POTASSIUM FERTILIZERS AND POTATO YIELD AND QUALITY IN THE COLUMBIA BASIN

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ABSTRACT
Potassium (K) fertilizer form (liquid or granular), source (chloride or sulfate), and time of application (preplant or in-season) were evaluated for their effect on potato tuber yield and quality in Washington's Columbia Basin. Overall, potato yield and quality were not strongly responsive to potassium fertilizer although preplant soil test K values suggested a K supplement according to current (1999) Washington guidelines. The highest tuber yield and quality were found when K fertilizer (either chloride or sulfate) was applied as a 100% preplant granular or liquid with 50% applied preplant followed by two in-season applications of 25% each, the first application at tuber initiation and the second 3 weeks later during tuber bulking. There was a production disadvantage when 75% of the total K was applied in-season. In addition, the results of this study strongly indicate that K source does not affect the tuber quality factor specific gravity.

INTRODUCTION
In Washington's Columbia Basin, potassium fertilizers are used routinely in potato (*Solanum tuberosum* L.) production to supplement naturally available soil potassium. Current guidelines (Lang et al., 1999) suggest the use of K fertilizer according to the equation lb K_20/A = (-2.25*soil test K)+600. Thus, 480 lb K_20/A is recommended for a soil test K value of 60 and 120 lb K_20/A when soil test K is 240.

When required, K typically is applied as a granular material prior to planting (preplant application). This region's potato production is predominated by center pivot irrigation systems, providing an opportunity to apply liquid potassium (K) fertilizer during the growing season (in-season applications). Currently up to 70% of the seasonal nitrogen fertilizer is applied through the pivots to increase N use efficiency in these systems (Lang et al., 1999). A limited number of growers in the region do apply liquid K fertilizers during the growing season (Lang and Stevens, 1997).

Research on K rates, preplant versus in-season applications, and material type (form and source) has not been conducted using Columbia Basin center pivot irrigation systems. Although Pacific Northwest research has shown a potato yield response to granular K (Jackson, 1983; Roberts, 1983; Westermann et al., 1994b), research in Idaho did not show a production advantage using liquid K fertilizers (Westermann and Tindall, 1995). In-season application of liquid K is a practice that growers could adopt if it was shown to provide a production advantage.

Potassium fertilizer source may influence potato quality. There are mixed conclusions about the relationship between potato specific gravity (SG) and K fertilizers. Some studies report a decrease in potato specific gravity with potassium fertilizer (versus an untreated control) which is decreased further with potassium chloride when compared to potassium sulfate (Wilcox, 1961; Murphy and Goven, 1966; McDole, 1978; Panique et al., 1997). Pacific Northwest research reports either no response of SG to K fertilizers (Rykbost et al., 1993) or a response to K rate but no difference between sulfate and chloride (Gavlak et al., 1989; Westermann et al., 1994 a,b).

The objectives of this research were to evaluate potato yield and quality response between 1) K source (sulfate or chloride) and 2) K fertilizer form (liquid or granular) and 3) determine if there is a production advantage from multiple in-season applications.

MATERIALS AND METHODS

This research was conducted from 1997 to 1999 in commercial fields in George, Washington. A different field was used each year due to regional crop rotation practices, however, all fields were managed by the same grower and were within a 0.75mi radius. Each site was on a Quincy fine sand (mixed, mesic, Typic Torripsamment). In 1997 and 1999 the cultivar 'Russet Burbank' and in 1998 the cultivar 'Russet Norkotah' were used. Each year, a plot area was established in a completely randomized block design that accommodated 36 plots, with each plot sized 4 rows wide (2.8 ft. row spacing) and 25 ft. long. Treatments were established using either no K (control) or K fertilizer at the recommended field average rate (Table 1), and examined fertilizer form, potassium source, and application timing (Table 2). All treatments were replicated 4 times. In-season K fertilizer applications corresponded with plant growth stages by applying 25% of the seasonal total at row closure, 25 % 3 weeks later at tuber bulking and, for the 75% in-season treatments, 25% 6 weeks after row closure. All other fertilizer and pest control applications were made by the grower as part of his standard field practices.

Two weeks prior to commercial harvest, the center six meters of the center two rows were harvested using a one row digger. Potato yield was determined through tuber weight. The tubers were then graded by visually separating them into cull and acceptable potatoes (% marketable), where cull potatoes were either small (under 108 g) or malformed (e.g., knobbed, cracked). Tuber specific gravity (tuber weight in air/tuber weight in water) was determined on a subsample of acceptable tubers.

