

Sustainable Pre- and Postharvest Approaches for Mitigating Stem-End Flesh Browning in 'Gala' Apples

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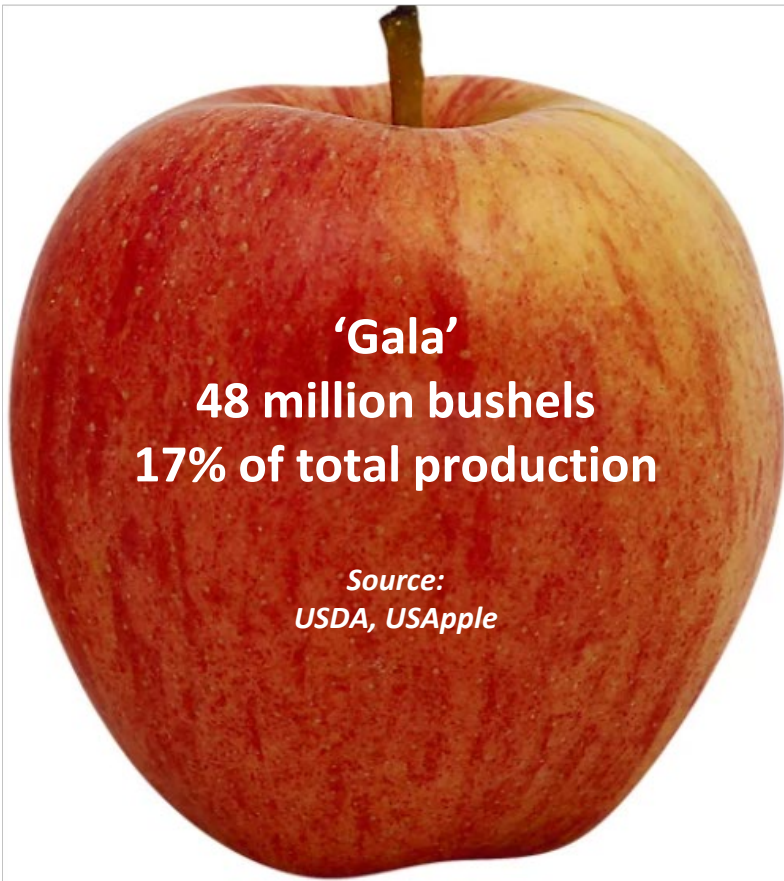
Horticulture Section, School of Integrative Plant Science, College of Agriculture and Life Science, Cornell University

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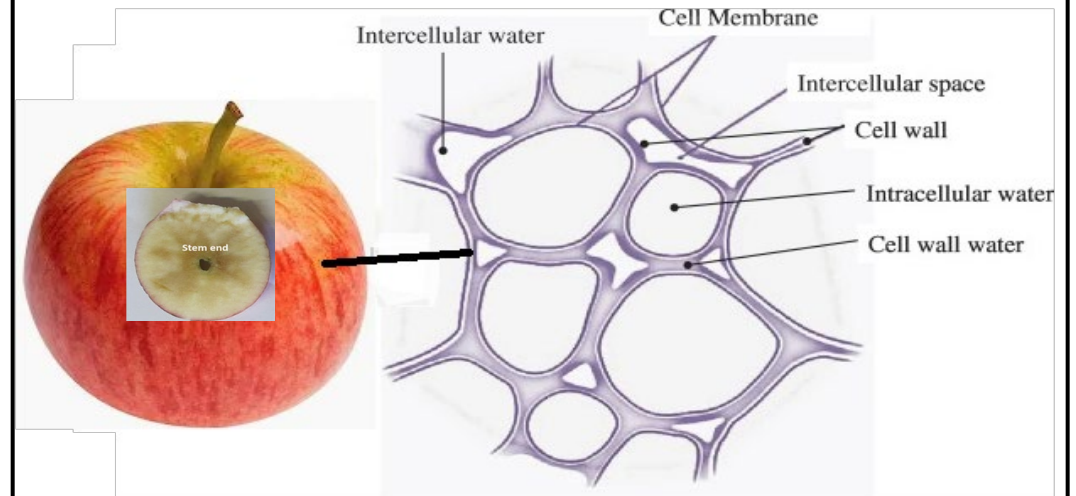
Topics for today

