POTASSIUM MANAGEMENT OF RUSSET BURBANK POTATOES IN SOUTHERN IDAHO[1]

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Historical soil test information for southern Idaho surface soils (0-12") shows that extractable K concentrations declined from 400-plus ppm in the late 1960's to 100-200 ppm today. Potatoes, silage corn, and alfalfa can remove nearly 400 lbs K/A-yr when high yields are achieved. Many irrigation waters contain 28-56 lbs/A-ft soluble K which is not sufficient to maintain soil test K concentrations with high K removal rates.

Recent data on the K fertilizer requirements of alfalfa, dry beans, Russet Burbank potatoes and soft white winter wheat supported the use of soil K concentrations recommended in University of Idaho fertilizer guides (Gavlak et al.,1989). For potatoes, K fertilization is not recommended when $NaHCO_3$ extractable K concentrations are greater than 158 ppm (McDole et al., 1987; Jones et al., 1970; Painter and Ohms, 1967; Iritani and Painter, 1963).

Relatively high potato yields (over 500 cwt/A) are being achieved by many of Idaho's potato growers. This production level typically removes over 200 lbs K/A in the tubers. In addition, petiole K concentrations below suggested critical concentrations during mid- and late-season tuber growth are being reported. As a preventive or corrective measure, some growers are applying K solutions during tuber growth with their irrigation systems. Data from Wisconsin indicates that in-season K applications do not enhance yields or quality, or improve fertilizer-use-efficiency over preplant or side-dressing applications (Kelling et al., 1994). Plant tissue diagnostic norms for petioles are generally not available to determine when to recommend this practice. In addition, it is not known how late during tuber growth K solutions could or should be applied without affecting tuber quality. The objectives of this study were to a) evaluate the K fertilizer requirements of Russet Burbank potatoes, b) the efficacy of K-solutions applied during tuber growth, c) the relative effectiveness of K-sources, and d) the K dynamics in the potato plant as related to petiole K concentrations. This paper reports the tuber yield and quality responses obtained with potassium fertilization.

METHODS AND MATERIALS

Four field experiments were established on grower fields in southern Idaho between 1992 and 1994 (Table 1). All cultural practices, including sprinkler irrigations were controlled by the respective grower. Russet Burbank seed was usually planted in late April and the crop harvested in late September.

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Table 1. Russet Burbank K Experiments.

Exp No.	Soil Series	STKC[a]
266-92	Wodskow sandy loam	102
267-93	Schodson loamy sand	85
268-93	Portneuf silt loam	126
270-94	Decker fine sandy loam	131

[a] ppm soil test K concentration, 0-12".

All experiments contained selected K rate, K source, broadcast *vs* banding, timing, and preplant, fertigation or split application variables. The 268-93 study only had K solutions applied during tuber growth as treatments. Solution K sources included KCl, K_2SO_4, and KTS (potassium thio-sulfate). Simulated K-fertigation applications were accomplished by spraying the K solutions on the respective treatment-plot during a sprinkler irrigation event. All fertigation treatments were started in early July and completed by mid-August. Preplant broadcast applications were applied before spring tillage preceding planting, while banded K-materials were placed in a single band four to six inches adjacent to the seed after planting. Individual plots were six-rows wide and 50 ft long. During fertigation only the inter-row area between the outside rows of adjacent plots was used as a foot-traffic lane.

Soil samples (1^{st} and 2^{nd} ft) were taken from each replication prior to preplant fertilizer application, air-dried, pulverized with a flay-grinder, and stored until analyzed according to standard soil testing procedures (Gavlak et al., 1994). Extractable K was determined on a $NaHCO_3$ extract. Plant sampling started at early tuber growth (late June) and continued on about a 21 day interval until vines died or were killed prior to harvest. Samples consisted of petioles from the fourth leaf, and the tops, tubers, and easily recoverable roots from a 5 ft row section. The second row from an edge of each plot was used for the whole plant samples. Tubers and roots were washed, and the tubers subsampled before drying. All plant samples were dried at 60°C, weighed, ground to pass a 40-mesh screen, and stored until analyzed. Analytical procedures are described by Westermann et al.(1994). Tuber yields, size quality and distributions were estimated from 40 ft of row per plot. Specific gravity was determined by the weight-in-air, weight-in-water method on a representative sample of number US# 1 and 2 tubers. Internal defects were also evaluated on the specific gravity sample in selected experiments.

Each experiment design was a randomized complete block, with four replications. All data were statistically analyzed with PROC ANOVA and PROC GLM procedures SAS(1982). Selected variables were further evaluated by orthogonal comparisons utilizing contrast statements analyzed with PROC GLM.

RESULTS AND DISCUSSION

Soil Applied K Effects.

Potassium fertilization significantly increased yields of ≥10 oz US#1 (L-US#1) and the percentage ≥10 oz tubers in two studies (Table 2). There was also a tendency for total yields to be increased in all three studies. Specific gravities decreased slightly in two out of the three studies. Large tubers (≥10 oz) were limited in 267-93 because of premature plant senescence.

