Ferticell® ProCal 3-0-0-20Ca on Honeycrisp Apples in Washington State

Research Summary for

Ferticell®

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Background: Washington's Apple Industry

The United States is the second largest producer of apples worldwide, and Washington state by far leads the nation in apple production. About 6 of every 10 apples consumed in the United States were grown in Washington. 2017 state yield was 134 million 40-pound boxes, and 2018 was forecasted to result in 131 million boxes[2]. About 14% of the crop was estimated organic[2]. More than 175,000 acres of the state are developed apple orchards, and they contribute well over $2 billion to the state's economy[2]. About 20,000 acres were certified organic in 2016, resulting in roughly $400 million in sales[1].

Initial capital investment is very high, up to $40,000 per acre for a newer variety on a trellis system. In-season input is also very intensive; herbicides are used to kill weeds on berms, fungicides control diseases like fireblight, and insecticides are used for pests like mites.

Apple production is concentrated in the Wenatchee area, the lower Columbia basin, and the Yakima valley. Soils in these areas are young and are typically sandy in texture, neutral to alkaline in pH, and high in carbonate content. Nutrients such as calcium may test adequate on chemical extraction analysis, but actual availability to the plant may be insufficient. There is little agreement between studies examining apple nutrient requirement. Generally, 1.9-2.2 lb nitrogen, 0.4 lb phosphorus, and 3.0-3.9 lb potassium per ton of harvested fruit are demanded by apple trees.

Honeycrisp, a variety developed by the University of Minnesota, is very popular with consumers for its sweet and tart flavor and crisp flesh. It comprises 8% of Washington's total apple crop. Nearly half of the organic apple acreage in Washington is Gala or Fuji, but Honeycrisp is the third most popular variety grown organic.

Honeycrisp, among other varieties, is susceptible to the physiological disorder bitter pit (figure 1). Bitter pit is often worse on young trees and large fruit. Irregular irrigation, excess nitrogen, and heavy pruning generally exacerbate the problem. Bitter pit has been linked to calcium deficiency and interplay of other nutrients, though researchers still do not fully understand the disorder. Growers resort to many in-season foliar calcium sprays to control the disease. Calcium chloride is the most common product used, due to its high calcium analysis and low price. The chloride salt can damage foliage, however, resulting in leaf burns. Calcium chloride is certified organic.

Figure 1. Bitter pit on Honeycrisp.

The objective of this trial was to quantify any change in bitter pit incidence as a consequence of Ferticell® applications.

[1]Granatstein, D. and E. Kirby. 2016. Recent Trends in Organic Tree Fruit. WSU CSANR.
[2]Kovis, T. 2018. Washington State Fresh Apple Forecast. Washington State Tree Fruit Association.
[3]NASS. 2017. State Agriculture Overview: Washington. USDA, Washington, DC.

Materials and Methods

The trial was established in Yakima, Washington, in a conventional Honeycrisp orchard. Trees were planted in a single 5' x 10' trellis system in 2014, and are in their second year of production. Irrigation is provided by a drip system, coupled with overhead cooling sprinklers. The soil series is Gorst cobbly loam, a fertile soil with loess and old alluvium parent material.

Plots consisted of four consecutive trees, with two-tree buffers. Treatments were replicated five times and arranged in a randomized complete block design. Treatments consisted of: grower standard PrimoCal + calcium chloride, Ferticell® ProCal, and Untreated (table 1).

Trial Treatments			
Treatment	*Product(s)*	*Rate*	*Details*
Untreated	n/a	n/a	n/a
Ferticell®	ProCal	2 lb/ac	3-0-0 Plus 20% Calcium
Grower standard	PrimoCalcium (GS Long)	1 gal/ac	Calcium citrate, 6% Ca
	CalQuik (Loveland)	4 lb/ac	Calcium chloride, 32% Ca

Table 1. Product, rate, and analysis for each treatment.

For the calcium treatments, applications commenced at late bloom on May 13 and continued every 6-8 days until August 26th for a total of 16 sprays. In the grower standard program, the first five applications were made with the PrimoCalcium product, and calcium chloride was used for the remainder of the season (6/17 – 8/26). All applications were made with a Stihl backpack mistblower (figure 2). Spray volume was 60 gal/ac until June 3rd, and 100 gal/ac for the remainder of the season. 100% coverage was achieved. All other fertility and pest management applications were consistent across the trial area and were made according to grower standard practice.

