Project Title: Postharvest system optimization for organic apple storage

Report Type: Final Project Report

Primary PI: Carolina A. Torres
Organization: Washington State University, Department of Horticulture
Telephone: 509-293-8808
Email: ctorres@wsu.edu
Address: Tree Fruit Research & Extension Center
Address 2: 1100 N Western Av.
City/State/Zip: Wenatchee/WA/98801

Co-PI: James Mattheis
Organization: USDA-ARS TFL
Telephone: 509-664-2280 ext. 249
Email: james.mattheis@usda.gov
Address: 1100 N Western Av
Address 2:
City/State/Zip: Wenatchee/WA/98801

Cooperators: David Granatstein (granats@wsu.edu), Lee Kalcsits (lee.kalcsits@wsu.edu), Stemilt Growers, Zirkle Fruit, RipeLocker, SCS, Inc.

Project Duration: 3 Years

Total Project Request for Year 1 Funding: $ 50,000.00
Total Project Request for Year 2 Funding: $ 50,600.00
Total Project Request for Year 3 Funding: $ 56,000.00

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Valent Biosciences (Retain OL), RipeLocker (vacuum units), WSU, USDA-ARS (CA chambers), Stemilt Growers & Zirkle Fruit (fruit for experiments), SCS (labpods maintenance)
Cost-sharing: $150,000
Notes: Funds for technical support ($30,000/yr), travel expenses ($3,000/yr), and 0.1 FTE (P.I) from start-up funds.

WTFRC Collaborative Costs: None

Budget 1
Primary PI: Carolina Torres
Organization Name: Washington State University
Contract Administrator: Anastasia Mondy
Telephone: 916-897-1960
Contract administrator email address: Anastasia.mondy@wsu.edu
Station Manager/Supervisor: Chad Kruger
Station manager/supervisor email address: ckruger@wsu.edu

Item	2019	2020	2021
Salaries			
Benefits			
Wages	20,000	16,000	16,000
Benefits	7,000	5,600	5,600
Equipment [1]	13,000	13,000	13,000
Supplies[2]	3,500	3,000	3,000
Travel			
RCA rental	6,500	13,000	13,000
Plot Fees			
Total	50,000	50,600	50,600

[1]Three LabPods (Storage Control Systems Inc) leasing for DCA-RQ.
[2]Fruit, laboratory consumables, boxes

OBJECTIVES:

1. Evaluate the combination of DCA systems and RA storage on fruit quality postharvest.
2. Evaluate the effect of organic Retain OL in combination with different storage systems on fruit maturity and quality postharvest.
3. Evaluate the performance of vacuum storage (RipeLocker) under different temperatures regimes on fruit quality and physiological disorder development.

SIGNIFICANT FINDINGS

1. All CA/DCA storage regimes evaluated, post conditioning at harvest, and a period in air (4 weeks) after CA/DCA opening, were suitable for long-term storage of Honeycrisp and Fuji apples. Nevertheless, preharvest managements (nutrition, pathogens, etc.) and seasonal climate greatly affected the amount of decay and incidence of physiological disorders during the storage period. The exploratory multivariate analyses including sites, bioclimatic indices, shoot length, fruit mineral content at harvest, crop load, and fruit maturity at harvest in all three seasons did not show consistent results to explain disorder's expression or softening rate postharvest in Honeycrisp.
2. In 2020, soft scald incidence in Honeycrisp was lower than in 2019 season, and it was significantly reduced by all CA/DCA storage regimes when compared to those observed in fruit stored in air for 4 months. Similar results were observed in 2021 season. Soggy breakdown only appeared in 2019 and 2021 seasons after 9 months in CA/DCA+4 weeks in air+7 days at 68°F, and mostly in one of the cool sites. Bitter pit was block-dependent all seasons. Incidence greatly increase during the air period (4 weeks) after CA/DCA.
3. Overall, the application of aminoethoxyvinylglycine (AVG- Retain OL) on Gala (2019 and 2020) and Honeycrisp (2019) apples effectively delayed fruit maturity progression preharvest, and maintained fruit firmness higher postharvest, although not always statistically significant and dose and timing-dependent, until 9 months in CA plus 7 days at 68°F when compared to the untreated control. Skin color development was negatively affected by AVG treatments preharvest in Honeycrisp.
4. Honeycrisp apples stored in low pressure (RipeLocker, RL) at 33°F were comparable in terms of fruit maturity to those stored in CA/DCA at 37°F (plus 4 weeks in air). Soft scald incidence was block-dependent the first year and slightly higher in RL-stored fruit in 2020 and 2021. Bitter pit (+lenticel blotch pit) was reduced by vacuum RL in most sites in 2019 and 2020 but not in 2021.

Similar results in fruit maturity for Fuji apples, as well as overall low disorder incidences, except internal browning in all CA/RL storage protocols in 2021 season.

Objective 1. Evaluate the combination of DCA systems and RA storage on fruit quality postharvest.

Activities:
During 2019, 2020 and 2021 temperature and relative humidity sensors were placed in every orchard in spring, and data collected at harvest. Maturity progression was monitored in fruit from all sites for both Fuji and Honeycrisp. This was done by sampling homogeneous fruit from 20 trees per block, 3-4 times (every 7-8 days) before harvest (WBH). At commercial harvest, fruit quality was performed in 18 fruit per Block, and peel samples were collected for further mineral analysis. After conditioning Honeycrisp apples at 50°F for 7 days and Fuji apples by delaying CA imposition for 20 days at 34°F, fruit were placed in different dynamic storage regimes (Table 1). Postharvest evaluations for Year 3 are currently being carried out and will end in July 2022.

RESULTS
Fruit Maturity & Physiological disorders
Honeycrisp: In 2019, differences in fruit maturity between Blocks after storage (Table 3) followed the same trend observed at harvest (Table 2). In general, fruit in all DCA systems lost 1.5 lb firmness in average with slight differences between Blocks and storage regimes, after 6 and 9 months plus 4 weeks in air. In 2020, maturity indices differed in fruit from different Blocks or their interaction with storage regimes in the case of I_{AD} (data not shown) and firmness in some cases (Table 3). In general, TA decreased 0.09% in average after long term storage with differences mostly between fruit from different Blocks and only between storage regimes after 9m+4wk+7 days at 68°F (Table 3). Overall, TA in 2019 was higher than in 2020 throughout storage (Table 3). Although harvest dates were similar or earlier in 2020 compared to 2019, fruit was smaller and less firm throughout storage (Tables 2 & 3).
In general, decay incidence was below 10% in average after 6 months and 19% after 9 months, with differences between blocks and storage treatments (Table 4). Soft scald incidence was block-dependent (highest in C21), and it was higher in 2019 and 2021 than in 2020 (Table 4). Only in 2019 the interaction Block x Storage regime was statistically significant (Table 4). These effects were observed until the end of the storage period (Table 4). Overall, there was significantly less soft scald in all CA/DCA storage regimes than that observed in fruit from the same Blocks stored in air for 4 months (data not shown).
Soggy breakdown followed the same trend as soft scald in 2019, with significantly higher incidences in Block C21 compared to the rest after 9m+4wk+7 days at 68°F (data not shown).
Bitter pit varied between blocks and storage regimes with the highest incidence observed in fruit from W25 and W42 during all three seasons and storage length (Table 4).
The exploratory multivariate analyses including sites, bioclimatic indices, shoot length, fruit mineral content at harvest, crop load, and fruit maturity at harvest in all three seasons did not show consistent results to explain disorder's expression or softening rate postharvest in Honeycrisp. A larger dataset is needed to increase correlations between variables.

