

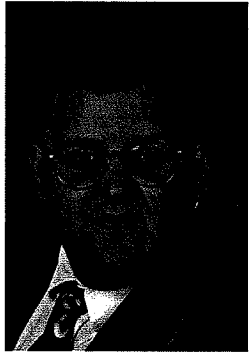
# Calcium's Effect on Potato Quality and Storability

## *Can Raising Seed Tuber Tissue Calcium Improve Its Performance?*

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### Importance of Calcium in Plants

Calcium plays a critical role in plant growth, development and the maintenance/modulation of many cell functions (Poovaiah and Reddy, 1993). This becomes evident when considering the importance of calcium in membrane structure and function as well as the structure of the cell wall. Calcium in the extracellular solution is necessary for the maintenance of selective permeability, i.e. membrane integrity. Calcium also provides stable, but reversible, inter-



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molecular linkages between pectic molecules, resulting in cell wall rigidity. The presence of extracellular

calcium increases the bond between the cell wall and the outer face of the cell/plasma membrane (Palta, 1996). Furthermore, the role of calcium as a secondary messenger in plant response to many environmental and hormonal signals [touch, wind, gravity, light, cold, heat, auxin, gibberellic acid, abscisic acid, and fungal elicitors] has been documented (Poovaiah and Reddy, 1993), and the impact of these environmental (drought, cold, heat) and biotic stresses on plants can be mediated by changes in cytosolic calcium (Palta, 1996). There is some evidence that calcium application can

<sup>1</sup> Research assistant and professor respectively. Use of trade names does not imply endorsement of the products named or criticism of similar ones not named.

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**Table 1.** Mean calcium content of tuber medullary tissue and soil test calcium levels by cultivar and year. Due to experimental design and seasonal variability intercultural and interyear comparisons are not valid.

Cultivar	Year	Mean Calcium Content <sup>1</sup>		LSD <sup>2</sup> ( $\alpha=0.05$ )	Soil Test <sup>3</sup> (ppmCA)
		Ammonium Nitrate	Calcium Nitrate		
Superior	1995	168.5b	202.7a	13.8	1340
	1996	297.7b	309.4a	9.1	1070
	1997	172.9b	201.5a	21.4	970
Atlantic	1995	101.7b	122.3a	10.4	1070
	1996	220.5b	246.3a	8.3	820
	1997	110.4a	116.3a	11.8	910
Dark Red Norland	1995	128.2b	156.3a	16.6	770
	1996	187.3b	204.9a	6.7	870
	1997	98.2b	103.1a	15.2	530
Snowden	1996	229.8b	252.4a	7.2	820
	1997	177.5b	203.8a	19.5	580
Russet Burbank	1997	98.7b	142.8a	16.8	610

<sup>1</sup> ug Ca/g dry wt. (ppm) of medullary and pith tissue internal to cortical ring.

<sup>2</sup> Means within the same row, having the same letter are not significantly different.

<sup>3</sup> Ammonium acetate extractable soil Ca in parts per million (ppm).

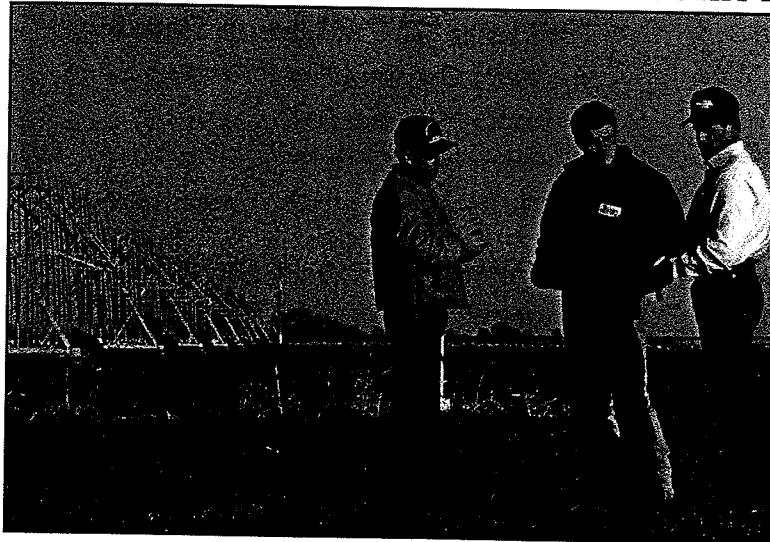
mitigate heat (Tawfik et al., 1996) and frost stress on potatoes (Vega et al., 1996).

