Russet Burbank Response to Foliar Applied Calcium

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Summary: A field experiment at the Sand Plain Research Farm in Becker, MN was conducted in 2010 to evaluate the effects of calcium (Ca) foliar feeding strategies on Russet Burbank potato tuber size and potato plant Ca uptake. A comparison was made between a non-foliar fed control, and treatments that included foliar fed 6% Ca as calcium nitrate or Carbomin calcium. In addition, strontium (Sr) nitrate and Carbomin Sr treatments that used 12% Sr as a tracer were examined to evaluate potential Ca uptake in potato plants. The use of Carbomin Ca produced tuber yields consistent with the use of Ca nitrate in a foliar feeding regimen. However, foliar feeding with Carbomin Ca can potentially reduce incidences of disqualifying brown center or hollow heart when compared with a Ca nitrate treatment. There were also no significant differences in yields between the two Sr treatments, but the yield of large tubers (> 14 oz) was lower in the Sr treatments when compared to the no foliar control. Incidence of tuber hollow heart and brown center was significantly lower with Carbomin Ca than with Ca nitrate and numerically lower than the control and the surfactant only treatments. Nutrient analysis of plant matter showed no significant differences among any treatment with respect to Ca concentration. However, Sr concentrations were significantly higher under a foliar feeding regimen, suggesting uptake. Very little significant difference was seen between Carbomin and the respective nitrate salts of either Ca or Sr, except in the early leaf samples where the Carbomin Sr treatment contained higher Sr than the Sr nitrate treatment. Foliar strontium application from either source did not increase strontium concentrations in the tuber peel or flesh. This indicates that little if any Sr is transported from the leaves to tubers following a foliar application.

Background: Calcium deficiency can occur in acidic, highly leached soils. In potato, deficiencies can result in poor tuber quality and storability, and reduced tuber size. Foliar feeding of Ca is one strategy used to overcome mild Ca deficiencies. Calcium nitrate has been used in foliar feeding regimens, but recently a new product, Carbomin Ca, has been introduced as an alternative. In this study we compared a no foliar application control with treatments that included a surfactant and 6% Ca nitrate or 6% Carbomin Ca. A surfactant only control was also examined. In addition, treatments that included 12% Sr nitrate or a Sr analog of Carbomin (12% Carbomin Sr) were included. The Sr is taken up and metabolized by the plant as if it was Ca and can be used as a tracer to determine Ca uptake efficacy. Soils generally have very low Sr, so native Sr will have little effect on Sr concentrations in plant tissue.

The objectives of this study were, under field conditions, to 1) compare the effects of Ca foliar feeding as Ca nitrate or Carbomin Ca on tuber yield and quality in Russet Burbank potato, 2) determine differences in potential Ca uptake between potato plants foliar fed with Ca nitrate and Carbomin Ca, and 3) Use Sr as a tracer for foliar Ca application.

Materials and Methods

The study was conducted at the Sand Plain Research Farm in Becker, Minnesota on a Hubbard loamy sand using the potato cultivar Russet Burbank. The previous crop was rye. Selected soil chemical properties before planting were as follows (0-6"): water pH, 6.1; organic matter, 1.9%; Bray P1, 46 ppm; ammonium acetate extractable K, Ca, Mg, and Sr, 81, 842, 160, and 4.3 ppm, respectively; Ca-phosphate extractable SO_4-S, 4 ppm; DTPA extractable Zn, Cu, Fe, and Mn, 1.1, 0.7, 34.0, and 7.4 ppm, respectively.

Whole “B” seed was hand planted in furrows on April 28, 2010. Four, 20 ft rows were planted for each plot with 18 ft of each of the middle two rows used for sampling and harvest. Spacing was 36 inches between rows and 12 inches within each row. Each treatment was replicated four times in a randomized complete block design. Weeds, diseases, and insects were controlled using standard practices. Rainfall was supplemented with sprinkler irrigation using the checkbook method of irrigation scheduling.

Treatments included a no foliar application control, a surfactant only control, two 6% Ca treatments and two 12% Sr treatments. Six treatments were tested and are listed below (Table 1).

Table 1. Calcium treatments tested in the Russet Burbank Ca foliar feeding study.