Fuji: In general, there were no major differences in fruit maturity at harvest between blocks within years (Table 5). Similar trends were observed postharvest, with no major differences between storage regimes (Table 6). Overall, TA in Year 1 and Year 3 were higher than in Year 2 until 9m+4wk+1 d at RT (Table 6). Among postharvest defects and disorders, decay and internal browning were the most prominent ones. Decay incidence was the highest in Year 3, and it significantly increase after CA opening plus 4 weeks in air (Table 7). In most cases, there was a significant block-effect (Table 7). Internal browning appeared after 9m+4w+7d (shelf-life) in all three seasons with significant block differences (Table 7). Superficial scald also appeared at this time-point with incidences below 5.0% in average and only in Year 1. CO_2

injury were also observed in all three season, but with very low incidences (0.6-1.1%) and significant differences between Block x Storage interaction (data not shown).

Table 1. Orchard information includes location, variety, rootstock, year planted, and harvest dates for all seasons.

Block	Location	Variety	Rootstock	Year planted	Harvest date (Year 1)	(Year 2)	(Year 3)
W25	Rock Island	Honeycrisp	B-9	2012	8/31/19	8/27/20	8/26/21
W42	Othello	Honeycrisp	B118	2009	9/2/2019	9/4/20	9/7/21
C21	Royal City	Firestorm	M9 337	1996	9/10/2019	9/1/20	9/3/21
C802	Quincy	Honeycrisp	M9-Pajam2	2010	9/6/2019	9/9/20	9/7/21
W18	Rock Island	Aztec Fuji	M9 337	2009	10/7/2019	10/6/2020	10/1/21
W40	Othello	Fuji	B118/M9-Pajam2	2010	10/3/2019	10/6/2020	10/6/21
C4	Royal City	Aztec Fuji	M26	2006	10/9/2019	10/8/2020	10/6/21
C902	Quincy	Fuji	M9 337	2009	10/4/2019	10/8/2020	10/6/21

Table 2. Maturity indexes (weight, green background color, red coverage, I_{AD}, flesh firmness, soluble solid content, starch index, internal ethylene concentration, IEC, titratable acidity, and respiration) for Honeycrisp apples from different Blocks (W25, W42, C21, C802) at commercial harvest in Year 1 (2019), Year 2 (2020), and Year 3 (2021).

Year	Orchard	Weight (g)	Background color (1-4)	Red coverage (%)	I_{AD}	Firmness (lb)	SSC (°Brix)	SI (1-6)	IEC (ppm)	TA (% malic acid)	Respiration Rate (mL CO_2/kg/h)
2019	W25	226.6 b[Z]	2.6 ab[Y]	80.7 a[Y]	0.65 b	16.4 a	15.2 a	4.2	2.8 b	N/A	N/A
	W42	212.9 b	2.1 b	55.7 c	0.82 a	14.1 c	11.8 c	4.4	27.1 a	N/A	N/A
	C21	265.4 a	3.4 a	87.8 a	0.38 c	15.7 ab	13.4 b	5.1	0.0 b	N/A	N/A
	C802	219.4 b	2.2 b	65.8 b	0.81 a	15.0 bc	11.8 c	4.3	10.4 ab	N/A	N/A
	Sign.	**	*	*	**	**	**	NS	**		
2020	W25	169.4 b[Z]	2.9	78.1 b[Y]	0.95 a[Z]	13.2	12.4 ab[Z]	1.8 b[Z]	0.0	0.55 a[Z]	18.6
	W42	176.2 b	2.4	60.3 b	0.87 a	12.6	11.4 b	4.4 a	0.0	0.45 b	18.8
	C21	186.6 b	3.1	94.1 a	0.42 b	13.4	11.5 b	4.7 a	0.0	0.44 ab	5.7
	C802	268.4 a	2.7	63.6 b	0.60 b	13.0	13.5 a	4.4 a	0.1	0.50 ab	14.5
	Sign.	*	NS	*	*	NS	*	*	NS	*	NS
2021	W25	254.6	2.4 bc	70.8 b	0.82 a	14.4 ab	12.8 a	3.4	0.0	0.50	22.7
	W42	225.3	2.2 c	65.0 b	0.84 a	13.4 b	11.7 bc	3.6	0.0	0.53	18.0
	C21	220.5	3.2 a	85.6 a	0.41 b	15.2 a	11.0 c	3.2	0.3	0.59	20.2
	C802	199.7	2.7 b	65.3 b	0.77 a	13.7 ab	12.2 ab	2.8	0.0	0.44	16.7
	Sign.	NS	**	**	**	*	*	NS	NS	NS	NS

[Z]Means followed by different letters are statistically different (ANOVA, *= P≤0.05; **: P≤0.01; NS: non-significant).Tukey's mean separation test (P≤0.05). N/A: not available

[Y]Kruskall Wallis (P≤0.05) and Dunn's for mean separation.

Table 3. Maturity indexes (flesh firmness, soluble solid content, starch index, titratable acidity internal ethylene concentration) for Honeycrisp apples stored in Controlled atmosphere (**CA**: 3.0% O_2/ 0.5% CO_2; **CA-ILOS**: 0.5% O_2/ 0.5% CO_2- 10 days & 1.0% O_2/0.7% CO_2 thereafter; **CA-RQ**: 3.0% O_2/0.5% CO_2) from different Blocks (W25, W42, C21, C802) at commercial harvest in Year 1 (2019), Year 2 (2020), and Year 3 (2021).