**Importance of Calcium to Potato**  
Calcium has also been linked to several key issues of quality in pota-

atoes (*Solanum tuberosum* L.). It has been shown that storage rot, due to *Erwinia carotovora* pv. *atroseptica*, decreases as tissue calcium concentration increases (McGuire and Kelman, 1984, 1986). In addition, the incidence of internal disorders such as hollow heart, internal brown spot, and brown center decreased when the calcium concentrations in the tuber tissue were increased (Collier et al., 1978 and Tzeng et al., 1986). Thus increasing tuber tissue calcium can significantly improve tuber quality and storability.

Storage organs, such as potato tubers, are naturally deficient in calcium. Since calcium moves with the water in the xylem, transpiration is the primary pathway for calcium transportation (Clarkson, 1984). Potato tubers, which are surrounded by moist soil, will have less transpiration as compared to above-ground parts of the plant. Consequently, low-transpiring organs, such as fruits and tubers, accumulate much less calcium per unit of fresh weight than leaves.

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**Table 2.** Total tuber yield by cultivar and year. Due to experimental design and seasonal variability intercultural and interyear comparisons are not valid. LSM means within the same row having the same letter are not significantly different (based on SAS General Linear Model procedure  $p < 0.2000$ )

Cultivar	Year	Total Yield <sup>1</sup>		Calcium Nitrate	
		Mean ±	SEM	Mean ±	SEM
Superior	1995	1.50b	0.13	1.85a	0.11
	1996	2.37a	0.06	2.45a	0.06
	1997	1.34a	0.06	1.38a	0.06
Atlantic	1995	1.84a	0.13	1.77a	0.12
	1996	2.96b	0.09	3.15a	0.10
	1997	1.78a	0.07	1.80a	0.07
Dark Red Norland	1995	1.37b	0.09	1.56a	0.09
	1996	2.65a	0.07	2.68a	0.08
	1997	1.36a	0.06	1.39a	0.06
Snowden	1996	2.89a	0.09	3.04a	0.09
	1997	1.47a	0.05	1.45a	0.05
Russet Burbank	1997	1.57a	0.06	1.66a	0.06

<sup>1</sup> kg/plant total tuber yield

Potato tubers accumulate calcium directly from the surrounding soil via functional roots on the tuber and

stolon (Kratzke and Palta, 1985). On a practical level, these results indicate that the placement of calcium is

important for enhancing calcium uptake by the tuber (Kratzke and Palta, 1986). Maximum increases in tuber calcium occur when calcium is mixed into the hill where the tubers are developing (Simmons and Kelling, 1987 and Simmons et. al. 1988). It is, therefore, of critical importance to realize that if improvements in tuber quality are to be made by increasing tuber calcium, the supplemental calcium application must be made during the tuber production cycle. In our related studies we have shown that the tuber calcium level can be enhanced by the application of calcium during the bulking period.

Elevating the level of tuber tissue calcium during the seed production cycle may have an impact on the quality of the plant the seed piece produces. The objective of the studies reported here was to enhance seed tuber calcium during the seed tuber production cycle and study the impact of this calcium enhancement on performance the following year.