Data analysis for crop yield and quality response to fertilizer treatments was conducted using analysis of variance using PROC GLM of PC SAS (SAS, 1998). Since yield, % marketable, and specific gravity (SG) all differed by year ($P = 0.0001, 0.0001, 0.0001$, respectively), the data analysis was conducted separately for each year.

Table 1: Preplant soil test potassium (K) values and fertilizer K application rates from 1997 - 1999, where fertilizer was applied at rates consistent with current guidelines for fertilizer management in Washington.

Year	Soil Test K (ppm)	K Fertilizer Rate (lb K_20/A)
1997	135	350
1998	154	325
1999	86	400

RESULTS AND DISCUSSION

In 1999, yield was significantly related to treatment (Table 3). Yield was significantly higher in plots fertilized with granular potassium sulfate (KS) or potassium chloride (KC) applied 100% preplant and liquid KS applied 50% in-season, than with 75% in-season application of KS or KC or 50% in-season application of KC. All other treatments were intermediate. Orthogonal

Table 2: Potassium fertilizer treatment numbers. Each liquid in-season applications contained 25% of the total seasonal K and the applications were made at row closure, three weeks later during tuber bulking, and, for the 75% in-season treatments, six weeks after row closure.

Potassium source	Fertilizer form	% Applied preplant	% Applied in-season	Treatment number
Control (none)	none	0	0	1
Potassium sulfate (KS)	granular	100	0	2
	liquid	100	0	4
		50	50	6
		25	75	8
Potassium chloride (KC)	granular	100	0	3
	liquid	100	0	5
		50	50	7
		75	75	9

contrasts indicate there was a difference in yield between plots with or without K fertilizer and between KS and KC. The values suggest that yield was lower in K fertilized plots than in the control (means 32.41 and 33.80 T/A, respectively). The decrease in yield can predominately be attributed to the use of potassium chloride (KC), since potatoes fertilized with this source had lower yields than those fertilized with potassium sulfate (KS) (means 31.58 and 33.24 T/A, respectively).

Marketable potato percentage (% marketable) varied with treatment in both 1998 and 1999. In both years, there was a difference in % marketable related to fertilizer form (Table 4). In 1998, when potatoes were fertilized with granular material there was a lower % marketable than with liquid fertilizer (means 91.86 and 92.18%, respectively). In 1999 there was a higher % marketable with liquid than granular fertilizer (means 86.61 and 84.60, respectively). The % marketable was reduced when potatoes received K fertilizers compared to the control treatment in 1998 (means 92.02 and 92.76%, respectively). In 1999, % marketable was lower with KC fertilizers than with KS (means 83.99 and 86.28%, respectively) (Table 4).

There were no relationships between SG and K fertilizer treatments (Table 5). The SG results in this study do not support results from studies conducted outside of the Pacific Northwest which showed a greater reduction in SG when potatoes are fertilized with KC than with KS (Wilcox, 1961; Murphy and Goven, 1966; Panique et al., 1997), but are consistent with research conducted in Oregon (Rykbost et al., 1993). In 1998, a year when extremely warm weather lead to poor potato

Table 3: Average potato tuber yield for three years with different potassium fertilizer form (liquid or granular), source (sulfate or chloride) and timing (100% preplant vs 50-75% in-season). Mean separation by Duncan Waller. n = 4

Treatment #	K Source	K Form	% Applied in-season	Yield (T/A) 1997	1998	1999
1	Control	none	0	20.02 a	39.74 a	33.80 abc
2	Potassium sulfate (KS)	granular	0	19.41 a	41.36 a	35.10 a
4		liquid	0	20.98 a	41.54 a	32.65 abc
6			50	21.47 a	39.59 a	34.47 a
8			75	20.67 a	39.17 a	30.73 c
3	Potassium chloride (KC)	granular	0	39.10 a	38.46 a	34.44 a
5		liquid	0	20.87 a	40.35 a	33.48 ab
7			50	21.54 a	37.68 a	31.25 bc
9			75	20.37 a	39.37 a	27.17 d
Level of Signficance (*P*)	treatment			0.9849	0.6527	0.0003
	control vs K fertilizer			0.9121	0.3772	0.0802
	sulfate vs chloride			0.3125	0.1793	0.0002
	granular vs liquid			0.9298	0.6052	0.7352
	preplant vs in-season			0.8951	0.9657	0.1903

SG throughout the Pacific Northwest (Dean, 1999), there was no relationship between K source, K form or time of K application and potato SG. In 1999 a KC treatment had high specific gravity, similar to the control. The average SG for potatoes receiving 0 K, KS or KC were 1.0826, 1.0815, and 1.0810, respectively, in 1997; 1.0757, 1.0680, and 1.0650, respectively, in 1998; and 1.0730, 1.0745, and 1.0734, respectively, in 1999. Orthogonal contrasts between K fertilizer treatments and the control, and between KS and KC indicate that there was no reduction in specific gravity with K, regardless of source (Table 5).

