rate with 100 and 200 pounds of potassium, respectively (treatments

Table 12. Effect of fertilizer treatments on yield, chip quality, and chemical composition of potato petioles (North Willamette Experiment Station, Experiment 1971-111, planted April 26)

Treatments[1] No.	N	P	K	Yield[2] Tons per acre	Percent No. 1	Chip quality	Nitrate-N (July 1)	Petiole analyses[4] P	K	Mg	Ca
							%	%	%	%	%
					Kennebec variety						
1.	0	1	1	8.4	57	4.3	.08	.58	11.0	.22	1.36
2.	1	1	1	17.1	66	4.3					
3.	1	1	2	17.5	85	4.1	.30				
4.	2	1	0	19.1	47	3.9		.50	10.5	.23	.96
5.	2	1	1	21.4	46			.48	11.9	.23	.98
6.	2	1	2	22.6	62	4.3	.78	.53	12.4	.20	.96
7.	3	1	0	21.7	46	3.7		.47	11.5	.36	1.16
8.	3	1	1	22.9	59	4.2		.47	11.5	.35	1.05
9.	3	1	2	24.2	60	4.0	1.91	.47	12.5	.32	1.03
10.	4	1	1	26.8	----	4.1					
					Norchip variety						
5.	2	1	1	18.8	59	4.5					
8.	3	1	1	21.4	51	4.8					
					Norgold variety						
5.	2	1	1	23.8	84						
8.	3	1	1	26.2	55						
					Russet Burbank variety						
5.	2	1	1	23.0	70						
8.	3	1	1	29.6	67						

[1] Rates of application:

N: 1, 2, 3, 4 = 50, 100, 200, 300 pounds nitrogen per acre; 0.5 and 1 as ammonium sulfate banded at planting, remainder broadcast as ammonium nitrate.

P: 1 = 160 pounds phosphorus (P_2O_5) per acre as concentrated superphosphate banded at planting.

K: 1, 2 = 100, 200 pounds potassium (K_2O) per acre as muriate of potassium banded at planting.

[2] Yield in tons per acre and percent of No. 1 potatoes; sample from each plot graded.

[3] Chip quality: 1 = very dark; 5 = light; 2, 3, and 4 are intermediate colors.

[4] Manganese analyses varied from 95 to 190 ppm, zinc analyses varied from 50 to 70 ppm; both of these nutrients were present in normal amounts.

4 versus 5, 6, and 7 versus 8 and 9). Again higher rates of potassium applied (treatment 6 and 9 with 200 pounds of K_2O per acre) produced the highest yield.

One sample of potatoes from each treatment was graded in a commercial grading operation. Data were quite variable and may have limited value. However, it was evident by comparing treatments 4, 5, and 6 with treatments 7, 8, and 9 that application of potassium probably improved grade and nitrogen had little effect on grade.

SUMMARY

A series of experiments was carried out from 1961 through 1971 to evaluate effects of fertilizer applications on yield and quality of potatoes grown in the Willamette Valley. Planting dates and soils on which potatoes are grown have shifted during this period. Average date of planting has moved from late May to mid-April to provide a longer growing season with potentially higher yields. Earlier planting dates and increased use of mechanical harvesting equipment encouraged shifting production areas to well-drained river bottom and valley floor soils.

Approximately half the potatoes in the Willamette Valley are produced after production of wheat or barley, with the straw incorporated in the seedbed in tillage operations. This improves the physical condition of the soil for potatoes but results in some immobilization of nitrogen.

Response from nitrogen

Yield increase from application of nitrogen on early planted (April 15 to 25) potatoes following cereal crops has been spectacular. Data for Kennebec potatoes from Tables 9, 10, and 11 summarizing yield increases, rate of nitrogen applied, and yield achieved for 1969, 1970, and 1971 at the North Willamette Experiment Station follow:

Year	N/A applied (*lbs*)	Yield increase (*T/A*)	Yield (*T/A*)
1969	150	8.5	19.5
1970	200	15.3	27.0
1971	200	14.6	23.6

These yields are in marked contrast to those achieved with later planting dates on earlier experiments (Tables 2, 3, 4, 5, 6). Yield increases from application of nitrogen are also much greater than those achieved in 1968 on the Sester Brothers farm and in 1969 on the Crocker farm, where a base application of 100 pounds of nitrogen per acre was applied after plowing down residue from a sugar beet seed production field.

