Effects of Calcium Sprays and AVG on Fruit Quality at Harvest and After Storage

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Abstract

This trial was conducted in a Bartlett pear orchard near Walnut Grove to evaluate fruit quality effects from foliar calcium and ReTain sprays. The trial used 5 treatments with 8 replicate trees. The treatments were: 1) Vigor-Cal + 9-24-3 at 2 qts./acre each, 2) Vigor-Cal + 9-24-3 at 4 qts./acre each, 3) ReTain alone 2 weeks before harvest, 4) Vigor-Cal + 9-24-3 at 4 qts./acre each and ReTain 2 weeks before harvest, and 5) untreated control. Soluble solids were slightly elevated in fruit treated with ReTain alone (#3), and significantly higher after 7 days of ripening. Only after 7 days of ripening were there differences in fruit firmness; fruit in the Vigor-Cal + 9-24-3 and ReTain treatment (#4) had the highest pressure (about 0.5 lb. increase) and ReTain-only fruit were intermediate between #4 and other treatments. After 6 weeks of storage, there was almost no scald or internal breakdown in any treatment. The lack of differences in fruit quality differences with Ca treatment shows that Ca was likely adequate in fruits. This study raises questions about the value of spraying foliar Ca and ReTain in some situations.

Introduction

Calcium. Preharvest nutritional status of fruit, especially with respect to calcium (Ca), is an important factor affecting potential storage life. Fruits with a high level of calcium have lower respiration rate and longer potential storage life than fruits containing low Ca (Fallahi et al., 1997; Li et al., 2005). Many physiological disorders in fruits are associated with Ca deficiency. The easiest way to maximize fruit Ca level is through a foliar spray. However, in some cases it is very difficult to achieve because of the restricted uptake and penetration of Ca into the fruit and its movement within fruit tissue (Mengel, 2002).

Excess soil potassium (K) has been shown to inhibit the uptake of Ca (Jackson, 2005). K is very mobile in the plant and readily moves in both in the phloem and xylem and to fruits, which are strong K sinks. Ca, on the other hand, moves only in the xylem and does not move laterally. K uptake is both passive (xylem) and active (phloem) in the plant, whereas Ca uptake is purely passive.

Gastol and Domagala-Swiatkiewicz (2006) investigated the effects of different foliar sprays on fruit quality and Ca content of Conference pear using the following treatments:

1. Control
2. Calcium chloride
3. Kalcisal (11% Ca, 0.1% Mg, 0.02% B)
4. Kalcisal+Kalcifos (2% Ca, 18% P, Mg 0.1%, 0.02% B)
5. Sanisal A (kaolin clay preparation)
6. Sanisal B (kaolin clay preparation)

Trees were sprayed five times, each at 0.5% concentration, at two week intervals followed by five sprays at 1.0% at one week intervals. Fruit samples were taken just before commercial harvest. After 120 days of storage, fruits were washed and analyzed. Of the elements investigated, the biggest difference in content was observed for Ca. Only pears from trees sprayed with Kalcisal and Sanisal B had an elevated Ca level. The highest concentration of Ca was found in the peel of fruits.

Increased Ca through three mid-summer calcium chloride ($CaCl_2$) sprays has been shown to reduce incidence of side rot (*Phialophora malorum*) in Bosc pears (Sugar et al. 1991). Foliar $CaCl_2$ sprays can

cause fruit russetting, which is not a problem with Bosc but could be with Bartlett. Analyses of fruit peel nutrient levels showed that Ca contents were significantly increased by $CaCl_2$ sprays containing at least 1.2 g Ca/liter. Lesion diameters of wound-inoculated fruit were also reduced by $CaCl_2$ spray treatments. The use of Ca sprays with low nitrogen resulted in a 50% reduction in blue mold (*Penicillium expansum*) compared to high-N blocks without $CaCl_2$ sprays.