- 1. Overview of Preharvest PGRs Use in the NY Apple Industry
- 2. Key Factors Influencing SEFB Development in ‘Gala’ Apples
- 3. Optimizing Preharvest PGRs Application to Improve Quality and Storability
- 4. Impact of Storage Temperature and Pre/Postharvest PGRs on FB Development
- 5. Best Practices for Long-Term Storage of ‘Gala’ Apples

Stem end flesh browning



Stem end flesh browning in 'Gala'



- Oxidative stress
- Chilling injury
- Minerals deficiency
- Strain
- Rootstock
- Carbon dioxide injury
- Anoxia or hypoxia
- Senescent

1- Overview of Preharvest PGR Use in the NY Apple Industry

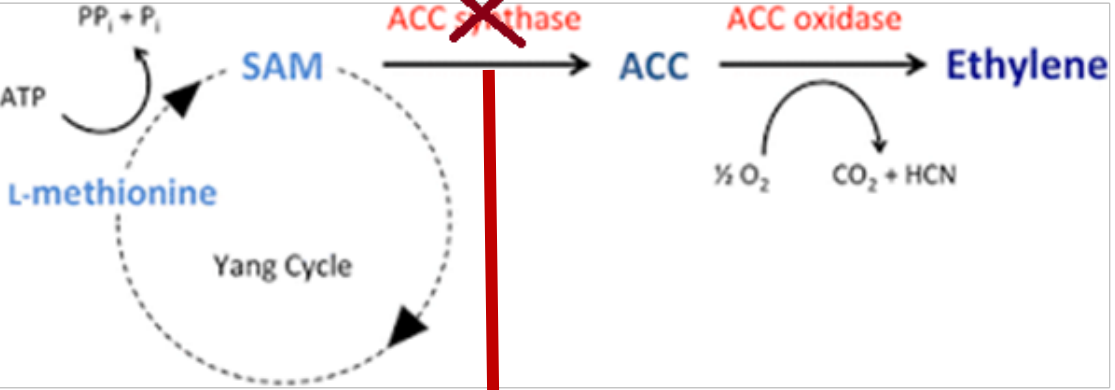
Pre and postharvest plant growth regulators (PGRs) to manage physiological disorders in 'Gala' apples

- 1- Aminoethoxyvinylglycine (AVG), commercialized as (ReTain®).
- 2- 1-methylcyclopropene (1-MCP), commercialized as (Harvista™).
- 3- 1-methylcyclopropene (1-MCP), commercialized as (SmartFresh™)