Factors	Firmness (lb)			SSC(°Brix)			TA (% malic acid)			IEC (ppm)		
						6m+4w+1d						
Orchard (**A**)	Year 1	Year 2	Year 3	Year 1	Year 2	Year 3	Year 1	Year 2	Year 3	Year 1	Year 2	Year 3
W25	14.6 a[Z]	13.8 bc	14.6 b	15.1	13.6 a	12.8 a	0.55 a	0.34 a	0.44	86.0	0.0	15.0
W42	13.5 b	13.2 c	13.4 c	12.5	11.7 b	11.2 c	0.42 b	0.29 bc	0.44	25.9	0.0	27.2
C21	13.1 b	14.9 a	14.8 a	12.4	11.6 b	12.4 ab	0.42 b	0.27 c	0.54	40.3	0.0	65.6
C802	14.3 a	13.9 b	13.6 c	12.0	13.6 a	11.7 bc	0.53 a	0.34 a	0.44	41.5	1.1	5.6
Sign.	**	*	**	*	*	**	**	*	**	**	NS	NS
Storage (**B**)												
CA	13.7	13.8	14.6	13.0	12.2 b	12.1	0.46	0.31	0.46	47.29	0.7	49.2
CA-ILOS	13.7	14.0	14.7	13.0	13.1 a	12.3	0.51	0.32	0.50	54.79	0.0	0.0
CA-RQ	14.1	14.1	14.7	13.0	12.5 ab	11.7	0.45	0.30	0.46	43.22	0.0	35.8
Sign.	NS	NS	NS	NS	*	NS	NS	NS	*	NS	NS	NS
A x B	NS	NS	NS	*	NS	NS	NS	NS	**	**	NS	NS
						6m+4w+7d						
Orchard (**A**)	Year 1	Year 2	Year 3	Year 1	Year 2	Year 3	Year 1	Year 2	Year 3	Year 1	Year 2	Year 3
W25	14.6	13.8 a	15.1 b	14.8	13.9	13.0	0.47 a	0.28	0.49 ab	79.5	0.0	71.3
W42	12.5	12.9 b	13.1 c	11.6	11.5	11.4	0.32 b	0.24	0.43 b	160.1	2.5	88.1
C21	13.2	14.2 a	15.2 a	13.0	12.1	12.9	0.45 a	0.24	0.54 a	63.2	0.0	35.9
C802	14.4	13.8 a	13.5 c	12.7	13.1	13.3	0.47 a	0.29	0.44 ab	89.0	2.0	95.1
Sign.	*	*	***	*	*	NS	***	NS	*	NS	NS	NS
Storage (**B**)												
CA	13.8	13.8	15.1	13.0	12.4	12.3	0.38 b	0.27	0.48	84.5	0.2	82.1
CA-ILOS	13.8	13.4	14.5	13.1	12.9	13.7	0.47 a	0.26	0.51	136.8	0.8	76.4
CA-RQ	13.5	13.8	14.8	12.9	12.6	11.9	0.42 ab	0.25	0.46	72.6	2.4	59.2
Sign.	NS	NS	NS	NS	NS	NS	*	NS	NS	NS	NS	NS
A x B	*	NS	NS	*	*	NS	NS	NS	NS	NS	NS	NS
						9m+4w+1d						
Orchard (**A**)	Year 1	Year 2	Year 3	Year 1	Year 2	Year 3	Year 1	Year 2	Year 3	Year 1	Year 2	Year 3
W25	15.5 a	14.1	14.2 b	14.8	12.9	12.8 a	0.63 a	0.38 ab	N/A	0.00	0.00	58.8
W42	13.8 b	13.5	13.3 b	11.8	11.2	11.1 c	0.44 c	0.35 ab	N/A	0.00	0.00	31.1
C21	12.7 c	14.3	15.3 a	12.1	11.3	12.7 a	0.47 bc	0.34 b	N/A	0.00	0.06	39.3
C802	15.0 a	13.4	13.7 b	11.8	12.6	11.6 b	0.57 ab	0.39 a	N/A	0.00	1.44	55.4
Sign.	**	*	**	**	*	**	*	*		NS	NS	*
Storage (**B**)												
CA	14.2	13.8	14.8	12.6	11.9	12.3 ab	0.53	0.38 a	N/A	0.00	0.47	55.3
CA-ILOS	14.1	13.6	14.8	12.6	12.3	12.3 a	N/A	0.38 a	N/A	0.00	0.00	49.0
CA-RQ	14.3	14.0	14.7	12.7	11.8	11.9 b	N/A	0.34 b	N/A	0.00	0.66	40.2
Sign.	NS	NS	NS	NS	*	*	NS	*		NS	NS	NS
A x B	NS	*	NS	***	*	NS	NS	*		NS	NS	NS
						9m+4w+7d						
Orchard (**A**)	Year 1	Year 2	Year 3	Year 1	Year 2	Year 3	Year 1	Year 2	Year 3	Year 1	Year 2	Year 3
W25	14.7 a	13.3 b	14.5 b	15.0	12.6	12.8 a	0.39 b	0.28 b	N/A	0.00	0.26	103.5 a

W42	12.8 b	13.0 b	13.1 b	12.2	11.0	13.3 c	0.39 b	0.32 ab	N/A	0.07	7.41	62.1 ab
C21	12.0 b	14.3 a	15.9 a	12.3	11.5	12.2 ab	0.33 b	0.30 ab	N/A	0.02	0.79	34.0 b
C802	14.2 a	13.4 b	13.6 b	12.4	12.6	11.8 bc	0.50 a	0.35 a	N/A	1.01	7.53	81.3 ab
Sign.	***	*	**	**	*	**	**	*		NS	NS	**
Storage (**B**)												
CA	13.2	13.7	14.8	12.8	11.8	12.0	NA	0.31 b	N/A	0.78	1.84	75.1
CA-ILOS	13.6	13.5	14.6	13.2	12.3	12.2	0.397	0.36 a	N/A	0.02	3.88	70.1
CA-RQ	13.6	13.4	14.6	12.9	11.6	12.0	0.428	0.26 c	N/A	0.02	6.28	68.7
Sign.	NS	NS	NS	NS	*	NS	NS	*		NS	NS	*
A x B	NS	NS	NS	**	*	NS	NS	NS		NS	NS	NS

[Z]Means followed by different letters are statistically different (ANOVA, *= P≤0.05; **: P≤0.01; NS: non-significant).Tukey's mean separation test (P≤0.05). N/A: not available

Table 4. Fruit defects (incidence, average %) in Honeycrisp apples stored in Controlled atmosphere with different protocols (**CA**: 3.0% O_2/ 0.5% CO_2; **CA-ILOS**: 0.5% O_2/ 0.5% CO_2- 10 days & 1.0% O_2/0.7% CO_2 thereafter; **CA-RQ**: 3.0% O_2/0.5% CO_2) from different orchard blocks (W25, W42, C21, C802) at 6 months, 6 months plus 4 weeks in air plus 1 day or 7 days at room temperature (68°F) in Year 1 (2019), Year 2 (2020), and Year 3 (2021).