AVG (ReTain™). AVG is an ethylene biosynthesis inhibitor that is derived via fermenting the naturally occurring antibiotic rhizobitoxine, Fruit color and size may be enhanced by allowing fruit to remain on the trees longer without adverse effects on storage life. This gives the product value in extending harvest if needed due to labor shortages.

AVG has shown more consistent effects on apple than on pear, partially because pears produce much less ethylene on the tree than apples, making spray timing more difficult (Elkins et al., 2012). AVG-treated apples have been shown to stay firmer, store longer, and develop less watercore than NAA-treated fruit, but in some instances AVG-treated fruit had slightly less sugar and color. Studies on pear have produced promising but inconsistent results, probably due in part to the trial locations—both the need for a stop-drop spray and the uptake and action of a stop-drop may be influenced by environment (Elkins et al., 2012). In addition to greater firmness, better green color retention and reduced internal browning have been reported.

In a California trial, AVG was applied as a single application on Bartlett pear trees 28, 21, 14, or 7 days before commercial harvest in 1996 and 1997 (Clayton et al., 2000). AVG suppressed ethylene production, softening, and loss of chlorophyll in ripening pears and mature green pears cold-stored for 4 months, but had little effect on softening during a ripening period of 6 days after 4 months of cold storage. Application at 14 or 7 days prior to initial harvest appeared most effective, delaying fruit maturation by 4-10 days depending on the maturity test. Premature ripening, prevalent in 1997, was dramatically suppressed in fruit treated with AVG. Ripening of both AVG- and non-AVG-treated fruit with ethylene reduced premature ripening by about half.

Dussi et al. (2002) found that preharvest application of AVG on Bartlett pear trees did not control preharvest fruit drop, but did significantly reduce fruit internal ethylene concentration. There was no difference in fruit maturity after keeping the fruits 100 days in cold storage at 0 °C.

Calcium and AVG Costs. A key factor in evaluating products is their cost effectiveness. A low product price and the ability to tank mix it with other applications makes it an attractive option. The grower price for Vigor-Cal is approx. $22/gal. and Agro-K 9-24-3 is $16 gal., so at 2 qts./acre each, the combined cost is about $9.50 per application, or $38 for 4 applications. There is no application cost since the products can be mixed with blight sprays.

The ReTain label states that data are not available on tank mixing with products (such as NAA) other than a few biological insecticides. However, testing in the North Coast has showed no compatibility problems (R. Elkins, personal communication). Applying NAA by pressure (i.e., 21.5 lbs.) may not match with the ideal timing of AVG – 2 weeks before harvest. ReTain is applied at 11.7 oz. (one bag) per acre, which costs $265.

The purpose of this project is to test the effects of in-season foliar calcium sprays, a pre-harvest AVG application, and the combination of both on Bartlett pear fruit quality at harvest and after storage with ripening.

Objectives:

1. Evaluate the effects of foliar calcium sprays and AVG (ReTain) on fruit size and quality on Bartlett fruit at commercial harvest.
2. Compare the effects of these products on postharvest fruit quality after storage and ripening.

Materials and Methods

The trial was conducted at the Cat Ranch just north of Walnut Grove. The orchard spacing is 18 x 10 ft. It is planted to alternating Bartlett and Starkrimson rows, and only the Bartlett trees were used in

the trial. The Bartlett trees were planted over 50 years ago. The experiment was set up as a randomized complete block design, with 5 treatments and 8 single-tree replications. The treatments used are shown in Table 1.

Table 1. Products, rates, and application timings used in the trial.