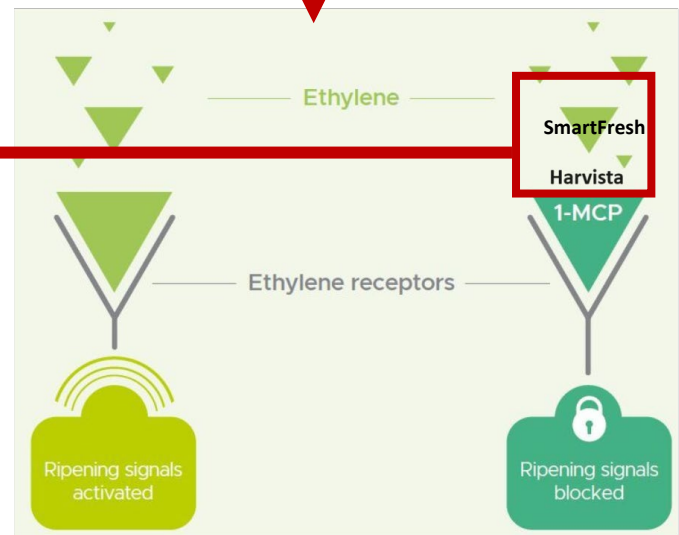
Effects on ethylene and fruit ripening

ReTain



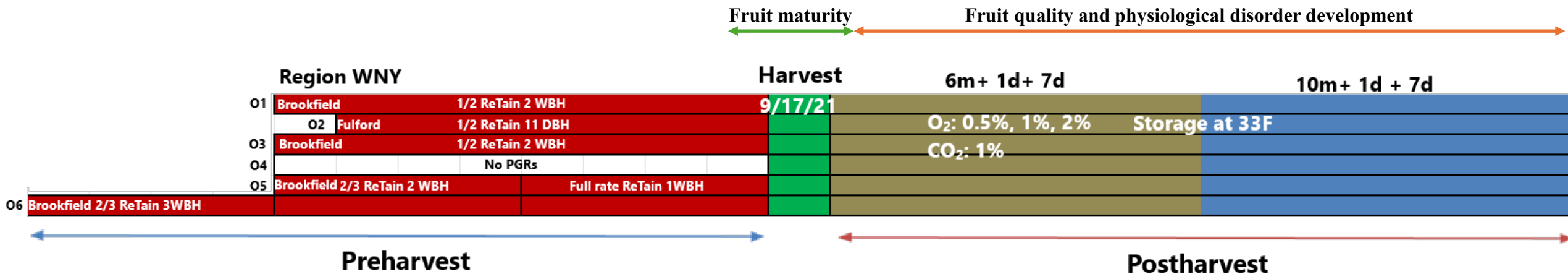
Natural ripening hormone in fruit

- ✓ Delay abscisic acid and fruit drop
- ✓ Delay fruit ripening
- ✓ Reduce fruit respiration
- ✓ Maintain fruit firmness



Source: <https://www.janssenpmp.com/sustainability/articles/maximising-freshness-benefits-and-applications-1-mcp>

Why do we need to optimize application time of Plant Growth Regulators (PGRs)?



Commercial orchards

Fruit maturity

- ✓ IEC (ppm)
- ✓ Firmness (lb)
- ✓ SSC (%)
- ✓ TA (%)
- ✓ SPI (0-8)
- ✓ I_{AD} index
- ✓ Fruit color