One day prior to the collaborating grower's first harvest pass on September 2, the trial area was hand-harvested. For the middle two trees per plot, fruit per tree was counted. Forty apples per tree were picked and weighed, and the number with bitter pit was recorded. Fifteen apples per tree were saved and stored at 65°F for six weeks. After storage, bitter pit incidence was noted. ANOVA with Tukey-Kramer modification ($\alpha = 0.10$) were performed for statistical analyses in SAS 9.4.

Figure 2. Application with Stihl backpack mistblower.

Results and Discussion

2018 Spring was relatively cool and wet, so bud break was a few days behind average (figure 3). Full bloom was reached by May 7. Some rootstock incompatibility was evident, but these trees were avoided when establishing plots. Fire-blight incidence was mild to moderate in the trial area. Tree growth progressed well, and fruit set was managed by chemical and hand-thinning. There were no clear visual differences in canopy vigor or fruit between treatments.

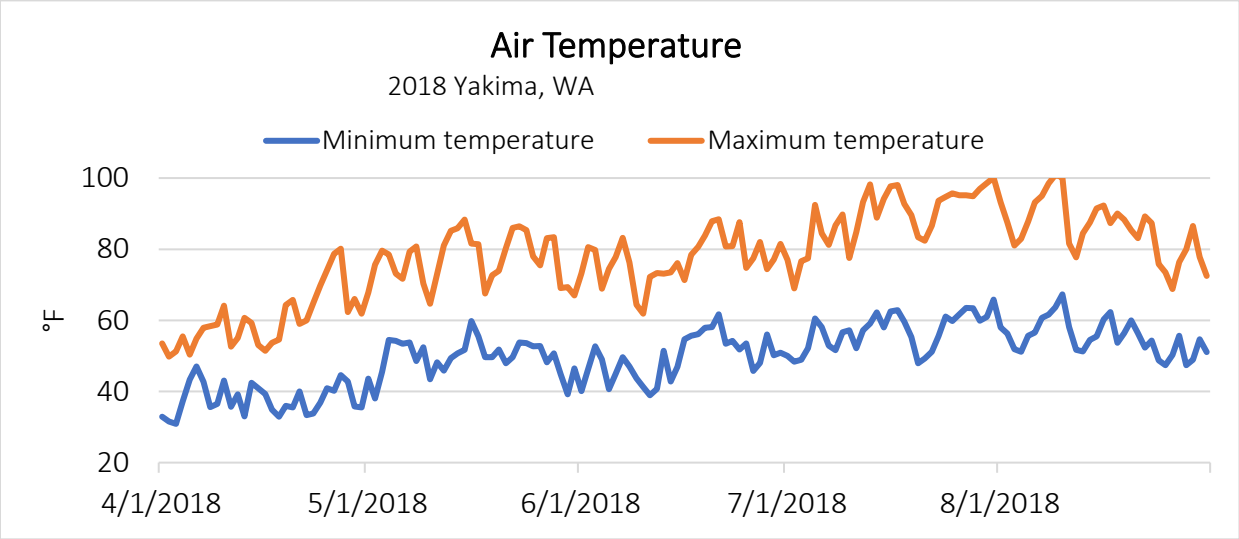

Figure 3. Maximum daily air temperature from April 1st to September 1st at the trial site is shown in orange, with minimum air temperature in blue. Data from AgWeatherNet.

Although quite rocky, a soil nutrient analysis taken at bloom revealed the site was fairly fertile. pH was slightly below neutral at 6.44, and organic matter content in the berms was high (2.18%). At 0.7, boron level was marginal. Calcium concentration was 2000 ppm, but percent base saturation was less than desirable at 56%. Other nutrients fell within sufficient ranges.

Fruit per tree was similar for Ferticell® ProCal and untreated, but trees treated with the grower standard program averaged about fewer 10 apples (table 2). Individual fruit weight was around 7.8 oz for all three treatments. Assuming 925 lbs./bin, yield was low but acceptable for third leaf trees (table 2). Numerically, the untreated plots produced the highest yield. Ferticell® ProCal was intermediate, and calcium chloride trailed by 6.3 bins, or 1.6%. It is unlikely the trial calcium treatments effected yield; factors such as fruit load had much greater bearing on harvested tonnage. In all yield parameters, no differences were statistically significant.