Treatments		Manufacturer	Rate/Acre	Applications
1	Untreated	--	--	--
2	Vigor-Cal + Agrobest 9-24-3*	Agro-K Corp.	2 qts.** 2 qts.	4 weekly, beginning Mar. 29
3	Vigor-Cal + Agrobest 9-24-3	Agro-K Corp.	4 qts. 4 qts.	4 weekly, beginning Mar. 29
4	Retain	Valent Biosci.	11.7 oz.	June 26 (2 wks. before predicted harvest)
5	(#3 + #4 above) Vigor-Cal + Agrobest 9-24-3 ReTain	 Agro-K Corp. Valent Biosci.	 4 qts. 4 qts. 11.7 oz.	 4 weekly, beginning Mar. 29 June 26 (2 wks. before predicted harvest)

**Vigor-Cal can be applied at 1-4 qts./acre, and is commonly applied at 2 qts./acre.*
***Agro-K 9-24-3 was included to help mobilize the Vigor-Cal in cold weather.*

Individual sprayed trees were separated by the Starkrimson tree in between. Bartlett trees were sprayed with Vigor-Cal in four weekly applications beginning March 29 using a Stihl SR 450 backpack mist blower, approximating a commercial rate of 100 gal./acre. ReTain was sprayed June 26 (2 weeks before the first expected commercial harvest) in a single application.

To see if the Ca was being taken up by the leaves and fruit, 10 non-bearing spur leaves and 10 young fruit per replicate tree were picked randomly from all sides of the trees and consolidated for treatments 1, 2, and 3 on April 22. Leaves were immediately placed into paper bags and cooled, brought back to the office and washed in soapy water, double rinsed, and taken to an analytical lab to determine N, P, K, and Ca content.

Just prior to the first commercial harvest (minimum size pick: 2¾"), fruit samples were taken on July 9 and 14, as close as possible to the predicted commercial harvest dates.

A total of 40 high fruit and 40 low fruit from each tree of each of the two varieties were randomly sampled, and fruit size and average weight were measured. The fruit were taken to the UC Davis postharvest lab, where 10 fruit per rep were evaluated for skin color, firmness, starch, soluble solids, and titratable acidity, and 10 fruit per rep were evaluated for the same parameters after being allowed to ripen. The remaining 60 fruit per rep were cooled at 32°F and used for post-storage evaluation of skin color, firmness, and storage disorders (scald and internal browning): 15 fruit each from each rep were evaluated after 1.5 and 3.5 months, with and without ripening.

At the second harvest (strip pick), 20 fruit per rep were used to evaluate fruit size and weight, skin color, firmness, soluble solids, and titratable acidity; no fruit from the second harvest were used for post-storage evaluation.

Results

Leaves showed elevated levels of N, P, and K in the Vigor-Cal treatments, but not higher Ca (Table 2). As a result, the N/Ca and K/Ca nutrient ratios were also increased. There were no clear patterns of nutrient increase in the fruit (Table 2), possibly because of the large mass of the fruit compared to surface area.

At the first harvest, fruit weights among the treatments were virtually identical (0.47-0.48 lb.). Soluble solids were elevated in fruit treated with ReTain alone at the first harvest, and significantly higher after 7 days of ripening (Table 3). Soluble solid levels of fruit treated with Vigor-Cal + 9-24-3

and ReTain were intermediate between fruit treated with ReTain alone and the other treatments. No differences were seen in soluble solids at the second harvest.

There were no differences in fruit pressure on the day of the first harvest (Table 4). However, after 7 days of ripening, fruit in the Vigor-Cal + 9-24-3 + ReTain treatment had the highest pressure (about 0.5 lbs. increase) and ReTain-only fruit were intermediate. After 6 weeks of storage, there were no fruit pressure differences among treatments, but then after ripening for 6 days, fruit treated with the high rate of Vigor-Cal + 9-24-3 were significantly softer than most other treatments. No fruit pressure differences were found in fruit from the second harvest. Virtually no scald or internal breakdown was found at any postharvest timing.

Discussion

An important benefit of foliar Ca applications in Bartlett pear is thought to be reduced postharvest storage problems (scald and internal breakdown) and better fruit quality. There were no such problems after 13 weeks of storage, even in pears that received no Vigor-Cal or 9-24-3, so this benefit was not apparent from our results. Vigor-Cal + 9-24-3 treatments had no effect on fruit firmness, which is consistent with results of other Ca trials (Carbo et al., 1998; Raese, 1994).