#### Experimental Methods

These studies were conducted over

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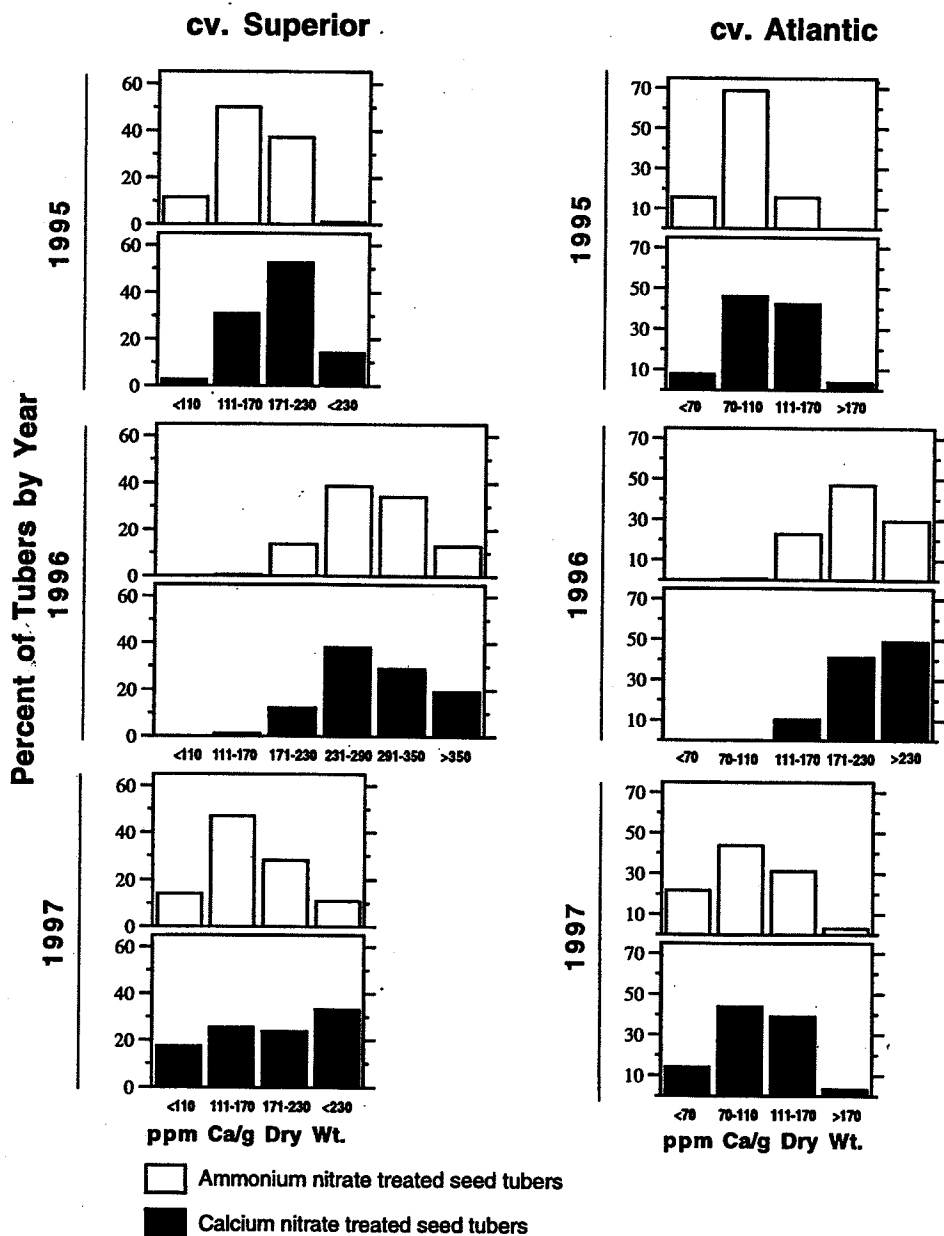
three seed production cycles and involved the following cultivars: Superior, Atlantic, Dark Red Norland, Snowden, and Russet Burbank. Calcium enhancement of seed tubers took place at a commercial seed production farm in northern Wisconsin, and the soil types were primarily silt loam (Superior, Atlantic, Dark Red Norland, Snowden) and Plainfield sand (Russet Burbank). The calcium content of these soils ranged from 1,060 lbs. Ca/acre to 2,680 lbs.