Table 2. Overall effect of K on tuber yields and specific gravity.*

Yield	266-92		267-93		270-94	
Parameter	-K	+K	-K	+K	-K	+K
Total	416	440	330	357	408	419
US#1	254	254	124	134	296	302
L-US#1	73a	106b	—	—	82a	103b
% ≥ 10 oz	17.5a	26.9b	—	—	29.8	33.6
S.G.	1.083	1.082	1.088	1.088	1.082	1.080

* Means within the same row and experiment followed by different letters are significant at $P \leq 0.05$.

Table 3. Effect of preplant broadcast KCl and K_2SO_4 on tuber yields and specific gravity.*

	K rate	Total	US#1	L-US#1	≥10 oz	S.G.
K Source	lbs/A	--------	cwt/A	--------	%	
			Experiment 266-92			
—	0	416a	324a	73a	19.9a	1.083b
KCl	100	429ab	351ab	101ab	25.9b	1.083b
KCl	200	429ab	337a	105ab	28.4b	1.081ab
K_2SO_4	200	451b	374b	115b	27.7b	1.082ab
KCl	400	445b	373b	118b	29.8b	1.080a
			Experiment 270-94			
—	0	408ab	296bc	82	29.8a	1.082b
KCL	150	421b	310c	91	29.6a	1.079a
K_2SO_4	150	401a	282b	94	33.0ab	1.081ab
KCl	300	419b	285b	100	35.1b	1.082b
K_2SO_4	300	450c	312c	102	32.9ab	1.078a
KCl	600	389a	256a	93	35.9b	1.077a

* Means within the same column and experiment followed by different letters are significant at $P \leq 0.05$.

Banding the K fertilizer after planting compared with preplant broadcasting significantly increased ≥10 oz tubers in only one study (Data not shown). Total yields, US#1 and L-US#1 were not affected by either placement. Specific gravities were similar (Data not shown).

Overall both KCl and K_2SO_4 had similar effects on tuber yields (Table 3). In 266-92, K_2SO_4 at 200 lbs K/A and KCL at 400 lbs K/A significantly increased total yields, US#1 and L-US#1. Similar trends occurred with 300 lbs K/A as K_2SO_4 in 270-94. The percentage of ≥10 oz tubers were increased in both studies by K applications. The higher tuber yields were found at the highest K rate (400 lbs K/A) in 266-92, while the highest K rate (600 lbs K/A) in 270-94 tended to decrease yields, especially US#1. This may indicate that very high K rates should be split, with a portion applied the previous fall to avoid possible detrimental effects. Potassium applications decreased specific gravities (Table 3). Slightly higher gravities often occurred when K_2SO_4 was the K source.

Fertigation K Effects.

Applying all the K fertilizer preplant tended to increased yields of total and L-US#1 tubers over splitting the K between preplant and fertigation (Table 4). Split applications also had a lower percentage of ≥10 oz tubers. In both studies, the K rate per fertigation event was 50 lbs K/A.

Table 4. Effect of K application method on tuber yields and specific gravity (Potassium rate for KCL and K_2SO_4 indicated.).[a]

Yield	266-92 (@ K=200)		270-94 (@ K=300)	
Parameter	Preplant	Split	Preplant	Split
Total	429b	388a	434	412
US#1	337b	298a	298a	315b
L-US#1	105b	72a	101b	82a
%≥10 oz	28.4b	21.9a	34.0b	26.9a
S.G.	1.081	1.081	1.079	1.079

[a] Means within the same row and experiment followed with different letters are significant at $P \leq 0.05$.

Higher K rates per fertigation event (25 *vs* 50 lbs K/A), as well as total amount applied with fertigation tended to reduce the percentage of ≥10 oz tubers (Table 5), corresponding to a small increase in US#1's and a reduction in L-US#1's. Specific gravity was not significantly changed with fertigation. The treatments with more splits (2xs *vs* 4xs) had fertigation K applications later in the growing season.

No consistent differences occurred between K-sources used for fertigation (Table 6). In 266-92, KTS was superior to KCl; while in 268-93, KCl had higher total yields, and KCL and K_2SO_4 both had higher L-US#1 yields than KTS. No significant differences occurred in 270-94. KTS had higher specific gravities than KCl in both 266-92 and 268-93, while K_2SO_4 was higher than KCl in only 268-93. Source effects were not apparent at different K rates (Data not shown).

Table 5. Effect of splitting K fertigation rates on tuber yields and specific gravity.[a]

Yield	268-93				270-94[b]		
	K_0	K_{50}	K_{100}		K_0	K_{50}	K_{150}
Parameter	----	2xs	2xs	4xs	----	2xs	3xs
Total	496	507	493	496	411	426	412
US#1	385	393	382	392	296a	294a	315b
L-US#1	169	151	142	150	92	99	82
%≥10oz	39.5b	33.8a	33a	33.8a	31.3b	34.8b	26.9a
S.G.	1.096	1.096	1.095	1.094	1.080	1.078	1.079

[a] Means within an experiment and row followed by different letters are significant at the $P \leq 0.05$.
[b] All 270-94 treatments had 150 lbs K/A broadcast preplant.