Average Yield			
Treatment	*Fruit per tree*	*Individual fruit weight (oz)*	*Yield (bins/acre)*
Ferticell® ProCal	81.2a	7.6a	36.1a
Calcium chloride	70.4a	7.8a	32.3a
Untreated	82.7a	7.9a	38.6a

Table 2. Average fruit per tree, individual fruit weight in ounces, and yield in bins per acre for each treatment. Values followed by the same letter indicate no significant difference (ANOVA, α = 0.10).

During the season, no bitter pit symptoms were evident. By the time of harvest, only a few apples showed bitter pit (table 3). This result was highly unexpected, as the trial was placed in a vigorous orchard with moderate crop load. Several growers in the area mentioned that their bitter pit problems were reduced this year compared to past seasons. Perhaps the climate or other external factors were conducive to lower bitter pit pressure.

At harvest, Ferticell® ProCal plots had under 1% bitter pit on average. Grower standard and untreated also had low bitter pit incidence, 2% and 4% respectively. No differences were statistically verified, though the results trended towards calcium programs suppressing bitter pit.

More bitter pit was exposed after storage (figure 4). This is a common occurrence; orchards that look clean at harvest can suffer severe pack-out losses due to bitter pit surfacing during controlled atmosphere storage. Nearly a quarter of the untreated apples were compromised by bitter pit. At only 4%, the bitter pit seen under calcium chloride treatment was statistically separated from untreated. Ferticell® ProCal bitter pit incidence was intermediate and was not statistically different from the other two treatments.

Bitter pit Incidence		
Treatment	*Bitter pit at harvest (%)*	*Bitter pit after storage (%)*
Ferticell® ProCal	0.67%a	10.67%ab
Calcium chloride	2.00%a	4.00%a
Untreated	4.00%a	22.67%b

Table 3. Average bitter pit percent at harvest and after six weeks of storage for each treatment. Values followed by the same letter indicate no significant difference (ANOVA, α = 0.10).

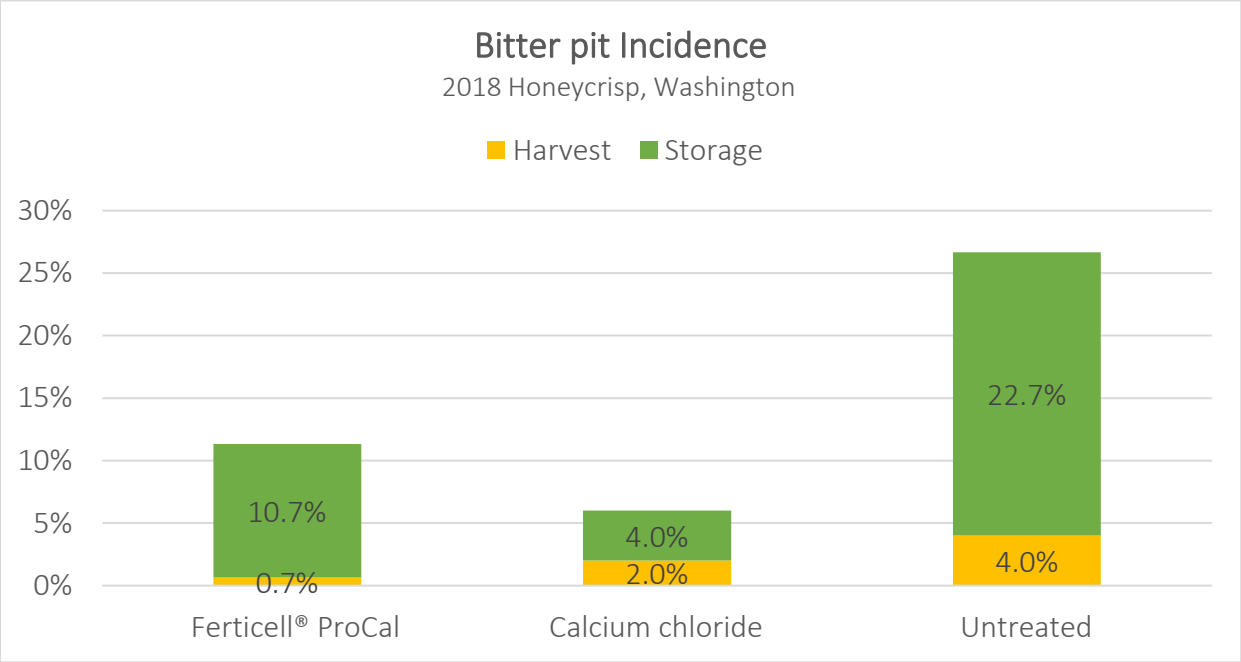

Figure 4. Average bitter pit incidence for each treatment at harvest and after storage.