Treatment #	Treatment
1	Control
2	Carbomin Ca (6%) + Surfactant
3	Calcium Nitrate (6%) + Surfactant
4	Carbomin Sr (12%) + Surfactant
5	Strontium Nitrate (12%) + Surfactant
6	Surfactant Only

A starter fertilizer containing 30 lb N/A, 130 lb P_2O_5/A, 181 lb K_2O/A, 20 lb Mg/A, and 46 lb S/A as a blend of ammonium phosphate (MAP), potassium chloride, potassium magnesium sulfate, and ammonium sulfate were applied to all plots at planting. The remaining 210 lb N/A was sidedressed as ESN and mechanically incorporated at emergence on May 25. Calcium and Sr foliar treatment solutions were mixed with LI 700 surfactant according to manufacturer’s directions and applied six times at a rate of 1 gal/A of either 6% (by weight) Ca nitrate or Carbomin Ca, or 1.09 gal/A of either 12% Sr nitrate or Carbomin Sr. Solutions were diluted to 25 gal in water prior to application. Foliar application was made with a CO_2 sprayer on June 16, June 28, July 7, July 19, August 2, and Sept. 1.

Plant stands were measured on June 2 and the number of stems per plant was counted on June 9. Whole leaf samples were collected on July 9 and August 5. Four whole plants were collected by hand-digging on Sept. 17. Shortly after on the same day vines were killed via mechanical beating. Plots were machine-harvested on Sept. 22 and total tuber yield, graded yield, tuber specific gravity, and the incidence of scab, hollow heart, and brown center were measured.

Tuber peels, whole tubers, the two whole leaf samples, and vines were analyzed for Ca and Sr content, along with Al, B, Cd, Cr, Cu, Fe, K, Mg, Mn, Na, Ni, P, Pb, and Zn, via a multi-element, ICP-dry ash method.

All trials of the experiment were statistically analyzed using ANOVA procedures on SAS and means were separated using a Waller-Duncan LSD test at $P = 0.10$.

Results

Rainfall and irrigation amounts are presented in Figure 1.

Tuber Yield: There were no significant differences in total tuber yield or marketable yield among any of the treatments. Only the category of tubers > 14 oz showed any significant difference. In this category, the no foliar control produced a significantly higher number of large tubers (> 14oz) than either of the Sr treatments or the 6% Carbomin Ca treatment. However, there were no significant treatment differences in the percent of tubers produced that were > 6 oz or > 10 oz.

Tuber Quality: The Ca nitrate treatment (trmt 3) produced significantly more tubers with brown center and hollow heart that were disqualified than any of the other treatments except the no foliar control (1). There was no significant difference among the remaining treatments. However, scab levels were low and not significantly different with means that ranged from 6.7 (Carbomin Sr trmt 4) down to 0.8% (no foliar trmt 1). There were no significant treatment differences with respect to tuber specific gravity.

Plant Matter Nutrient Concentration: Ca concentrations were not significantly affected by treatment in any part of the plant or tuber (Table 3). There were also no consistent numerical trends with respect to Ca. In the leaf samples and vines, Sr content was significantly higher in the treatments where Sr was applied as a foliar feed. However, only one of the leaf sample sets displayed a significant difference between the Sr nitrate and Carbomin Sr treatments. The July 9 leaf samples had significantly higher Sr concentrations in the Carbomin Sr (trmt 4) than the Sr nitrate (trmt 5). The vine samples (although not significant) trended the other way numerically (trmt 5 > 4) while the August 5 leaf samples contained nearly identical Sr concentrations in trmts 4 and 5. Foliar Sr application from either source did not increase Sr concentrations in the tuber peel or flesh. This indicates that little if any Sr is transported from the leaves to tubers following a foliar application.

Conclusions

The use of Carbomin Ca produced tuber yields consistent with the use of Ca nitrate in a foliar feeding regimen. However, foliar feeding with Carbomin Ca can potentially reduce incidences of disqualifying brown center or hollow heart when compared with a Ca nitrate treatment. There were also no significant differences in yields between the two Sr treatments, but the yield of large tubers (> 14 oz) was lower in the Sr treatments when compared to the no foliar control. Nutrient analysis of leaf, vine and tuber tissue showed no significant differences among any treatment with respect to Ca concentration. However, Sr concentrations were significantly higher under a foliar feeding regimen for leaves and vines, suggesting uptake. Very little significant difference was seen between Carbomin and the respective nitrate salts of either Ca or Sr, except in the early leaf samples where the Carbomin Sr treatment contained higher Sr than the Sr nitrate treatment. Foliar Sr application from either source did not increase Sr concentrations in the tuber peel or flesh. This indicates that little if any Sr is transported from the leaves to tubers following a foliar application.