Decay (%)									
	6m			6m+4w+1d			6m+4w+7d		
Orchard (**A**)	Year 1	Year 2	Year 3	Year 1	Year 2	Year 3	Year 1	Year 2	Year 3
W25	0.9	1.3	0.0	1.3	3.9	5.5	7.2	7.8 a	14.6
W42	1.3	0.9	0.0	6.2	3.9	2.9	8.3	6.1 ab	7.1
C21	0.4	0.9	0.0	5.3	1.1	0.0	7.2	1.1 b	6.8
C802	1.8	0.4	0.0	3.1	0.6	5.5	8.3	3.3 ab	9.9
Sign.	NS	NS		NS	NS	*	NS	*	NS
Storage (**B**)									
CA	1.7 a	0.6	0.0	5.3 a	1.7	3.8	10.0 a	3.8	6.1
CA-ILOS	1.7 a	0.6	0.0	4.3 ab	1.3	3.9	9.8 a	3.3	16.9
CA-RQ	0.0 b	1.3	0.0	2.3 b	4.2	2.8	3.6 b	6.7	5.7
Sign.	*	NS		*	NS	NS	**	NS	NS
A x B	NS	NS		NS	*	NS	*	NS	NS
Soft Scald (%)									
	6m			6m+4w+1d			6m+4w+7d		
Orchard (**A**)	Year 1	Year 2	Year 3	Year 1	Year 2	Year 3	Year 1	Year 2	Year 3
W25	0.9	0.0	0.0	3.1	0.0	0.6 b	4.4	1.7	0.6 b
W42	8.0	0.0	0.0	8.0	0.0	0.6 b	10.6	0.6	0.6 b
C21	11.1	0.0	0.0	12.4	0.0	14.6 a	20.0	0.0	15.2 a
C802	0.0	0.0	0.0	0.44	0.6	0.5 b	0.6	0.6	0.5 b
Sign.	**	NS		**	NS	**	**	NS	**
Storage (**B**)									
CA	7.3	0.0	0.0	9.0	0.4	2.4	11.3	1.3	2.4
CA-ILOS	4.3	0.0	0.0	5.7	0.0	6.0	11.3	0.4	6.5
CA-RQ	3.3	0.0	0.0	3.3	0.0	3.8	4.2	0.4	3.8
Sign.	**	NS		**	NS	NS	**	NS	NS
A x B	**	NS		**	NS	NS	**	NS	NS
Soggy Breakdown (%)									
	6m			6m+4w+1d			6m+4w+7d		
Orchard (**A**)	Year 1	Year 2	Year 3	Year 1	Year 2	Year 3	Year 1	Year 2	Year 3
W25	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.6	0.0
W42	0.0	0.0	0.0	0.0	0.0	0.0	1.7	0.0	0.0

C21	0.0	0.0	0.0	0.0	0.0	0.0	8.9	0.6	0.0
C802	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.6	0.0
Sign.	NS	NS	NS	NS	NS	NS	**	NS	NS
Storage (**B**)									
CA	0.0	0.0	0.0	0.0	0.0	0.0	6.3	0.0	0.0
CA-ILOS	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.0	0.0
CA-RQ	0.0	0.0	0.0	0.0	0.0	0.0	1.3	1.3	0.0
Sign.	NS	NS	NS	NS	NS	NS	**	NS	NS
A x B	NS	NS	NS	NS	NS	NS	**	NS	NS
				Bitter Pit (%)					
		6m			6m+4w+1d			6m+4w+7d	
Orchard (**A**)	Year 1	Year 2	Year 3	Year 1	Year 2	Year 3	Year 1	Year 2	Year 3
W25	0.0	7.3 a	0.0	1.8	10.6 a	3.5	3.9	14.4 a	4.6
W42	8.9	4.7 ab	0.0	11.6	9.4 a	0.6	17.2	10.0 a	2.3
C21	7.6	0.4 c	0.0	9.8	1.1 b	1.7	13.9	1.1 b	1.7
C802	0.4	0.9 bc	0.0	1.8	1.7 b	0.7	3.9	2.2 b	0.7
Sign.	**	*	NS	**	*	NS	**	*	NS
Storage (**B**)									
CA	2.7	3.5	0.0	4.7	5.0	0.0 b	8.3	6.3	0.0 b
CA-ILOS	5.3	2.6	0.0	7.0	5.0	1.9 ab	10.8	7.5	1.9 ab
CA-RQ	4.7	3.8	0.0	7.0	7.1	2.9 a	10.0	7.1	5.0 a
Sign.	NS	NS	NS	NS	NS	*	NS	NS	**
A x B	**	NS	NS	**	NS	NS	**	NS	NS

[Z]Kruskal-Wallis (P≤0.05); [Y]Different letters within columns indicate statistically significant differences (Dunn test).

Table 5. Maturity indexes (weight, green background color, red coverage, I_{AD}, flesh firmness, soluble solid content, starch index, internal ethylene concentration, IEC, titratable acidity, and respiration) for Fuji apples from different Blocks (W18, W40, C4, C902) at commercial harvest in Year 1 (2019), Year 2 (2020), and Year 3 (2021).

Season	Orchard (A)	Weight (g)	Background color (1-4)	Red coverage (%)	I_{AD}	Firmness (lb)	SSC (°Brix)	SI (1-8)	IEC (ppm)	TA (% malic acid)	Respiration Rate (mL CO_2/kg/h)
2019	W18	237.3 b	3.0	93.9	1.13 a	16.6 ab	14.0 a	6.6	0.36	N/A	N/A
	W40	503.1 a	3.0	94.2	0.87 b	17.8 a	13.1 ab	6.1	0.19	N/A	N/A
	C4	244.9 b	3.0	95.0	1.06 a	17.0 a	13.6 ab	6.2	0.22	N/A	N/A
	C902	523.3 a	3.0	100.0	1.13 a	16.2 b	11.9 b	6.8	0.32	N/A	N/A
	Sign.	**	NS	NS	**	*	*	NS	NS	-	-
2020	W18	181.0	2.4	91.4	1.04 b	15.4	14.1 a	3.9	0.00	0.35	37.8
	W40	187.2	2.5	81.7	0.67 c	16.4	13.7 a	5.7	0.00	0.38	28.7
	C4	189.1	2.1	79.7	1.07 b	16.3	12.3 b	5.2	0.00	0.35	33.2
	C902	190.0	2.0	74.2	1.26 a	16.9	12.3 b	5.2	0.00	0.33	33.4
	Sign.	NS	NS	*	*	NS	*	NS	NS	NS	NS
2021	W18	222.8	4.0	89.4 b	0.99 a	17.7	15.1 a	3.9 b	0.00	0.51	33.6 a
	W40	226.1	4.0	98.8 ab	0.80 b	17.5	13.2 b	4.9 a	0.02	0.40	13.7 b
	C4	220.6	4.0	97.6 a	0.88 ab	18.6	15.6 a	3.8 b	0.29	0.41	17.4 ab
	C902	228.1	4.0	93.6 ab	0.92 ab	18.1	13.3 b	5.3 a	0.04	0.41	17.9 ab
	Sign.	NS	NS	**	*	NS	**	**	NS	NS	*