The finding of no differences in leaf or fruit Ca content shortly after completion of the four foliar sprays was important to note, as it appears that little or no Ca was taken up into the tissues whereas N, P, and K from the fertilizer additive were taken up. Ca is immobile in plant tissues, so it did not move to other tissues. ReTain did seem to elevate soluble solid levels at the first harvest, and it increased firmness by 0.5 lb., but only after 7 days of ripening and no storage. This seems to show that the use of ReTain may provide little benefit in some situations, and it may not be cost-effective given the high price for ReTain.

Table 2. Nutrient levels and ratios in non-bearing spur leaves and young fruit from three of the treatments, sampled April 22 after four foliar nutrient sprays.

NUTRIENT LEVELS				
LEAVES				
Treatment	**% N**	**% P**	**% K**	**% Ca**
Untreated control	2.58	0.26	1.60	1.24
2 qt. Vigor-Cal + 2 qt. 9-24-3	2.94	0.31	1.74	1.20
4 qt. Vigor-Cal + 4 qt. 9-24-3	2.96	0.35	1.78	1.23
YOUNG FRUIT				
Treatment	**% N**	**% P**	**% K**	**% Ca**
Untreated control	2.48	0.35	1.98	0.20
2 qt. Vigor-Cal + 2 qt. 9-24-3	2.92	0.34	1.93	0.23
4 qt. Vigor-Cal + 4 qt. 9-24-3	2.41	0.36	1.92	0.21
NUTRIENT RATIOS				
	LEAVES		FRUIT	
	N/Ca	**K/Ca**	**N/Ca**	**K/Ca**
Untreated control	2.08	1.29	12.40	9.90
2 qt. Vigor-Cal + 2 qt. 9-24-3	2.45	1.45	12.70	8.39
4 qt. Vigor-Cal + 4 qt. 9-24-3	2.41	1.45	11.48	9.14

Table 3. Total soluble solids of fruit at first harvest, at first harvest + 7 days ripening, and at second harvest.

Treatment	1st Harvest	1st Harvest + 7d	2nd Harvest
Untreated control	11.95 a[1]	13.63 b	12.1 a
2 qt. Vigor-Cal + 2 qt. 9-24-3	12.48 a	13.46 b	12.2 a
4 qt. Vigor-Cal + 4 qt. 9-24-3	12.45 a	13.49 b	11.9 a
ReTain alone	12.90 a	14.21 a	12.1 a
4 qt. Vigor-Cal + 4 qt. 9-24-3 + ReTain	12.46 a	13.85 ab	12.5 a
P value	*0.12*	*0.01*	*0.34*

[1]Mean separation (in columns) by Duncan's multiple range test at P value shown.

Table 4. Fruit firmness measurements at both harvests, and after different lengths of storage and ripening for first harvest only. (W = weeks of storage, D = days of ripening)

	1st Harvest						2nd
Treatment	**0W0D**	**0W7D**	**6W0D**	**6W6D**	**13W0D**	**13W4D**	**Harvest**
Untreated control	19.1 a[1]	2.65 bc	18.1 a	2.28 a	16.4 a	1.86 a	20.8 a
2 qt. Vigor-Cal + 2 qt. 9-24-3	18.9 a	2.68 bc	17.9 a	2.10 ab	16.9 a	2.00 a	20.4 a
4 qt. Vigor-Cal + 4 qt. 9-24-3	19.4 a	2.44 c	18.0 a	1.78 c	17.3 a	1.93 a	20.9 a
ReTain alone	18.7 a	2.94 ab	17.8 a	2.10 ab	17.2 a	1.89 a	20.4 a
4 qt. Vigor-Cal + 4 qt. 9-24-3 + ReTain	18.8 a	3.13 a	18.4 a	1.88 bc	17.4 a	1.79 a	20.9 a
P value	*0.10*	*0.01*	*0.38*	*0.01*	*0.71*	*0.17*	*0.50*

[1]Mean separation (in columns) by Duncan's multiple range test at P value shown.

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