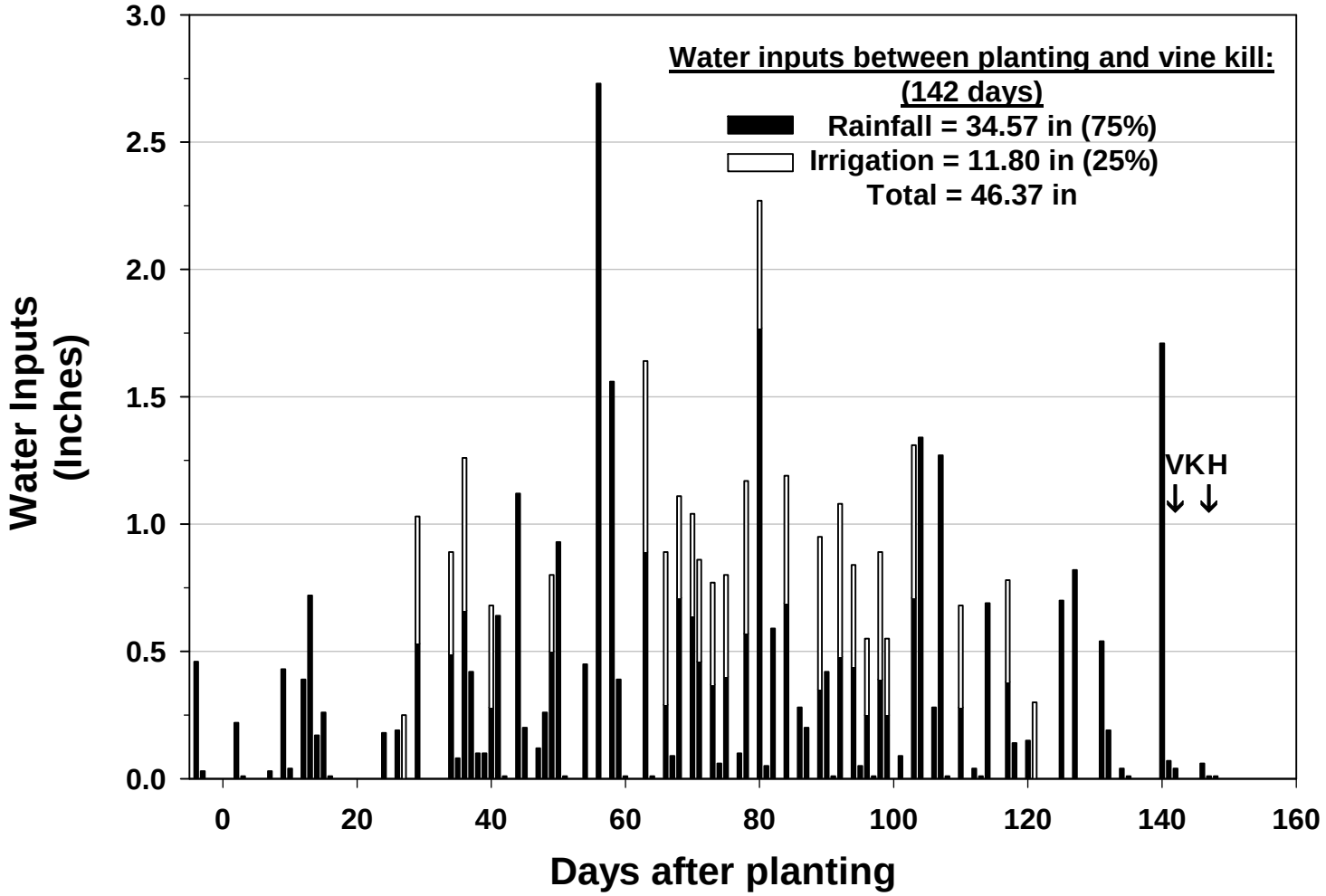

Figure 1. Rainfall and irrigation amounts during the 2010 growing season. Planting (April 28); VK = Vine Kill (Sept 17); H = Harvest (Sept 22)

Table 1. Effect of Ca foliar feeding strategies on Russet Burbank tuber yield and size distribution.