[Z]Means followed by different letters are statistically different (ANOVA, *= P≤0.05; **: P≤0.01; NS: non-significant).Tukey's mean separation test (P≤0.05).

Table 6. Maturity indexes (flesh firmness, soluble solid content, starch index, titratable acidity internal ethylene concentration) for Fuji apples stored in Controlled atmosphere (**CA**: 0.8% O_2/ 0.8% CO_2; **CA-ILOS**: 0.6% O_2/ 0.8% CO_2- 10 days & 0.8% O_2/0.8% CO_2 thereafter; **CA-RQ**: 0.8% O_2/0.8% CO_2) from different Blocks (W18, W40, C4, C902) at commercial harvest in Year 1 (2019), Year 2 (2020), and Year 3 (2021).

Factors	Firmness (lb)			SSC(°Brix)			TA (% malic acid)			IEC (ppm)		
						6m+4w+1d						
Orchard (A)	Year 1	Year 2	Year 3	Year 1	Year 2	Year 3	Year 1	Year 2	Year 3	Year 1	Year 2	Year 3
W18	14.8 a	16.0	17.0	14.9 a	15.8	16.4	0.372 a	0.299 a	0.469	0.0	0.0	0.0
W40	15.2 a	16.7	15.2	13.5 b	14.7	13.6	0.372 a	0.258 ab	0.314	0.6	0.1	0.1
C4	15.1 a	15.6	16.9	14.6 a	13.8	16.6	0.291 b	0.197 c	0.299	0.1	0.3	0.0
C902	14.0 b	14.7	16.8	13.4 b	14.4	14.8	0.376 a	0.243 bc	0.409	0.5	0.0	0.0
Significance	**	*	*	**	*	**	*	*	**	NS	NS	NS
Storage (B)												
CA	14.6	16.2	16.5	13.9	14.5	15.3	0.372 a	0.255	0.365	0.0 b	0.0	0.0
CA-ILOS	15.0	16.7	16.4	14.3	14.9	15.3	0.326 b	0.254	0.362	0.8 a	0.0	0.1
CA-RQ	14.7	16.0	16.5	14.1	14.5	15.4	0.361 ab	0.238	0.390	0.1 b	0.2	0.0
Significance	NS	*	NS	NS	NS	NS	*	NS	*	*	NS	NS
A x B	NS	*	**	NS	*	**	NS	NS	**	NS	NS	NS
						6m+4w+7d						
Orchard (A)	Year 1	Year 2	Year 3	Year 1	Year 2	Year 3	Year 1	Year 2	Year 3	Year 1	Year 2	Year 3
W18	15.2	16.4 b	17.2	15.1 a	15.9 a	15.5	0.352 a	0.293 a	0.387	0.0	0.0	0.0
W40	15.1	17.2 a	16.4	14.1 b	14.8 b	13.7	0.352 a	0.278 ab	0.293	0.0	0.0	0.2
C4	14.9	16.0 b	17.4	14.6 b	14.1 c	16.3	0.278 b	0.191 c	0.255	1.8	0.1	0.0
C902	14.7	17.0 a	17.5	13.4 c	14.3 bc	14.3	0.370 a	0.238 bc	0.345	1.2	1.4	3.0
Significance	NS	*	*	*	*	**	*	*	**	NS	NS	*
Storage (B)												
CA	14.6 b	16.6 ab	16.8	14.0 b	14.8 ab	15.0	0.339 ab	0.253	0.351	0.0	0.0	0.5
CA-ILOS	15.0 a	17.0 a	17.6	14.5 a	15.0 a	15.1	0.362 a	0.262	0.372	0.0	0.1	0.2
CA-RQ	15.2 a	16.4 b	16.8	14.4 a	14.5 b	14.8	0.313 b	0.234	0.237	2.3	1.1	1.7
Significance	**	*	NS	*	*	NS	*	NS	**	NS	NS	NS
A x B	NS	NS	**	NS	NS	**	NS	NS	**	NS	NS	*
						9m+4w+1d						
Orchard (A)	Year 1	Year 2	Year 3	Year 1	Year 2	Year 3	Year 1	Year 2	Year 3	Year 1	Year 2	Year 3
W18	14.8	16.5	16.7	15.2	15.3	15.9	0.290	0.289 a[Z]	0.437	0.1 b	0.0	0.0
W40	15.0	16.8	16.0	13.6	14.0	14.4	0.303	0.261 ab	0.481	1.1 ab	0.0	0.1
C4	14.8	15.8	16.7	14.3	15.3	16.7	0.242	0.187 c	0.251	2.2 a	0.0	0.0
C902	15.0	17.1	16.9	13.0	13.8	15.0	0.336	0.252 b	0.365	2.2 a	0.0	0.0
Significance	NS	*	NS	*	NS	**	NS	*	NS	*	NS	NS
Storage (B)												
CA	15.1	16.7	16.3	14.2	15.4	15.2	0.307	0.253	0.355	1.4	0.0	0.0
CA-ILOS	14.8	16.7	16.8	13.9	14.4	15.8	0.260	0.251	0.355	1.1	0.0	0.0
CA-RQ	14.8	16.1	16.1	14.0	14.0	15.8	0.312	0.237	0.456	1.7	0.0	0.0
Significance	*	*	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
A x B	*	*	NS	*	NS	**	NS	NS	NS	NS	NS	NS
						9m+4w+7d						
Orchard (A)	Year 1	Year 2	Year 3	Year 1	Year 2	Year 3	Year 1	Year 2	Year 3	Year 1	Year 2	Year 3
W18	15.5	16.5	17.2	15.4 a	15.2 a	15.8	0.255 a	0.283 a	0.378	0.1 b	0.0	0.0
W40	15.2	16.8	15.9	13.9 bc	14.2 b	14.3	0.244 a	0.236 b	0.293	0.1 b	0.0	0.0
C4	14.9	15.9	17.1	14.8 ab	13.9 b	16.9	0.170 b	0.199 c	0.253	15.2 a	0.2	0.0
C902	15.1	17.1	16.6	13.4 c	13.8 b	16.6	0.265 a	0.231 bc	0.278	0.3 b	0.0	0.0
Significance	NS	*	NS	*	*	**	*	*	**	*	NS	-
Storage (B)												
CA	15.4	16.9	16.4 b	14.4	14.3	15.2	0.250	0.251 a	0.289	3.2	0.0	0.0
CA-ILOS	15.3	16.9	17.4 a	14.2	14.5	15.6	0.222	0.245 a	0.327	5.9	0.0	0.0
CA-RQ	14.9	15.9	16.6 ab	14.5	14.1	15.6	0.230	0.215 b	0.287	2.6	0.2	0.0
Significance	NS	*	*	NS	NS	NS	NS	*	NS	NS	NS	-