Fruit quality and physiological disorders

- ✓ Firmness
- ✓ SSC (%)
- ✓ TA (%)
- ✓ I_{AD} index
- ✓ Physiological disorders

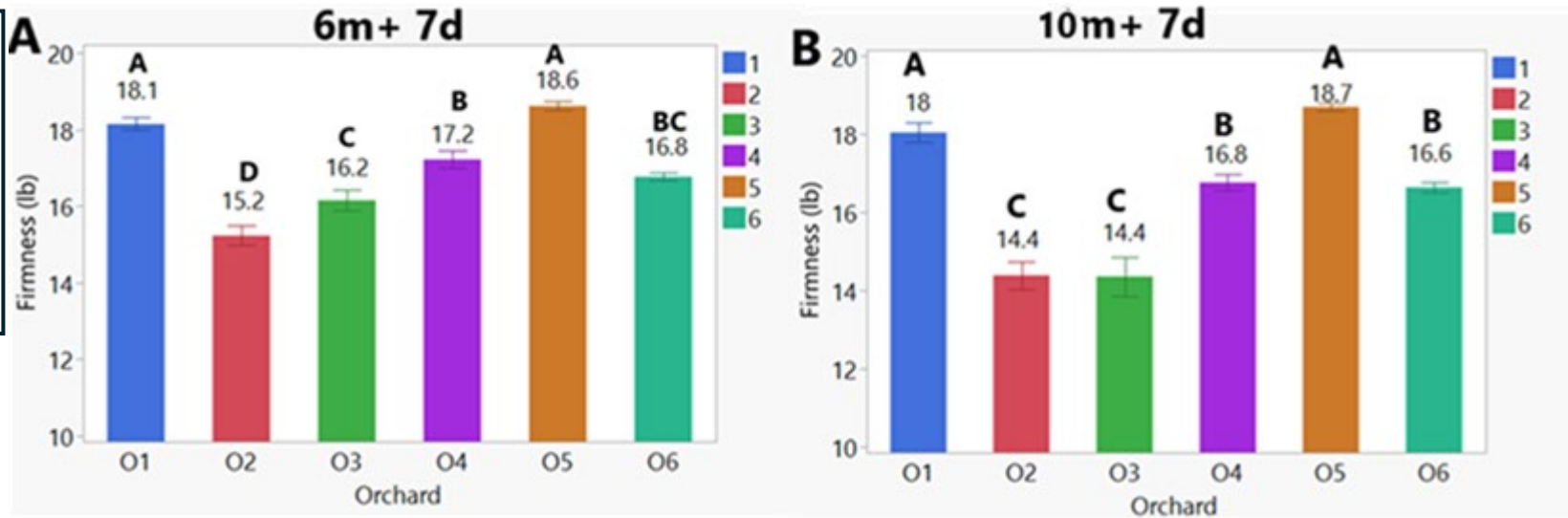
Maturity at harvest

Orchard	IEC (ppm)	Firmness (lb)	SSC(%)	TA (%)	SPI (1-8)	I _{AD} value (0-5)
O1	1.5 ab	19.1 ab	12.8 b	0.49 ab	4.4 b	0.26 c
O2	1.3 bc	16.0 d	11.4 c	0.44 bc	5.2 ab	0.25 c
O3	1.9 a	17.4 c	13.4 a	0.49 ab	5.4 a	0.22 c
O4	1.5 ab	18.0 bc	13.2 ab	0.47 ab	5.0 ab	0.43 b
O5	0.3 d	19.4 a	11.6 c	0.50 a	3.0 c	0.62 a
O6	0.9 c	17.4 c	11.9 c	0.39 c	4.5 ab	0.40 b
P value	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001

