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EFFECTS OF FOLIAR CALCIUM APPLICATION ON PEACH FRUIT QUALITY, SHELF-LIFE, AND FRUIT ROT

Kathryn C. Taylor, Ph.D.
Department of Horticulture, University of Georgia
Byron, GA 31008, U.S.A.
kctaylor@uga.edu
and
Phillip Brannen, Ph.D.
Department of Plant Pathology, University of Georgia
Athens, GA 30602. U.S.A.
pbrannen@uga.edu

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Abstract

This is an intermediate report of the impacts of several calcium formulations applied throughout the peach fruit development and growth period. Calcium nitrate, calcium chloride, or a calcium amino acid chelate (Metalosate® Calcium), were assessed for their effect on the quality and shelf life of peach fruit. All caused improvements in fruit firmness, peel growth cracking, and reduced post harvest fruit rots. Metalosate® Calcium caused increased fruit size.

Introduction

Calcium is an essential component for plant cell function, and plant tissue integrity (Conway, 1982; Conway and Sams, 1987; Elad and Kirshner, 1992). Calcium's physiological activity as a second messenger in cellular biochemistry and its requirement in cell wall structure make it important to fruit growth and development, as well as general fruit quality (Kadir, 2004; Kazuhiro et al, 2004), the rate of fruit senescence (Ferguson, 1984; Gerasopoulos and Drogoudi, 2005), disease resistance (Elmer, 2006; Lanauskas and Kvikliene, 2006; Tobias et al, 1992; Volpin and Elad, 1991), and other stresses (Yuen, 1993). While not all impacts of calcium on fruit quality, shelf-life, and fruit rot appear positive (Crisosto et al, 1997; Ellis et al, 1996; Lester and Grusak, 2004), it is clear that calcium formulation, rate, and timing impact the efficacy of calcium on several parameters (Crisosto et al, 1997; Elmer et al, 2006; Kazuhiro et al, 2004). This is an intermediate report of the impacts of several calcium formulations applied throughout the peach fruit development and growth period.

Materials and Methods

During the 2005-2007 seasons, peach trees in Byron, GA, USA were either untreated or treated with calcium nitrate, calcium chloride, or a calcium amino acid chelate (Metalosate® Calcium) at two week intervals from shuck split (just before peach flower petal fall, late March) until shortly before harvest (late July). Sixteen trees for each treatment were designated in the orchard in a completely randomized design and treated as single tree replicates in the analysis. Data were analyzed by analysis of variance and means were separated by Fisher's protected least squared difference test.

In 2005 the 'Sunprince' peach trees were four years old. They were planted with a spacing of 5.5 m (18.0 ft.) between trees in the row, and 6.1 m (20 ft.) between rows. Trees were irrigated using microsprinklers, replacing evapo-transpirational loss completely on a weekly basis from bloom through harvest. Trees were maintained with standard cultural and pest management regimes (Horton and Johnson, 2006; Horton et al. 2005-2007), including a late summer $Ca(NO_3)_2$ side dressed application of 23 kg/acre (51 lbs./acre or 57 kg/Ha). Trees were pruned and thinned according to industry standard, with fruit spaced about 6 inches (15 cm) along the fruit bearing shoots, resulting in approximately 250 fruit per tree in 2005 and 300 fruit per tree in 2006. In 2007, the peach crop was severely diminished in central Georgia by a freeze event on April 9. Therefore, trees were only evaluated for impact of calcium chloride on brown rot disease incidence, as a part of a brown rot management program. Calcium chloride was chosen as the formulation based on the work or Elmer et al (2006). It was compared to other, more standard brown rot management schemes. These fruit were harvested on 18 Jul 2007, inoculated with *Monilinia fructicola*, placed at room temperature and observed for brown rot after 4 and 7 days.