A x B	NS	*	NS	NS	NS	**	NS	NS	**	NS	NS	-

[Z]Means followed by different letters are statistically different (ANOVA, *= P≤0.05; **: P≤0.01; NS: non-significant).Tukey's mean separation test (P≤0.05).

Table 7. Fruit defects (incidence, average %) in for Fuji apples stored in Controlled atmosphere (**CA**: 0.8% O_2/ 0.8% CO_2; **CA-ILOS**: 0.6% O_2/ 0.8% CO_2- 10 days & 0.8% O_2/0.8% CO_2 thereafter; **CA-RQ**: 0.8% O_2/0.8% CO_2) from different Blocks (W18, W40, C4, C902) at 9 months plus 4 weeks in air plus 1 day or 7 days at room temperature (68°F) in Year 1 (2019), Year 2 (2020), and Year 3 (2021).

					Decay (%)				
	9m			9m+4w+1d			9m+4w+7d		
Orchard (**A**)	Year 1	Year 2	Year 3	Year 1	Year 2	Year 3	Year 1	Year 2	Year 3
W18	0.4	0.4	1.7	0.9	3.9	1.0	13.3	5.6 ab	11.7
W40	0.9	0.4	2.3	4.0	1.7	1.8	8.9	10.6 a	1.8
C4	0.0	0.4	2.0	2.2	2.2	8.0	6.7	1.7 b	10.8
C902	0.4	0.0	2.3	3.6	1.1	4.6	10.6	2.8 b	10.3
Significance	NS	NS	NS	*	NS	*	NS	*	NS
Storage (**B**)									
CA	0.7	0.0	1.6	2.3	2.1	3.8	7.5	5.8	7.1
CA-ILOS	0.7	0.3	2.0	4.0	2.5	2.9	11.3	4.6	8.9
CA-RQ	0.0	0.6	2.7	1.7	2.1	5.9	10.8	5.0	9.0
Significance	NS	NS	NS	NS	NS	NS	NS	NS	NS
A x B	NS	NS	NS	*	NS	NS	NS	NS	NS
					Internal Browning (%)				
	9m			9m+4w+1d			9m+4w+7d		
Orchard (**A**)	Year 1	Year 2	Year 3	Year 1	Year 2	Year 3	Year 1	Year 2	Year 3
W18	0.0	0.0	0.0	0.0	0.0	0.0	0.0 b	0.0 b	7.0
W40	0.0	0.0	0.0	0.0	0.0	0.0	17.2 a	3.9 a	8.4
C4	0.0	0.0	0.0	0.0	0.0	0.0	0.0 b	0.0 b	4.9
C902	0.0	0.0	0.0	0.0	0.0	0.0	0.6 b	0.0 b	11.1
Significance	-	-	NS	-	-	-	*	*	NS
Storage (**B**)									
CA	0.0	0.0	0.0	0.0	0.0	0.0	2.9	0.0	8.3
CA-ILOS	0.0	0.0	0.1	0.0	0.0	0.0	3.8	2.1	8.3
CA-RQ	0.0	0.0	0.0	0.0	0.0	0.0	6.7	0.8	6.8
Significance	-	-	NS	-	-	-	NS	NS	NS
A x B	-	-	NS	-	-	-	NS	NS	NS

[Z]Kruskal-Wallis (P≤0.05); [Y]Different letters within columns indicate statistically significant differences (Dunn test).

Obj. 2. Evaluate the effect of organic Retain OL in combination with different storage systems on fruit maturity and quality postharvest.

Activities:
During Years 1 and 2 different Retain OL treatments were applied to Gala and Honeycrisp commercial blocks in Hood River, OR (Year 1), and Gala in a. commercial block in Manson, WA. In all experiments treatments consisted in 10 fl oz/acre applied 4 and 1 week before harvest (T2), 20 fl oz/acre. (Full dose), 1 week before harvest (T3) plus an untreated control (T1) in Year 1, and all of them plus full dose 3 (T4) and 1 day (T5) before harvest in Year 2. Fruit was harvested twice: at commercial harvest and 7 days later. Maturity indices were evaluated from 27 days before harvest (DBH) until harvest and after 3, 6, and 9 months in CA storage plus 7 days at room temperature (68°F).

RESULTS

Year 1: When treatments were harvested according to the untreated fruit (H1) optimum maturity, Retain-treated fruit (T2, T3) was only significantly higher after 9 months in CA plus 7 days at RT (9.1 lb versus 7.8 lb) in Gala. Conversely, when they were harvest at the optimum maturity in the Retain-treated fruit (H2, approx. 1 week later), T3 showed consistently (although not always statistically different) higher flesh firmness and SSC from 3 until 9 months of storage than the rest of the treatments, except at 9 months plus 7 days at RT. This was also true in Honeycrisp. Both, T2 and T3 significantly affected red skin color (% coverage) in Honeycrisp apples. There were no consistent differences between treatments in IEC, SI, SSC or I_{AD} in Gala throughout storage. In Honeycrisp apples, only the I_{AD} values were consistently higher (less ripen), but not always statistically different, in Retain OL-treated fruit in comparison to the Untreated control. There were no statistical differences between defects incidences between treatments in any of the experiments.

Year 2: In general, all Retain OL treatments affected flesh firmness, I_{AD}, starch degradation (index) and fruit respiration progression preharvest. Retain OL-treated fruit maintained higher I_{AD}, flesh firmness effectively delaying the commercial harvest. T2 maintained the highest flesh firmness in fruit postharvest, although not always significantly different from T3 in H1 and T3, T4 and T5 in H2. Similar results were observed for the I_{AD} (chlorophyll degradation) values, which were higher (less degraded) in T3 compared to the rest of the Retain treatments (Table 8).