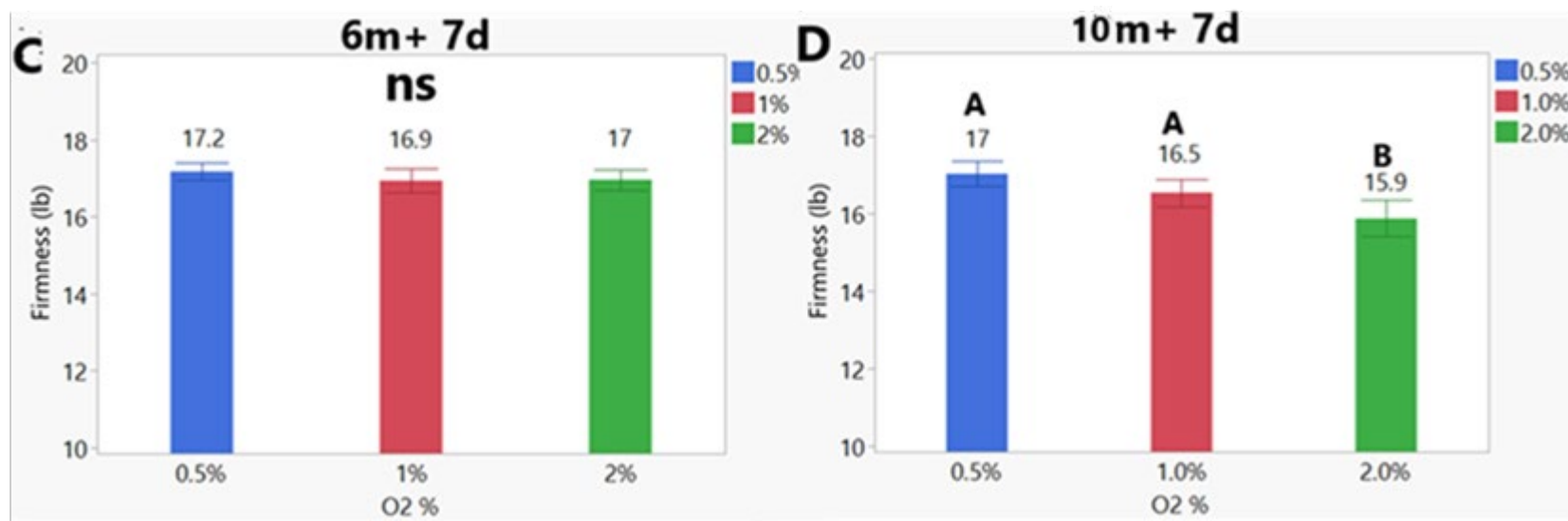
Flesh firmness after storage

1 lb dropped by advancing storage →

1 lb dropped compared to harvest



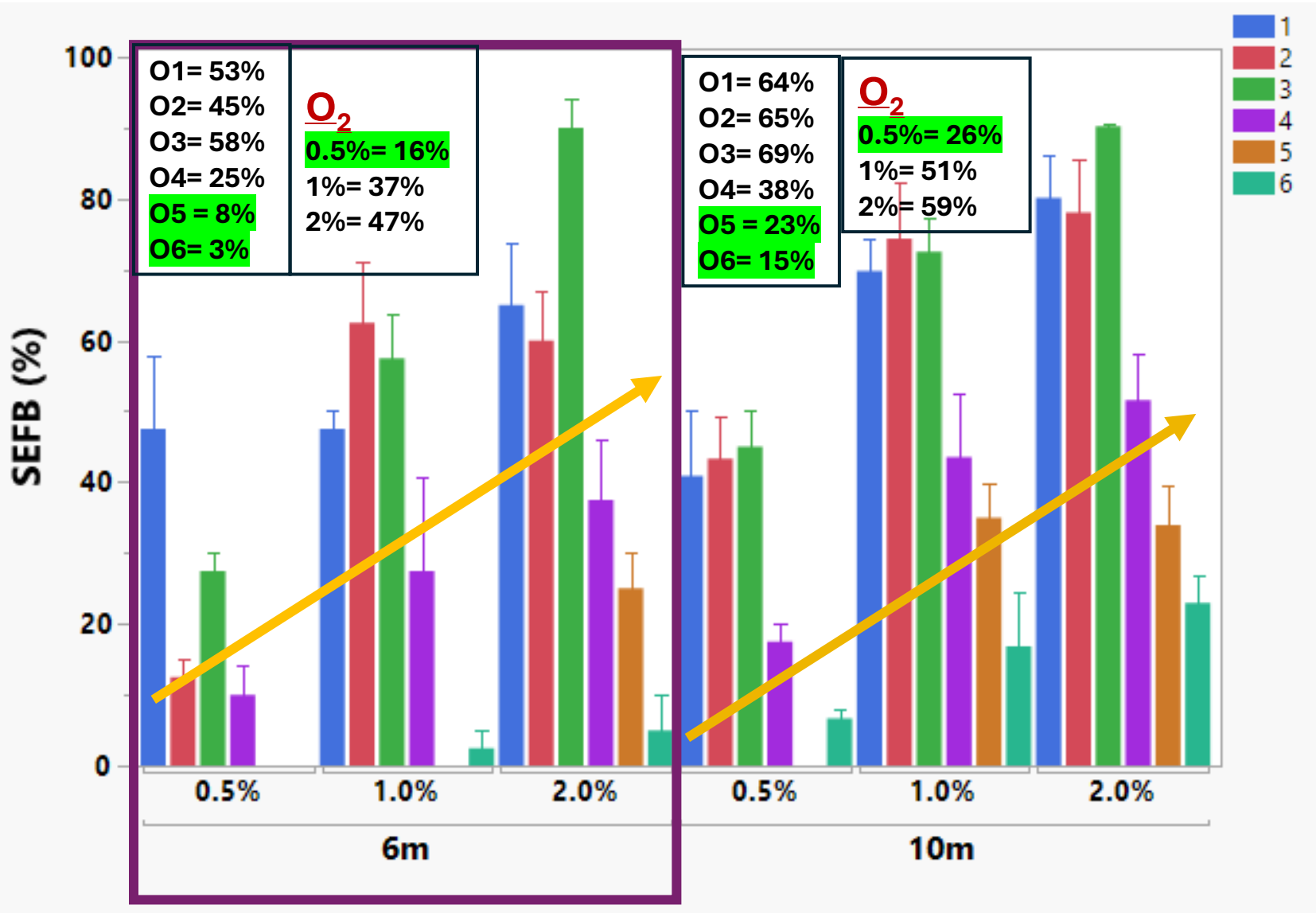
2 lb dropped compared to harvest



0.6-1.1lb dropped at 2% compared with 0.1 and 0.5%, respectively

FB (%) after storage at 33°F+ 7d at 68°F

Take home messages

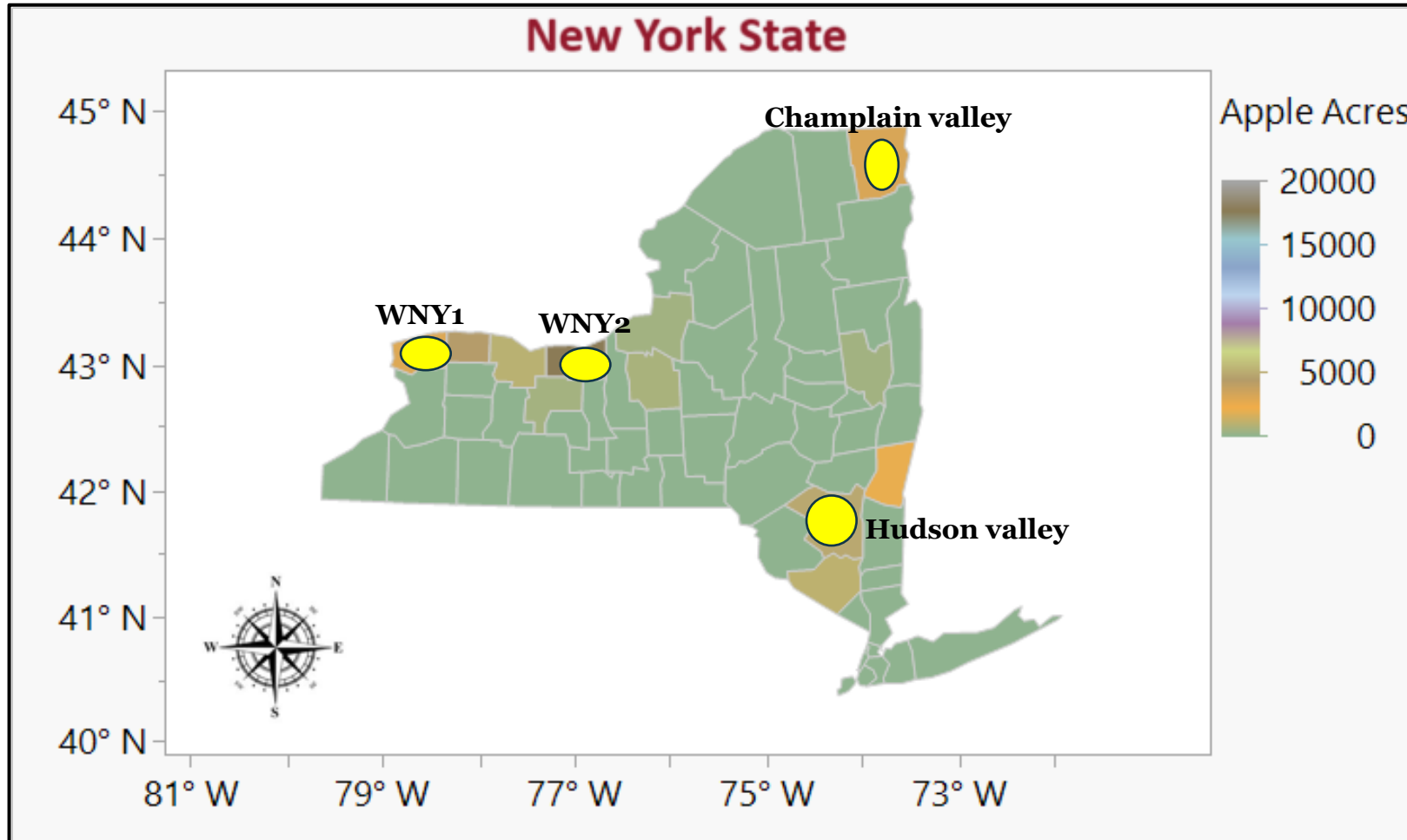


- FB increased by advancing storage time as **14%**
- FB varied between orchard blocks **(0- 100%)**
- FB delayed by decreasing Oxygen
 - 0.5% compared with 1% O₂= 20%**
 - 0.5% compared with 2% O₂= 30%**
 - 1% compared with 2% O₂= 10%**
- O5 with repeated ReTain application, was less mature and zero FB at 0.5%
- The industry need to adjust the timing of PGR application based on specific orchards.