Ca/acre (See Table 1). Nutrient applications were made three times during the tuber bulking period: hilling, hilling +3 weeks, and hilling +6 weeks. The nutrients were dissolved in one gallon of irrigation water contained in a watering can and then hand applied to each 10-foot row. The total calcium delivered was 150 lbs. Ca/acre (50 lbs. Ca/application) from liquid calcium nitrate (9-0-0-11, Hydro Agri of North America) with nitrogen balanced across treat-

ments using ammonium nitrate (34-0-0) delivered at the same application times (50 lbs. nitrogen/application). The total nitrogen for all plots was 225 lbs./acre, regardless of source.

The seed tubers were harvested at maturity and stored in cold conditions until planting the following spring. Prior to planting, the seed tubers were washed with deionized water to remove any remaining soil, and a longitudinal slice, approxi-

Figure 1: Impact of supplemental calcium nitrate application on tuber tissue calcium concentration of five potato cultivars (Superior, Atlantic, Dark Red Norland, Snowden, and Russet Burbank). Each tuber was sampled and analyzed for tuber calcium concentration individually (tissue internal to the cortical ring). Data are on the proportion (percentage) of tubers within various ranges of calcium concentration with ammonium nitrate and calcium nitrate applications. All values are expressed in ppm Ca/g dry weight.



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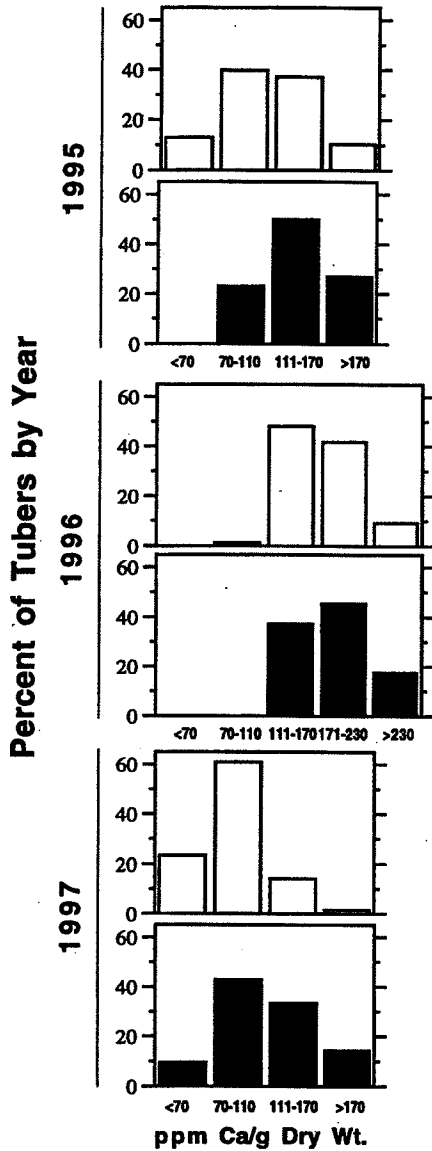
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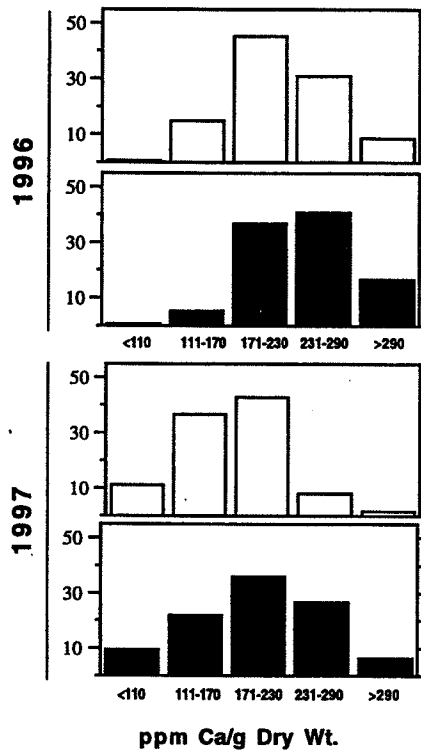