Table 8. Maturity indexes (weight, chlorophyll degradation (I_{AD}), flesh firmness (lb) soluble solid content, starch index, and titratable acidity (% malic acid)) for Gala apples treated with Retain OL (1: Untreated Control; 2: 10 Fl Oz/Ac, 21 DBH+7DBH; 3: 20 Fl Oz/Ac, 7 DBH; 4: 20 Fl Oz/Ac, 3 DBH; 20 Fl Oz/Ac, 1 DBH) and stored in Controlled atmosphere (0.8% O_2/ 0.8% CO_2) for 9 months plus 7 days at 68°F. Year 2 (2020) season.

	Eval. Time	Trt	Wt (g)	I_{AD}	Firmness (lbs)	SSC (°Brix)	Starch Index (1-6)	Acidity (% malic acid)
H2 Gala	3 mo	1	187.91	0.175 a[Z]	13.39 a	13.6 b	6.0 c	0.216
		2	176.31	0.448 b	15.09 b	12.0 a	5.1 a	0.200
		3	187.73	0.465 b	14.48 a,b	12.2 a	5.5 b	0.162
		4	186.67	0.483 b	13.96 a,b	11.9 a	5.9 c	0.207
		5	187.79	0.422 b	14.16 a,b	12.4 a	6.0 c	0.213
	p-value		0.643	<0.001	0.003	<0.001	<0.001	0.173
	3 mo +7d	1	189.84	0.164 a	12.83 a	13.6 b	6.0	0.224 a,b
		2	184.01	0.550 c	14.92 b	12.4 a	6.0	0.232 b
		3	194.74	0.390 b	14.32 b	12.9 a,b	6.0	0.177 a
		4	191.96	0.419 b	14.12 b	12.9 a,b	6.0	0.203 a,b
		5	184.32	0.367 b	14.33 b	12.6 a	6.0	0.218 a,b
	p-value		0.613	<0.001	<0.001	0.001	-	0.033
	6 mo	1	169.77	0.271 a	12.76 a	12.3	8.0	0.105
		2	175.46	0.509 b,c	14.73 c	12.7	8.0	0.110
		3	175.66	0.526 c	14.28 b,c	12.4	8.0	0.138
		4	184.53	0.379 a,b	13.66 a,b	12.7	8.0	0.109
		5	182.68	0.456 b,c	13.89 b,c	12.4	8.0	0.102
	p-value		0.404	<0.001	<0.001	0.444	-	0.626
	6 mo +7d	1	-	0.274 a,b	11.97 a	12.9	8.0	0.094
		2	-	0.531 c	14.88 b	13.1	8.0	0.105
		3	-	0.496 c	14.14 b	12.7	8.0	0.096
		4	195.92	0.321 b	13.97 b	12.7	8.0	0.114
		5	194.56	0.183 a	14.76 b	13.0	8.0	0.121
	p-value		0.865	<0.001	<0.001	0.625	-	0.704
	9mo	1	184.84 a	0.172 a	10.50 a	13.4	8.0	0.171
		2	208.89 b,c	0.400 b	14.72 b	13.0	8.0	0.159

	3	197.11	a,b	0.418	b	14.59	b	12.9		8.0	0.168
	4	237.91	c	0.384	b	11.88	a	13.1		8.0	0.140
	5	199.51	a,b	0.370	b	13.73	b	13.0		8.0	0.148
p-value		<0.001		<0.001		<0.001		0.109		-	0.385
9mo +7d	1	198.46	a,b	0.147	a	9.59	a	13.8	b	8.0	0.156
	2	193.13	a	0.360	b	14.87	b	13.3	a,b	8.0	0.197
	3	212.49	b,c	0.327	b	14.00	b	13.2	a,b	8.0	0.190
	4	199.64	a,b	0.300	b	12.63	b	13.2	a,b	8.0	0.193
	5	195.69	a	0.269	a,b	13.35	b	12.8	a	8.0	0.193
p-value		0.020		0.001		<0.001		0.020		-	0.059

[Z]Means followed by different letters are statistically different (ANOVA, P≤0.05).Tukey's mean separation test (P≤0.05).

Objective 3. Evaluate the performance of vacuum storage (RipeLocker) under different temperatures regimes on fruit quality and physiological disorder development.

Activities:
After commercial harvest, fruit from all commercial blocks in Obj. 1 and both cultivars, Honeycrisp and Fuji, were placed in vacuum storage (approx. 10% of regular atmosphere) bins (RipeLockers, RL) at 37°F (only Year 1) and 33°F after conditioning (see Obj. 1). Postharvest evaluations for Year 3 are currently being carried out and will be finish in July 2022.

RESULTS
Honeycrisp: In 2019 season, there were no major differences in maturity between vacuum RL and regular CA storage. Nevertheless, fruit stored in RL33 had less chlorophyll degradation (I_{AD} value) and less respiration after 9 months+4 wks+7 days at 68°F in all three seasons. Differences in fruit volatiles, including ethanol, were observed right after 9 months of storage in season 2020 and 2021, but they tended to disappear after 4 weeks in air (data not shown). The effect of the storage regime over soft scald was block-dependent in Year 1, and slightly higher in fruit stored in RL33 in Year 2 (Table 9). The same for soggy breakdown in Year 2. Bitter pit (+lenticel blotch pit) was significantly reduced by vacuum RL in most sites, regardless of differences in lot susceptibility. Similar results were observed in Year 2 (Table 9).

Table 9. Physiological disorders (incidence, average %) in Honeycrisp apples from different orchard blocks (W25, W42, C21, C802) stored in Controlled atmosphere (3.0% O_2/ 0.5% CO_2) or vacuum/low pressure in Ripelockers at 37°F (RL37) or 33°F (RL33) for up to 9 months plus 4 weeks in air plus 7 days at 68°F in Year 1 (2019), Year 2 (2020), and Year 3 (2021).