A simple efficiency metric was calculated for each program by dividing the percent bitter pit control relative to untreated by the pounds of calcium per acre applied (figure 5). In the Ferticell® ProCal treatment, 57.5% control was achieved with a total of 6.4 lb/ac calcium. Control was 77.5% with 17.4 lb/ac calcium in the grower standard program. Therefore, Ferticell® ProCal was twice as effective as calcium chloride, in terms of bitter pit reduction per unit calcium.

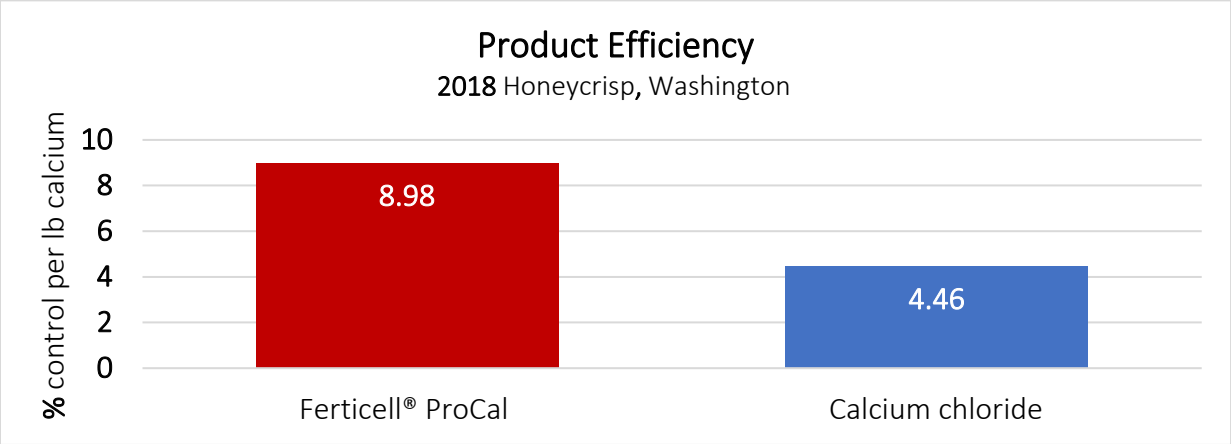

Figure 5. Product efficiency (defined as percent control relative to untreated divided by pounds per acre calcium applied) for each program.

At an average price of $48 per box for size 88-72 Washington fancy Honeycrisp, gross return was very high (figure 5). Note that while bitter pit losses were accounted for, other pack-out culls like rots were not included. 23 boxes per bin were assumed.

Due to higher yield and relatively low bitter pit incidence, the Ferticell® ProCal program resulted in over $37,000 per acre gross return. Untreated plots trailed by 4%, with grower standard calcium chloride resulting in the poorest gross return. Although the calcium chloride program led to minimal bitter pit losses, the higher initial yield from the untreated plots compensated for its heavy cull percent.