Calcium applications were made, as outlined in Table 1, during seasons 2005-2007. All applications were made at a volume of 3.5 L (118.3 fl. oz.) per tree (to run off) with hand-gun application. Fruit were sampled for nutrient analysis and fruit were harvested, as outlined in Table 1. Fresh fruit samples were washed in 0.01N nitric acid with 0.01% detergent and rinsed in deionized water prior to drying at 65°C (149°F). Sampled fruit were peeled and sub samples of peel and flesh were dried as above for tissue analysis. The coded 50.0-gram (1.8-oz) samples were analyzed by Albion Laboratories, Inc. for calcium and other plant nutrients. When fruit were harvested in 2005 and 2006, they were weighed in the field and evaluated for size by passing the fruit over a grading table. Fruit in each size category were counted. A 16-fruit set was prepared by randomly selecting fruit from the total fruit from each tree for each harvest date. This sub sample was weighed, evaluated subjectively for % red overblush color, and for background color using Clemson Chips 1-6. The fruit were also assessed for firmness using a Magness-Taylor penetrometer fitted with a 8-mm (0.3-in) probe, and for total soluble solids with an Atago brix refractometer.

After evaluation of fruit on 27 Jul 2006, a set of samples of 30 fruit was taken from each treatment for post harvest evaluation of rhizopus and brown rot. After 11 and 16 days in storage at 2-4°C (36-39°F), fruit was evaluated.

Results and Discussion.

When these studies were initiated, they were designed to assess the effect of calcium nitrate on fruit firmness and shelf life. At that time, the decision was made to include two other calcium formulations at the same level of elemental calcium for comparison. This was the basis of our decision for the level of each material used that year. It is apparent in the data that follows that use of Metalosate® Calcium at that level had a negative impact on fruit quality. Assessment of the level of calcium in the fruit suggested that the Metalosate® Calcium rate should be significantly reduced. The label recommended rate of this material was then included in the 2006

experiment along with the higher rate. As stated earlier, in 2007, due to the freeze that spring, only calcium chloride was assessed for impact on brown rot suppression as part of a larger pathology study.

Table 1
Treatment Application Concentrations and Dates, Tissue Sampling Dates, Harvest Dates, and Dates of Post Harvest Evaluation of Peach Fruit

Treatment	2005	2006	2007
Calcium Nitrate 12.0 ml/L (15.4 fl. oz./100 gal.)	5 Apr, 19 Apr, 3 May, 18 May, 31 May, 15 Jun, 28 Jun, 12 Jul	27 Mar, 30 Apr, 12 May, 28 May, 11 Jun, 25 Jun, 7 Jul	
Calcium Chloride 27.0 mg/L (0.4 oz./100 gal.)	5 Apr, 19 Apr, 3 May, 18 May, 31 May, 15 Jun, 28 Jun, 12 Jul	27 Mar, 30 Apr, 12 May, 28 May, 11 Jun, 25 Jun, 7 Jul	19 Apr, 2 May, 24 May, 4 Jun, 14 Jun, 29 Jun, 11 Jul
Metalosate® Calcium 2.5 ml/L (32.0 fl. oz./100 gal.) 16.0 ml/L (204.7 fl. oz./100 gal.)	---- 5 Apr, 19 Apr, 3 May, 18 May, 31 May, 15 Jun, 28 Jun, 12 Jul	27 Mar, 30 Apr, 12 May, 28 May, 11 Jun, 25 Jun, 7 Jul 27 Mar, 30 Apr, 12 May, 28 May, 11 Jun, 25 Jun, 7 Jul	
Tissue Sampling	2 Aug	10 May, 12 Aug	3 Jun, 18 Jul
Harvest Dates	26 Jul, 29 Jul, 1 Aug, 5 Aug	13 Jul, 17 Jul, 20 Jul, 24 Jul, 27 Jul, 31 Jul, 4 Aug	18 Jul
Post Harvest Evaluation		27 Jul, 7 Aug, 13 Aug	23 Jul

Table 2
Peel and Flesh Calcium Concentrations for the 2005 through 2007 Trials

Treatment	Flesh Ca (ppm)	Peel Ca (ppm)	Flesh Ca (% of UTC)	Peel Ca (% of UTC)
2005	(Late)	(Late)	Late)	(Late)
Control	274.0b	606.4	100.00	100.00
$Ca(NO_3)_2$	285.4b	677.5	104.15	111.92
$CaCl_2$	246.7b	563.3	90.02	92.89
Metalosate® Calcium (16)	379.6a	695.0	138.7	114.68
2006	(Early/Late)	(Early/Late)	(Early/Late)	(Early/Late)
Control	239d/197d	633c/560c	100/100	100/100
$Ca(NO_3)_2$	318c/283c	705c/660c	133/143	111/118
$CaCl_2$	293c/296c	674/618	123/150	106/110
Metalosate® Calcium (16)	972a/877a	989a/802a	407/445	156/143
Metalosate® Calcium (2.5)	445b/438b	719bc/720b	186/222	114/129
2007	(Early/Late)	(Early/Late)	(Early/Late)	(Early/Late)
Control	284/248	628/585	100/100	100/100
$CaCl_2$	334/279	658/617	118/113	105/105

Values within the same sampling time (early or late) year and column were compared for differences. Means followed by the same letters are not significantly different according to Fisher's protected LSD test.