	Soft Scald (%)								
	9m			9m+4w+1d			9m+4w+7d		
Orchard	Year 1	Year 2	Year 3	Year 1	Year 2	Year 3	Year 1	Year 2	Year 3
W25	0.0	0.0	0.4	2.6	0.0	0.0 b	0.9 b	1.7	0.0 b
W42	1.6	0.3	2.8	3.6	0.8	7.1 ab	11.9 a	1.7	9.3 ab
C21	5.0	0.3	3.5	6.6	0.8	11.0 a	13.5 a	0.8	11.7 a
C802	0.4	0.3	0.6	3.1	2.5	0.0 b	6.2 ab	2.5	0.9 ab
P value	*	NS	NS	NS	NS	*	*	NS	*
Storage									
CA	3.0	0.0	1.6	3.7	0.0 b	3.7	5.8	0.4 b	3.0
RL33	1.4	0.5	1.7	4.8	2.1 a	4.5	10.2	2.9 a	6.3
RL37	0.8	N/A	N/A	1.5	N/A	N/A	7.9	N/A	N/A
P value	NS	NS	NS	NS	*	NS	NS	*	NS
A x B	*	NS	NS	*	NS	NS	NS	NS	NS
	Soggy Breakdown (%)								
	9m			9m+4w+1d			9m+4w+7d		

Orchard	Year 1	Year 2	Year 3	Year 1	Year 2	Year 3	Year 1	Year 2	Year 3
W25	0.0	0.0	0.0	0.0	0.0	0.0	0.9	0.0 b	0.0
W42	0.0	0.0	0.0	0.0	0.0	0.0	0.7	2.5 a	0.0
C21	0.0	0.0	0.0	2.2	0.0	0.0	12.8	0.0 b	0.0
C802	0.0	0.0	0.0	0.0	0.0	0.0	0.9	0.0 b	0.0
P value	-	-	-	≤0.05	-	-	NS	≤0.05	-
Storage									
CA	0.0	0.0	0.0	1.7	0.0	0.0	7.5	0.0	0.0
RL33	0.0	0.0	0.0	0.0	0.0	0.0	2.1	1.3	0.0
RL37	0.0	N/A	N/A	0.0	N/A	N/A	1.0	N/A	N/A
P value	-	-	-	*	-	-	NS	NS	-
A x B	-	-	-	*	-	-	NS	*	-
				Bitter pit + Lenticel blotch pit (%)					
	9m			9m+4w+1d			9m+4w+7d		
Orchard	Year 1	Year 2	Year 3	Year 1	Year 2	Year 3	Year 1	Year 2	Year 3
W25	0.0	4.8 a	2.2 ab	1.8	14.2 a	0.9	2.0	14.2 a	4.0
W42	6.1	6.1 a	3.3 a	9.4	7.5 a	2.8	14.4	9.2 a	3.7
C21	2.7	0.6 b	0.0 b	5.7	0.8 b	0.0	8.1	0.8 b	0.0
C802	3.3	1.3 ab	0.3 b	5.3	1.7 b	0.0	9.0	1.7 b	0.0
P value	*	*	*	*	*	NS	*	*	NS
Storage									
CA	2.4	5.1	1.3	6.4	6.7	0.6	7.9	7.5 a	0.0
RL33	3.7	1.3	1.1	5.3	5.4	0.7	7.4	5.4 b	2.9
RL37	3.0	N/A	N/A	3.0	N/A	N/A	9.4	N/A	N/A
P value	NS	*	NS	NS	NS	NS	NS	*	NS
A x B	*	NS	NS	NS	NS	NS	NS	NS	NS

[Z]Kruskal-Wallis (P≤0.05; *); [Y]Different letters within columns indicate statistically significant differences (Dunn test).

Fuji: In Year 1, fruit maturity at harvest and during the storage season was mostly similar between treatments (Block x Storage regime), with some exceptions where the maturity index was block-dependent, especially after 9 months of storage (Table 3). Superficial scald appeared after 9m+4w+7d. The effect of the storage regime over its expression was block-dependent. No superficial scald was observed in Year 2 or 3. Internal browning, CO2 injury and bitter pit incidences were below 4% in average in Year 1. Only internal browning was observed in Year 3, in all Blocks and mostly during 9m+4w+7d. In this case, higher levels were observed in RL33 treatment.

Executive Summary

Project Title: Postharvest system optimization for organic apple storage

Keywords: Honeycrisp, Fuji, fruit quality, cold storage, DCA

Abstract:
In order to evaluate different postharvest technologies for organic apples, 'Honeycrisp' and 'Fuji' apples from four different orchards were picked at commercial harvest during 3 consecutive seasons (2019-2021) and placed into different controlled atmosphere regimes. For 'Honeycrisp' these were: 1. CA (3% O_2/0.5% CO_2); 2. CA-RQ (3% O_2/0.5% CO_2), and 3. CA-ILOS (Initial low oxygen stress; 0.5% O_2/0.5% CO_2 -10 days, 1.0% O_2/0.7% CO_2 thereafter) after conditioning fruit for 7 days at 50°F. For 'Fuji' apples CA regimes were: CA: 0.8% O_2/ 0.8% CO_2; CA-ILOS: 0.6% O_2/ 0.8% CO_2- 10 days, and 0.8% O_2/0.8% CO_2 thereafter; CA-RQ: 0.8% O_2/0.8% CO_2 with pre-conditioning of 4 weeks in air before CA imposition. Fruit maturity and physiological disorders development were assessed after six and nine months of storage plus four weeks in air (37°F or 34°C) and 7 days at 65°F ('shelf-life'). Overall, all CA/DCA storage regimes evaluated were suitable for long-term storage of organic Honeycrisp and Fuji apples. Nevertheless, preharvest managements (nutrition, pathogens, etc.) and seasonal climate greatly affected the amount of decay and physiological disorders development during the storage period.
In 2020, soft scald incidence in Honeycrisp was lower than in 2019 season, and it was significantly reduced by all CA/DCA storage regimes when compared to those observed in fruit stored in air for 4 months. Similar results were observed in 2021 season. Soggy breakdown only appeared in 2019 and 2021 seasons after 9 months in CA/DCA+4 weeks in air+7 days at 68°F, and mostly in one of the cool sites. Bitter pit was block-dependent all seasons. Incidence greatly increase during the air period (4 weeks) after CA/DCA. In general, Fuji had very low level of defects and disorders with the most prominent ones being decay and internal browning, both of which appeared during air storage after CA/DCA and after 7 days at 68°F, respectively.
Overall, the application of aminoethoxyvinylglycine (AVG- Retain OL) on Gala (2019 and 2020) and Honeycrisp (2019) apples effectively delayed fruit maturity progression preharvest, and maintained fruit firmness higher postharvest, although not always statistically significant and dose and timing-dependent, until 9 months in CA plus 7 days at 68°F when compared to the untreated control. Skin color development was negatively affected by AVG treatments preharvest in Honeycrisp.
Honeycrisp apples stored in low pressure (RipeLocker, RL) at 33°F were comparable in terms of fruit maturity to those stored in CA/DCA at 37°F (plus 4 weeks in air). Soft scald incidence was block-dependent the first year and slightly higher in RL-stored fruit in 2020 and 2021. Bitter pit (+lenticel blotch pit) was reduced by vacuum RL in most sites in 2019 and 2020 but not in 2021.