Table 4: Average % marketable potatoes produced with different potassium fertilizer form (liquid or granular), source (sulfate or chloride) and timing (100% preplant vs 50-75% in-season). Mean separation by Duncan Waller. n = 4

Treatment #	K Source	K Form	% Applied in-season	% Marketable 1997	1998	1999
1	Control	none	0	91.27 a	92.76 abc	86.74 a
2	Potassium sulfate (KS)	granular	0	92.66 a	92.94 ab	86.98 a
4		liquid	0	89.44 a	90.93 bc	85.22 a
6			50	90.25 a	90.82 c	87.71 a
8			75	91.38	91.75 abc	85.22 a
3	Potassium chloride (KC)	granular	0	90.23 a	90.79 c	86.24 a
5		liquid	0	90.43 a	91.96 abc	85.71 a
7			50	90.49 a	93.20 a	84.96 a
9			75	92.66 a	92.41 abc	79.05 b
Level of Signficance (*P*)	treatment			0.8019	0.0332	0.0015
	control vs K fertilizer			0.5650	0.0467	0.4359
	sulfate vs chloride			0.4104	0.2755	0.0022
	granular vs liquid			0.3097	0.0336	0.0801
	preplant vs in-season			0.6665	0.5824	0.2984

Overall, the results from this experiment indicate that applying granular K fertilizers at rates consistent with current guidelines (Lang et al., 1999) provided a yield advantage in one of three years. Quality, as % marketable in one year, was greater with KS fertilizer than with KC, and, in another year was higher without than with K fertilizer. In one year, % marketable was higher with liquid than with granular K fertilizer but the next year was higher with granular than with liquid K fertilizer.

Table 5: Average potato tuber specific gravity for three years with different potassium fertilizer form (liquid or granular), source (sulfate or chloride) and timing (100% preplant vs 50-75% in-season). Mean separation by Duncan Waller. n = 4

Treatment #	K Source	K Form	% Applied in-season	Specific Gravity		
				1997	1998	1999
1	Control	none	0	1.0826	1.0757	1.0730
2	Potassium sulfate (KS)	granular	0	1.0808	1.0643	1.0758
4		liquid	0	1.0817	1.0629	1.0742
6			50	1.0814	1.0642	1.0744
8			75	1.0822	1.0646	1.0738
3	Potassium chloride (KC)	granular	0	1.0800	1.0665	1.0752
5		liquid	0	1.0819	1.0643	1.0739
7			50	1.0815	1.0673	1.0725
9			75	1.0805	1.0619	1.0715
Level of Signficance (*P*)	treatment			0.8040	0.4506	0.5620
	control vs K fertilizer			0.3968	0.8394	0.3104
	sulfate vs chloride			0.6478	0.4323	0.1683
	granular vs liquid			0.5820	0.6168	0.6183
	preplant vs in-season			0.7432	0.1941	0.6541

CONCLUSIONS

The K fertilizer treatments did not give a clear indication of a yield or quality advantage when compared to a control (0 K) treatment. In this study, when there was a response to K fertilizers, potato yield and quality were highest with 100% granular K fertilizer, regardless of source, and with the liquid KS treatment with 50% in-season application made across two applications (each 25% of total) when compared to other K management treatments. Using 75% of the annual K as liquid in-season applications had an adverse affect on potato yield and quality. In contrast to other reports, SG, an important tuber quality factor, was not adversely affected when KC was used. It is noteworthy that there was no influence of K source (KC or KS) on SG during the 1998 growing season, a season typified by poor specific gravity throughout the Pacific Northwest. Even during the 1997 and 1999 growing seasons, when regional SGs were more typical, there was no influence of K source on SG.

ACKNOWLEDGMENTS

The authors thank the Phosphate Potash Institute for funding this project and also thank Bill Sharpe and Arnie Greenwalt for technical assistance.

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