Although the calcium nitrate and calcium chloride treatments numerically improved calcium levels in fruit peel and flesh, generally the calcium chelated with amino acids was present in peel and flesh at significantly higher levels (Table 2). Calcium treatments had lower impacts on fruit size in 2005 than 2006. One explanation may be that the period from April 1 to July 31 had twice as much rainfall in 2005 as 2006. It is likely that some of the calcium was washed from the surfaces of leaves and fruit with rain events.

Assessment of fruit yield and quality in 2005 (Figure 1) demonstrated that the untreated control and Metalosate® Calcium treatments produced greater total field weight per tree than the other treatments, but individual fruit size, ground color, % red overblush, firmness, or percent total soluble solids were not changed. The proportion of fruit that was in the size category of 2.75 inches (6.99 cm) and larger was not different among calcium nitrate, $CaCl_2$, and Metalosate® Calcium treatments and was less than the untreated control. Not apparent in this data was our observation that the quality of Metalosate® Calcium fruit was visually poor. The poor appearance of this fruit was supported by the apparent advancement of its ripening when one considers the numerically redder, and less firm values demonstrated in the study. Because of the apparent poor quality of the fruit we decided to look at lowering the rate of Metalosate® Calcium to the labeled rate of 2.5 ml/L (32.0 fl. oz./100 gal) in the 2006 trial.

In 2006 a number of differences were apparent. Although the overall yield was similar among the treatments, there were differences among treatments in the

distribution of harvested fruit among the size classes (Figure 2). Both Metalosate® Calcium treatments had more fruit shifting to larger size categories, with fewer fruit in the smaller size categories. While a greater proportion of the 16.0 ml/L (204.7 fl. oz../100 gal.) treatment fruit was 3.00 inches (7.62 cm) or larger, the fruit again were of poorer quality than any other treatment. Not only was firmness lower, post harvest quality was compromised with a level of fruit rot similar to the untreated control after storage (Figure 3). It was apparent that the lower concentration of Metalosate® Calcium gave both good fruit quality, and increased fruit size, with a greater proportion of the fruit falling in the 2.75 inches (6.99 cm) and larger size group. Calcium nitrate also favored a shift to larger sizes without compromising quality. However, the size increase was not as great as Metalosate® Calcium. Again, there were no differences among the treatments in 2006 with regard to fruit color, or total soluble solids. There was a numerical trend toward increased firmness in the $CaCl_2$, calcium nitrate, and Metalosate® Calcium treatments that would be expected with the observed decrease in fruit rots after storage (Figure 2).

Tobias et al (1993) demonstrated that calcium treatment delayed degradation of cell wall structure in apples, limiting the incidence and spread of *Botrytis cinerea*. This phenomenon likely explains our finding that all the calcium treatments had a reduction in growth cracks of the peel relative to the control.

Differences among treatments in 2006 were more apparent than the previous year. With regard to fruit size, this was probably due to two factors. The first being the fact that when moisture is in excess, which was the case several times during the fruit ripening period, fruit will tend to have greater increases in size without further interventions.