**cv. Dark Red Norland**

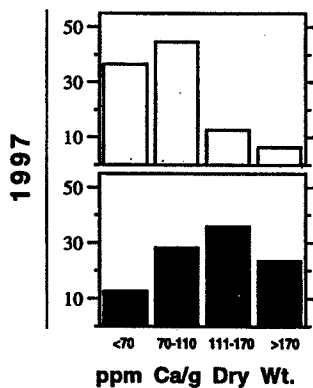


□ Ammonium nitrate treated seed tubers  
 ■ Calcium nitrate treated seed tubers

**cv. Snowden**



**cv. Russet Burbank**



mately 0.25 inch, was taken from the middle of each tuber. Care was taken to ensure that the apical bud region and stolon attachment were removed as well as the skin and cortical tissue ring. Trimmed slices from each individual tuber were diced, dried in a forced air oven, ground to pass a 40 mesh screen, and ashed in a muffle furnace. Individual tuber samples were prepared for atomic absorption measurement by digesting the ash with 2N HCl and then brought to a standard volume with lanthanum chloride solution. The calcium content of each tuber sample was read using an atomic absorption flame spectrophotometer (Varian model Spectra AA20).

Seed pieces were evaluated at the Hancock Agriculture Experiment Station (Plainfield Sand, soil calcium ranging from 720-860 lbs./acre) for their performance. At planting each seed tuber to be evaluated was sliced with a potato chip slicer in the field and individual tubers were planted at two foot intervals to minimize intrarow competition between the plants. This also facilitated total tuber yield measurements from each individual seed piece. (Individual seed tubers were tracked at all times with a code number and tag, which was buried with each seed piece.) Tubers from each treatment (calcium nitrate or ammonium nitrate) during the seed production year were handled identically in the evaluation year and received exactly the same standard nutrient regime (i.e. no supplemental calcium was given during the evaluation year). Total yield evaluations were made on each plant by hand harvesting and weighing all of the tubers produced.

**Results**

We analyzed over 3,000 individual tubers during the past three seasons, and as a result of this analysis we conclude that: **It is possible to increase the calcium concentration of the seed tuber tissue, even in soils that test high in native calcium, with the supplemental application of calcium.**

Results of the seed tuber calcium concentration are given in Table 1. The mean tuber calcium varied from year to year for the same cultivar, indicating seasonal effects on the calcium accumulation in the tubers. In the three years of the study 11 out of

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the 12 trials showed a significant increase in tuber calcium concentration with the application of calcium nitrate (based on L.S.D. with  $\alpha = 0.05$ ). In some cases this increase in calcium concentration was over 45 percent as compared to the ammonium nitrate treatment (Table 1, Russet Burbank). It is also important to note that this increase in calcium concentration was found even in soils that tested 1,340 ppm of available calcium (Table 1, Superior 1995).

**Supplemental calcium application results in a higher proportion of tubers with increased tissue calcium.**

In addition to the increase in the mean tuber calcium we found a dramatic shift in the proportion of tubers with a higher amount of calcium (Figure 1). For example, in the cultivar Atlantic, the percentage of tubers containing over 130 ppm calcium increased from 20 to 50 percent with supplemental calcium nitrate application (Figure 1). Similarly, in the cultivar Superior, the percentage of tubers containing over 190 ppm calcium increased from 40 to nearly 70 percent. Such results were also found

for the Dark Red Norland, Snowden, and Russet Burbank cultivars.