Calcium Treatments		N Treatment	Tuber Yield										
Trmt #	Foliar Treatment	N Rate	0-3 oz	3-6 oz	6-10 oz	10-14 oz	>14 oz	Total	#1 > 3 oz	#2 > 3 oz	Total Marketable	> 6oz	> 10 oz
		lb N / A	cwt / A									%	
1	None	240	67.9	263.6	220.2	71.0	56.1	678.8	415.3	195.6	610.9	51.2	18.8
2	Carbomin Ca (6%) + Surfactant	240	75.6	298.3	215.4	77.0	30.3	696.6	435.5	185.5	621.0	46.4	15.4
3	Calcium Nitrate (6%) + Surfactant	240	79.9	299.1	208.6	59.2	38.4	685.3	430.3	175.1	605.4	44.6	14.2
4	Carbomin Sr (12%) + Surfactant	240	78.9	274.0	212.3	57.3	19.6	642.0	432.7	130.5	563.2	45.0	12.0
5	Strontium Nitrate (12%) + Surfactant	240	76.7	309.9	203.8	66.6	25.4	682.4	419.9	185.8	605.7	43.3	13.4
6	Surfactant Only	240	68.4	290.7	218.9	81.4	42.8	702.2	415.1	218.7	633.7	48.6	17.5
		Significance[1]	NS	NS	NS	NS	*	NS	NS	NS	NS	NS	NS
		LSD (0.1)	--	--	--	--	22.1	--	--	--	--	--	--

[1]NS = Non significant; ++, *, ** = Significant at 10%, 5%, and 1%, respectively.

Table 2. Effect of Ca foliar feeding strategies on Russet Burbank tuber quality.

Calcium Treatments		N Treatment	Tuber Quality[1]					
Trmt #	Foliar Treatment	N Rate	Specific Gravity	HH	HH DQ	BC	BC DQ	Scab
		lb N / A		%				
1	None	240	1.0777	4.15	3.30	4.15	3.30	0.83
2	Carbomin Ca (6%) + Surfactant	240	1.0790	1.65	1.65	1.65	1.65	5.00
3	Calcium Nitrate (6%) + Surfactant	240	1.0787	6.65	5.00	8.33	5.00	2.50
4	Carbomin Sr (12%) + Surfactant	240	1.0754	0.83	0.00	1.65	0.00	6.68
5	Strontium Nitrate (12%) + Surfactant	240	1.0768	2.48	0.83	4.15	0.83	2.50
6	Surfactant Only	240	1.0788	4.15	0.83	5.00	0.83	5.83
		Significance[2]	NS	**	*	*	*	NS
		LSD (0.1)	--	3.74	2.85	3.65	2.85	--

[1]HH = Hollow Heart; DQ = Disqualified (i.e > 3/4" in diam); BC = Brown Center

[2]NS = Non-significant; ++, *, ** = Significant at 10%, 5%, and 1%, respectively.

Table 3. Effect of foliar feeding strategies on nutrient concentration and uptake in Russet Burbank potato plants.

Treatment #	Foliar Treatment	Ca					Sr				
		Tuber		Above Ground[1]			Tuber		Above Ground[1]		
		Peel	Flesh	Leaf #1	Leaf #2	Vine	Peel	Flesh	Leaf #1	Leaf #2	Vine
		---------- ppm ----------									
1	None	966	225	13574	12589	9789	4.74	1.17	39.6	30.8	42.8
2	Carbomin Ca(6%)+Surfactant	1149	233	11830	11383	9745	6.07	1.39	34.4	27.0	46.1
3	Calcium Nitrate(6%)+Surfactant	1032	232	12498	12343	9730	5.70	1.34	37.0	32.9	46.5
4	Carbomin Sr(12%)+Surfactant	1095	232	13731	11406	10436	5.86	1.25	1427.5	1194.2	165.3
5	Strontium Nitrate(12%)+Surfactant	1101	242	12201	10845	10723	6.21	1.36	1076.6	1194.3	183.0
6	Surfactant Only	1078	219	11665	11232	9590	6.21	1.06	34.0	26.4	41.8
Significance[2]		NS	NS	NS	NS	NS	NS	NS	**	**	**
LSD (0.1)		--	--	--	--	--	--	--	**237.9**	**144.7**	**64.2**

[1]Leaf #1 samples collected on July 9 2010; Leaf #2 collected on August 5, 2010; Vines harvested on Sept 17, 2010.

[2]NS = Non significant; ++, *, ** = Significant at 10%, 5%, and 1%, respectively.