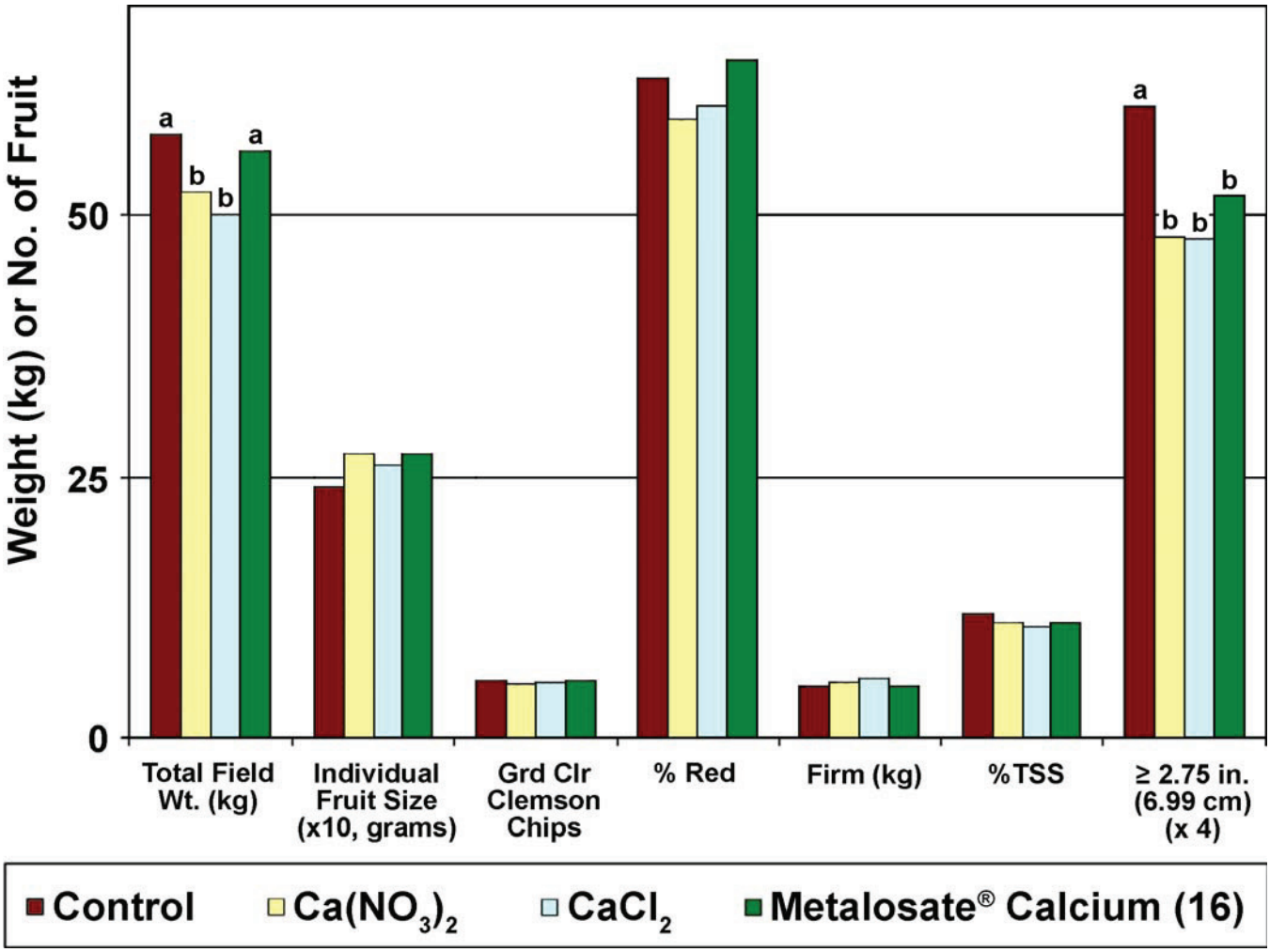

Figure 1. Calcium Effect on Fruit Yield, Size, and Quality in 2005

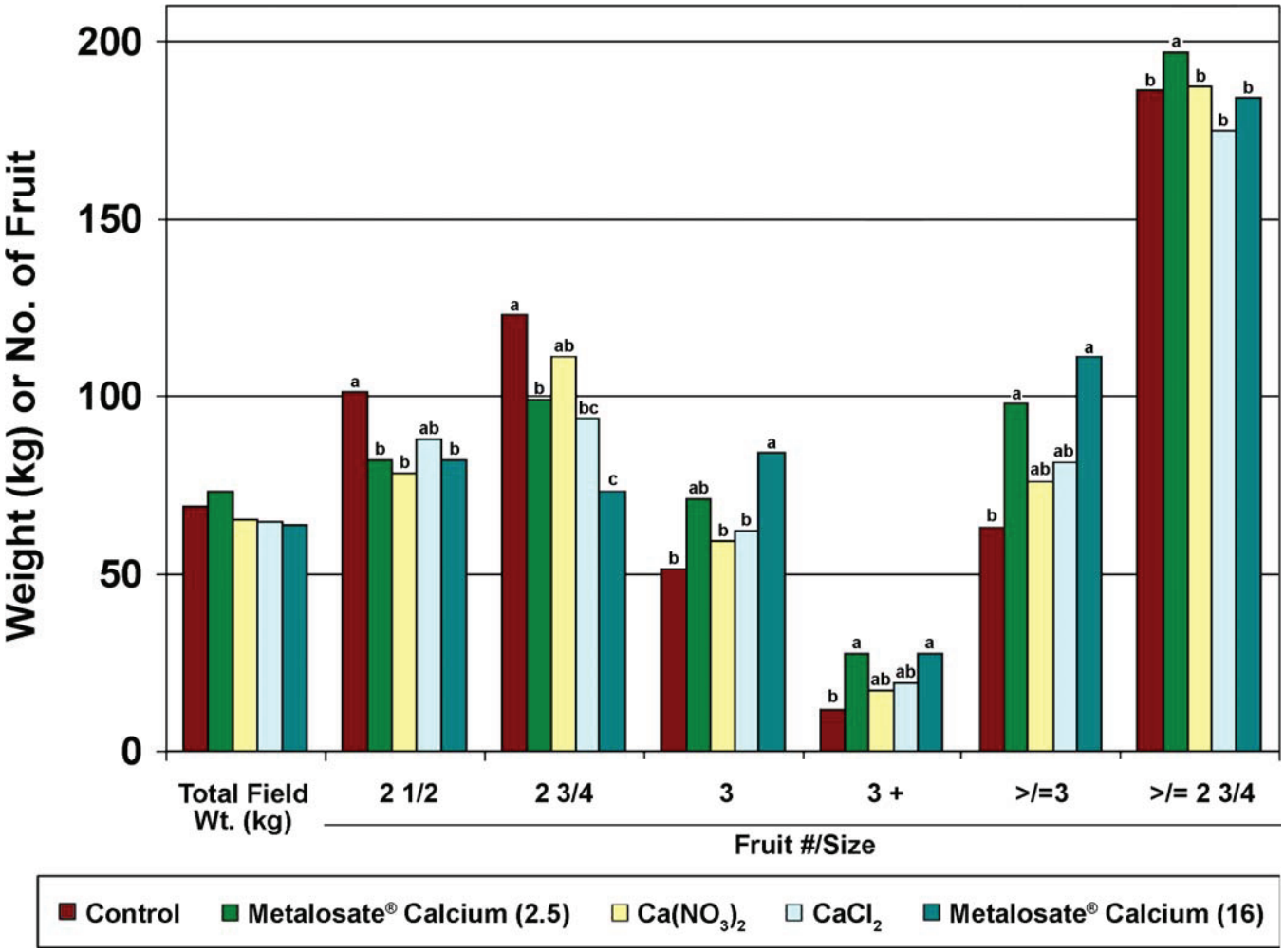

Figure 2. Calcium effect on fruit size distribution and yield in 2006

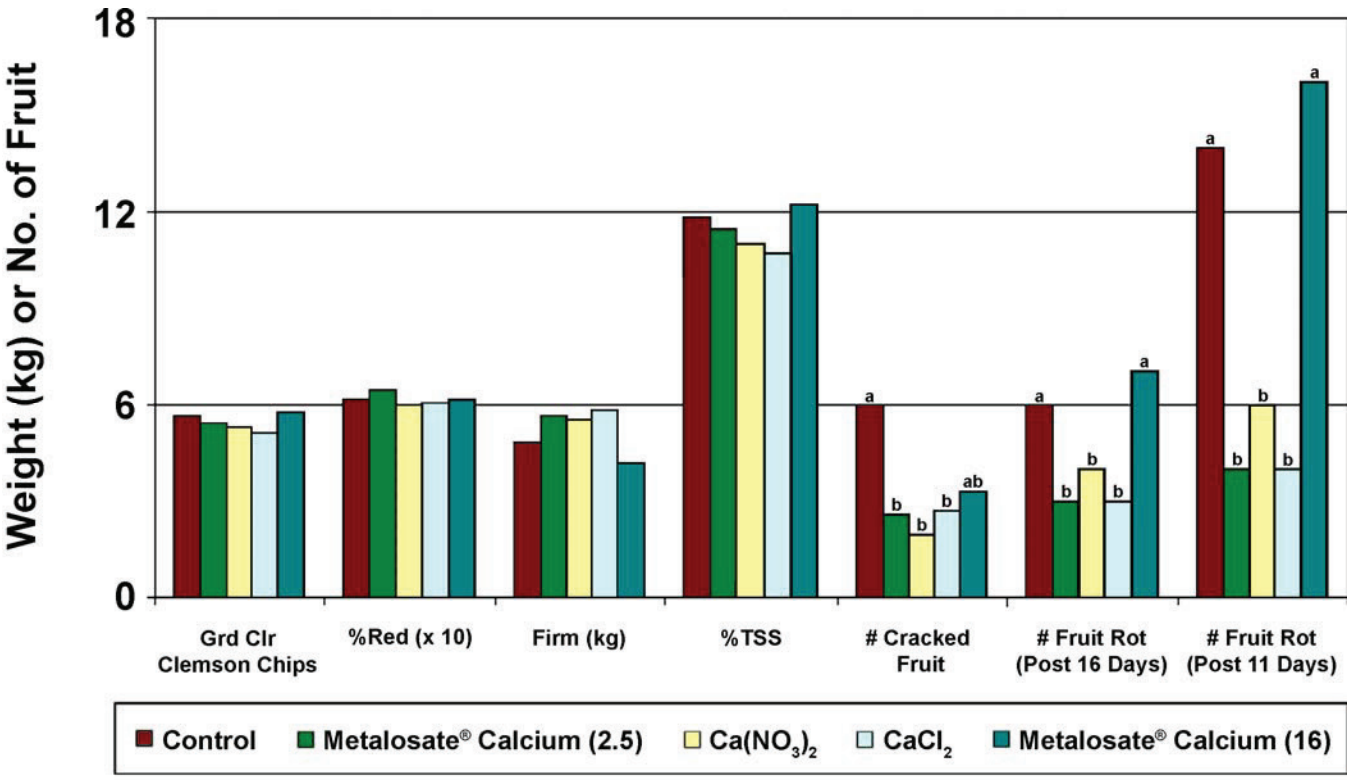

Figure 3. Calcium effect on fruit quality and post harvest rots in 2006.

Table 3
Effect of $CaCl_2$ as part of a brown rot management program

Treatment and Rate/Acre	Brown Rot Incidence* (% Infected Fruit)	
	4 Days After Harvest	7 Days After Harvest
Untreated Control	25.0 a	76.3 a
Propimax 3.6EC (119 ml)	26.9 a	78.2 a
Propimax 3.6EC (119 ml) + $CaCl_2$ (10.1g)	14.7 ab	57.7 b
Propimax 3.6EC (119 ml) + Sulfur 90EP (4.1 kg)	21.8 ab	69.9 ab
Propimax 3.6EC (119 ml) + Captan 90EP (3.6 kg)	12.8 ab	62.2 ab
LSD (P=0.05)	14.8	16.0

**Brown rot incidence was recorded on fruit stored at ambient temperature. Means followed by the same letters are not significantly different according to Fisher's protected LSD test.*

Thus, even if the calcium treatments may be responsible for some increases in fruit size and therefore yield, it is not likely to be apparent in a rainy peach season. Secondly, the excessive rain likely served to reduce foliar calcium levels and dampen the impact of the element in 2005.

In our assessment of $CaCl_2$ as a part of a pest management program, we determined that in the 2007 season, addition of $CaCl_2$ reduced the incidence of brown rot occurring in storage at room temperature (Table 2). Again, it is likely that this is attributable to maintenance of cell wall integrity by delaying the degradation of the cell wall's pectic polymers, to which calcium is essential (Tobias et al, 1992). Clearly pre-harvest application of calcium has positive impacts on fruit quality and shelf life. We still have much to do to verify these preliminary findings, but with this intermediate report of our progress, the possibility of using calcium supplementation to improve fruit quality and shelf-life seems very likely.

Additional study will be undertaken in 2008 to replicate the 2006 study, and expand the 2007 study to include the other calcium formulations.

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