**Some cultivars consistently accumulate higher calcium than others.**

There are variations in the accumulation of calcium among cultivars and during different seasons. (Table 1). However, similar differences are found between cultivars from season to season. For example, Superior and Snowden consistently had higher calcium than Atlantic and Dark Red Norland (Table 1). Thus, for different cultivars, there appears to be a different threshold of calcium uptake by the tubers. It is this level that may be critical for the improvement of tuber seed piece quality. These results also suggest that there is genetic variability for tuber calcium among various cultivars. Which means that there may be a possibility to improve tuber calcium and calcium related quality characteristics via a directed plant breeding program focused on maximizing tuber tissue calcium concentrations.

**Enhanced calcium may improve seed tuber performance.**

Seed tubers with enhanced calcium

concentration tended to produce plants with higher tuber yield, although the results were not generally statistically significant (Table 2). In 5 of the 12 tests, we found yield increases greater than 5 percent, from tubers raised with supplemental calcium nitrate. Only in three cases was this yield increase statistically significant (based on the General Linear Models Procedure of LSMeans separation  $p < 0.20$ ). Interestingly tuber calcium and tuber yield was highest in 1996 for all the cultivars (Table 2). We are continuing this research to evaluate the potential of improved performance of seed tubers through and by increase in tissue calcium levels.

#### Literature Cited

Clarkson, D.T. 1984. "Calcium transport between tissues and its distribution in the plant." *Plant Cell Environ.* 7:449-456.

Collier, G.F., D.C. Wurr, and V.C. Huntington. 1978. "The effect of calcium nutrition on the incidence of internal rust spot in the potatoes." *J. Agr. Sci* 91:241-243.

Kratzke, M.G. and J.P. Palta. 1985. "Evidence for the existence of functional roots on potato tubers and stolons: Significance in water transport to the tuber." *Amer. Potato J.* 62:227-236.

Kratzke, M.G. and J.P. Palta. 1986. "Calcium accumulation in potato tubers: Role of the basal roots." *HortScience* 21:1022-1024.

McGuire, R.G. and A. Kelman. 1984. "Reduced severity of *Erwinia* soft rot in potato tubers with increased calcium content." *Phytopathology* 74:1250-1256.

McGuire, R.G. and A. Kelman. 1986. "Calcium in potato tuber cell walls in relation to tissue maceration by *Erwinia carotovora* pv. *atroseptica*." *Phytopathology* 76:401-406.

Palta, J.P. 1996. "Role of calcium in plant responses to stresses: Linking basic research to the solution of practical problems." *HortScience* 31:51-57.

Poovaliah, B.W. and A.S.N. Reddy. 1993. "Calcium and signal transduction in plants." *CRC Crit. Rev. Plant Sci.* 12:185-211.

Simmons, K.E. and K.A. Kelling.



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1987. "Potato responses to calcium application in several soil types." Amer. Potato J. 64:119-136.

Simmons, K.E., K.A. Kelling, R.P. Wolkowski, and A. Kelman. 1988. "Effect of calcium source and application method on potato yield and cation composition." Agron. J. 13-21.

Tawfik, A.A., M.D. Kleinhenz, and J.P. Palta. 1996. "Application of calcium and nitrogen for mitigating heat stress effects on potatoes." HortScience 31:51-57.

Tzeng, K.C.A., A. Kelman, K.E. Simmons and K.A. Kelling. 1986. "Relationship of calcium nutrition to internal brown spot of potato tubers and subapical necrosis of sprouts." Amer. Potato J. 63:87-97.

Vega, S.E., J.B. Bamberg, and J.P. Palta. 1996. "Potential for improving freezing stress tolerance of wild potato germplasm by supplemental calcium fertilization." Amer. Potato J. 73:397-409. ♦

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