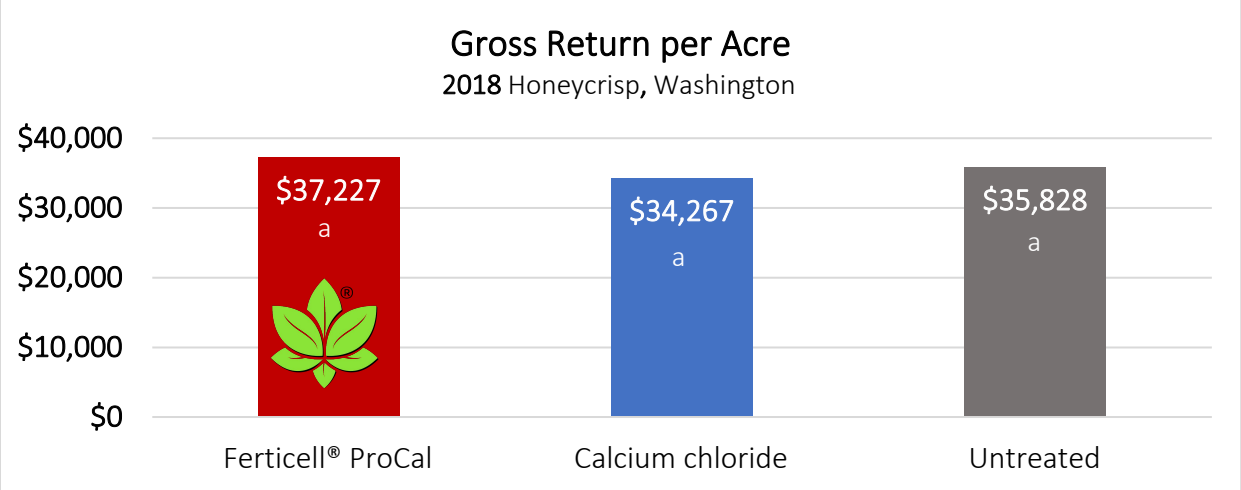

Figure 5. Average gross return in dollars per acre for each treatment. Values marked by the same letter indicate no significant difference (ANOVA, $\alpha = 0.10$).

Conclusions

There were over 80 fruit per tree in both Ferticell® ProCal and untreated plots, while the grower standard calcium chloride plots averaged 70 fruit per tree. These fruit load numbers correlated well with yield. There were no statistical differences between treatments, and it was not concluded that calcium program effected yield.

Untreated plots, which received no calcium inputs during the season, unexpectedly showed low bitter pit levels at harvest. There was a numeric trend for calcium applications decreasing bitter pit incidence in the orchard, with Ferticell® ProCal the top performer. No differences were statistically verified, however.

Much higher bitter pit was found after storage. Untreated apples averaged 22.7% bitter pit cull, which was statistically greater than the 4% cull observed under the calcium chloride program. Ferticell® ProCal was intermediate and not statistically different from the other two treatments.

Despite having fewer apples per tree on average, the grower standard calcium program held bitter pit at very low levels – a total loss of 6%. Ferticell® ProCal applications led to a combined bitter pit level of 11.4%. Bitter pit percent was more than double in the untreated apples, at 26.7% overall.

Compared to untreated, the grower standard program resulted in 78% bitter pit control while Ferticell® ProCal achieved 58% control. Because much less calcium per acre was applied in the Ferticell® ProCal treatment, the efficiency was higher. Per unit of calcium applied, bitter pit reduction was nearly double for the Ferticell® ProCal product compared to the calcium chloride program.

Based on these results, Ferticell® ProCal was effective in managing bitter pit. It could be an excellent alternative to calcium chloride, especially early season when fruit marking is of concern. Used in rotation with calcium chloride, Ferticell® ProCal would lower the overall chloride salt load while maintaining bitter pit reduction.

Photographs

Appendix A: Data by Replicate

Treatment	*Rep.*	*Fruit per tree*	*Apple weight (oz)*	*Yield (bins/ac)*	*Bitter pit at harvest (%)*	*Bitter pit after storage (%)*	*Gross return ($/ac)*
Grower standard calcium chloride	1	106	7.10	44.33	0	0	48937
		52	8.10	24.78	0		27359
	2	88	8.53	44.20	0	0	48801
		97	7.01	40.01	0		44176
	3	45	8.59	22.75	0	13.33	23437
		62	8.00	29.20	0		30085
	4	48	7.18	20.28	0	0	22393
		53	7.62	23.76	0		26232
	5	66	7.79	30.25	13.33	6.67	27832
		87	8.53	43.70	6.67		43422
Ferticell® ProCal	1	85	9.07	45.37	0	13.33	46744
		91	8.49	45.48	0		46865
	2	69	10.07	40.90	0	6.67	43647
		138	5.88	47.74	0		50952
	3	74	7.81	34.01	0	6.67	36297
		60	7.67	27.09	0		28908
	4	56	4.73	15.58	0	0	17197
		77	5.93	26.88	0		29677
	5	83	7.20	35.18	6.67	26.67	31069
		79	9.19	42.76	0		40911
Untreated	1	71	8.77	36.65	0	46.67	31016
		79	9.97	46.38	0		39255
	2	78	6.02	27.62	0	13.33	28462
		82	6.52	31.46	0		32415
	3	73	6.56	28.19	0	33.33	25934
		79	10.49	48.76	0		44859
	4	84	6.82	33.70	0	13.33	34727
		106	9.17	57.24	6.67		54766
	5	100	6.24	36.73	6.67	6.67	36497
		75	8.90	39.27	26.67		30351