Two factors were involved in the North Willamette Experiment Station experiments: (1) they were established in April to take advantage of a longer growing season, and (2) cereal crops preceded the potato crop each year. Optimum yields were produced on these experiments when petioles from the Kennebec variety had 2.5 to 2.0 percent nitrate nitrogen at the time larger tubers were 0.75 inches in diameter. The nitrate nitrogen content was 1.73 percent on petiole samples from the Sester Brothers farm (1968) on treatments with optimum yield; these treatments had not received added nitrogen at planting time but had received phosphorus and potassium fertilizer.

Rates of 150 to 200 pounds of nitrogen per acre increased the grade (percent number one) by reducing the number of small tubers; this rate of nitrogen did not decrease chip quality.

Results from these experiments indicate that (1) in the Willamette Valley, 150 to 200 pounds of nitrogen per acre should be applied on April-planted potatoes after production of a cereal crop, (2) 50 to 100 pounds of nitrogen per acre should be adequate for potatoes planted in late May following a row crop with nitrogen carryover, and (3) 1.5 to 2.0 percent nitrate nitrogen in the petiole of the most recently matured leaf (when larger tubers are 0.5 to 0.75 inches in diameter) indicates an adequate level of nitrogen fertilization to carry the crop to maturity. Excessive rates of nitrogen can delay maturity of potatoes and thus accentuate storage problems.

Response from phosphorus

Yields and quality of potatoes have consistently increased from application of phosphorus at planting time. Results from experiments reported in this bulletin indicate yield increases were obtained from 60 to 100 pounds of phosphorus per acre applied in a band near the seed at planting regardless of phosphorus soil test values. When soil test values drop below 40 ppm phosphorus, as shown by the Oregon State University Soil Testing procedure, application rates should be increased to 150 to 180 pounds of phosphorus per acre.

Soil test values on experimental sites ranged from 9 to 154 ppm of phosphorus. On the Cascade soils, with the lower phosphorus soil test values, there was a marked reduction in both yield and percentage of marketable potatoes on plots not receiving phosphorus.

Response from potassium

Response from application of potassium was measured on all but one location (North Willamette, 1969).

Plant analysis data from experiments reported in this bulletin were not extensive enough to adequately identify a "critical potassium" level. However, results from these experiments combined with results from other areas show that 10.0 percent potassium in petioles sampled when tubers are 0.5 to 0.75 inches in diameter should indicate an adequate level of potassium fertilization.

One hundred pounds of potassium (K_2O) per acre should be applied when soil analysis values range from 300 to 400 ppm potassium (K). Application rates should be increased to 150 to 250 pounds of potassium (K_2O) per acre when soil test values drop below 300 ppm of potassium.

When potassium (K_2O) application rates exceed 100 pounds per acre, most of the potassium should be broadcast and plowed down before planting. Excessive amounts of soluble fertilizer salts in the band at planting can reduce seedling vigor. Also, excessive amounts of chloride (most potassium is applied as potassium chloride which is muriate of potash) in the band at planting time may result in excessive amounts of manganese being taken up by plants growing on acid soils.

Response from magnesium

Response from application of magnesium was measured on the John Rowell farm in 1962, where soil analysis values were 0.80 milliequivalents magnesium per 100 grams of soil and on the North Willamette Experiment Station (Expt. 1970-105) with 1.4 milliequivalents magnesium per 100 grams of soil. However, magnesium responses were not measured on the Red Soils Experiment Station in 1962 or on the Sester Brothers farm in 1968 with comparable magnesium soil analysis values. There was no response from application of magnesium on the other experimental locations.

When magnesium soil test values are below 0.8 milliequivalents per 100 grams of soil, it is advisable to include 10 to 15 pounds of magnesium (Mg) per acre with the fertilizer banded at planting time as potassium-magnesium sulfate (trade names Sul-Po-Mag or K-Mag). If the pH is below 5.5 on these fields, dolomite lime should be applied the fall before planting.

Response from lime

In 1962 there was a response from application of lime on the experiment on the John Rowell farm, where soil pH was 5.5 and calcium and magnesium levels were 2.8 and 0.8 milliequivalents per 100 grams of soil, respectively. There was no indication of scab in this experiment. Lime was not applied in other experiments.

Lime should be applied in the fall before the potato crop when soil pH is 5.5 or lower and when the soil analysis is 5 milliequivalents of calcium per 100 grams of soil or lower. Lime should be thoroughly mixed with the soil to reduce the possibility of scab.

Response from boron and other micronutrients

Response from application of boron was evaluated in one experiment in 1961 without any response.

Extensive plant analyses, carried out on potato experiments since 1968, indicate adequate levels of zinc, manganese, and copper.