Table 6. Effect of fertigation with different K-sources on tuber yields and specific gravity.[a]

Yield	266-92 @K=100		268-93 @K=50,100			270-94 @K=150	
Parameter	KCl	KTS	KCl	K_2SO_4	KTS	KCL	K_2SO_4
Total	378a	418b	523b	486a	484a	417	417
US#1	315a	337b	402b	403b	373b	307	309
L-US#1	94a	114b	154b	157b	135a	102	88
%≥10oz	26.2	29.4	33.2	35.2	32.5	33.4	29.1
S.G.	1.082a	1.084b	1.093a	1.097b	1.096b	1.080	1.079

[a] Means followed with a different letter within an experiment and row are significantly different at $P \leq 0.05$.

Petiole K Concentration.

Petiole K concentrations decreased with time after tuber initiation (Data not shown). Concentrations were initially higher with broadcast placement compared with banding or fertigation treatments. Concentrations for split treatments were intermediate. Treatments receiving K_2SO_4 were generally higher than those receiving KCl or KTS. Petiole K concentration responded within 15-20 days after a fertigation application. The relationship between the petiole K concentration and K-uptake rate balance (total plant uptake/tuber uptake) showed that the average K concentration was 6.4% when the K-balance was '1' (Fig. 1). The 'balance' concentration was somewhat dependent upon the average tuber growth rate, varying between 5.5 and 7.7 %K among experiments (Data not shown).

CONCLUSIONS

These studies support the continued use of current soil test K concentrations in Idaho's fertilizer guide for potatoes. Recommended K fertilization rates should be increased for potato production, particularly on the coarser textured soils. Potassium fertilization increased the portion of $\geq$10 oz tubers. In general, K-source did not affect total tuber yields, however K_2SO_4 treatments tended to have higher yields of US#1 tubers and slightly higher specific gravities than KCl treatments. A preplant K application was more effective than splitting the application between preplant and fertigation or applying all the fertilizer during tuber growth (via fertigation). Fertigated K applications should be used when a K deficiency is likely to reduce tuber growth rates before normal maturation. Growers should avoid K fertigation rates >25 lbs K/A per event during tuber growth and K applications during late growth (~ 30 days before vine kill or normal maturity). A preferred K-source for fertigation was not indicated by the data. The petiole contained less than 6.4% K when the plant's K-uptake rate balance was less than one.

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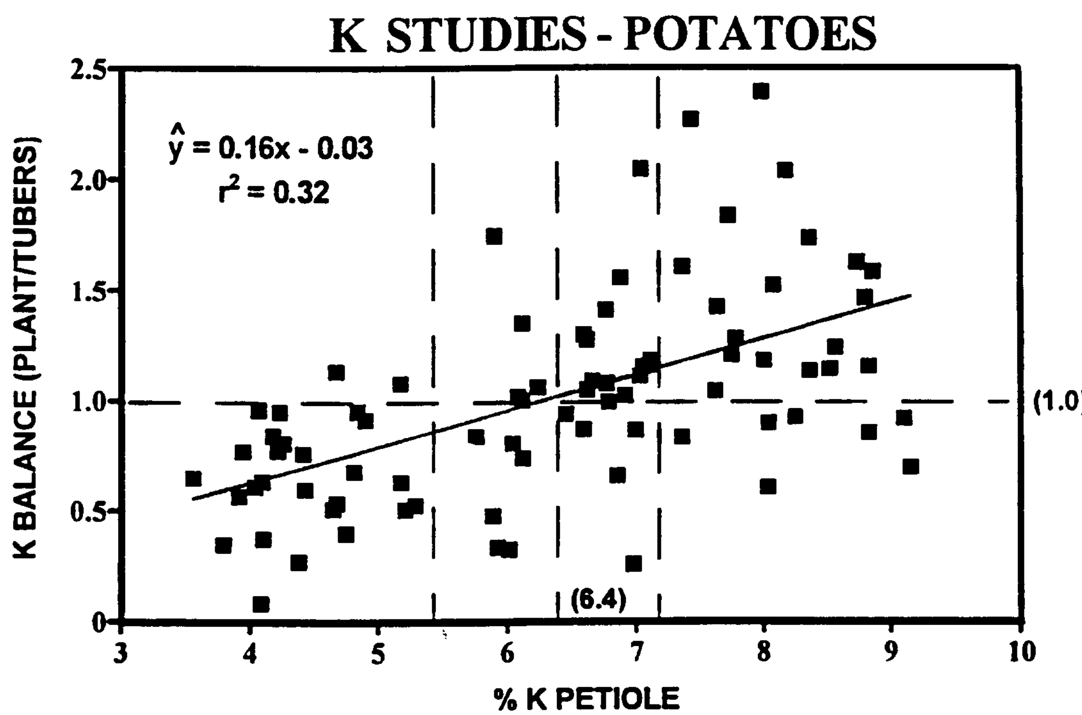

Fig. 1. Relationship between petiole K percentage and K-uptake rate balance (whole plant K uptake/tuber K uptake) during tuber growth.