2- Key Factors Influencing SEFB Development in 'Gala' Apples

Factors affect physiological disorders development in 'Gala apples (Screening)

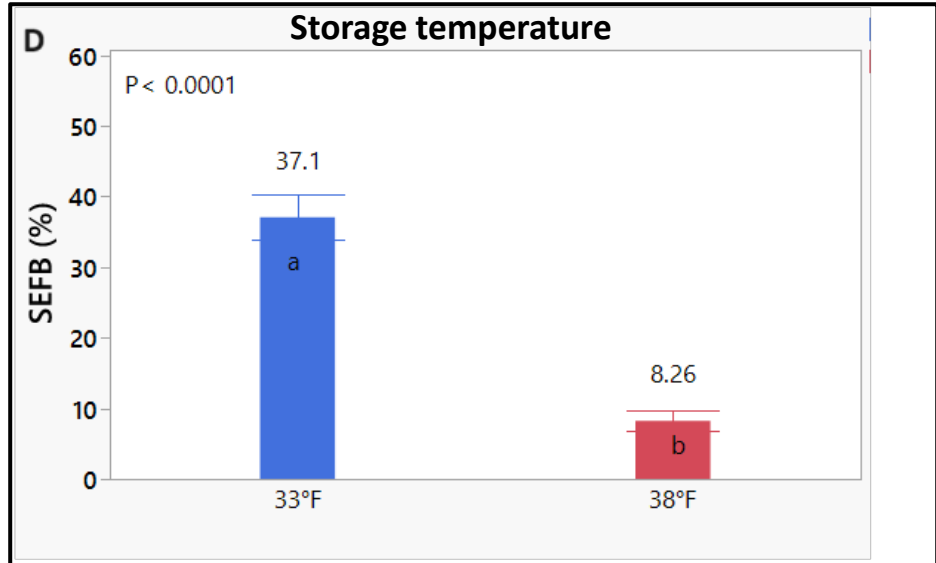
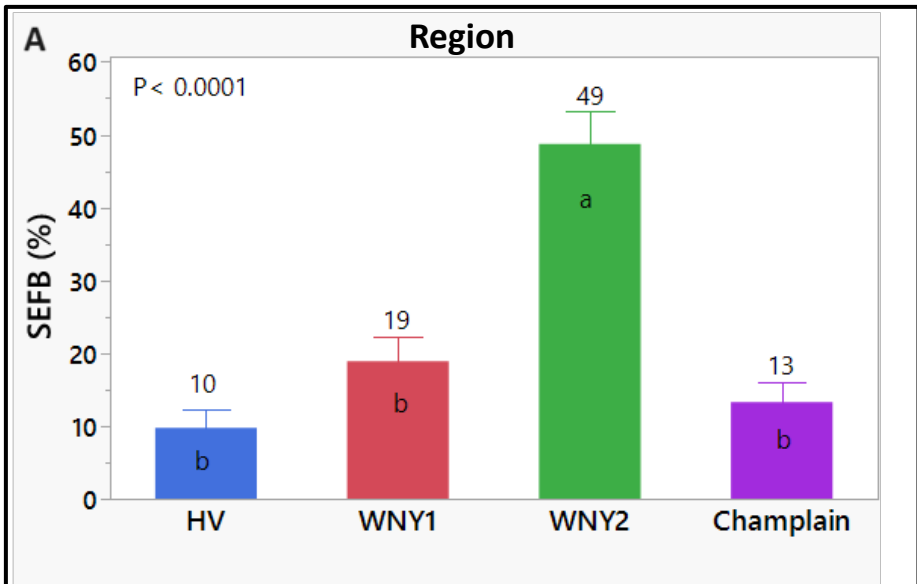
- Data from 1 year
- 6 orchard blocks from every region
- Commercial harvest
- Storage at 33 or 38°F
- 0.5% O₂ and 1% CO₂



- Region
- Orchard block
- Strain
- Storage temperature
- Maturity indices
- Flesh minerals

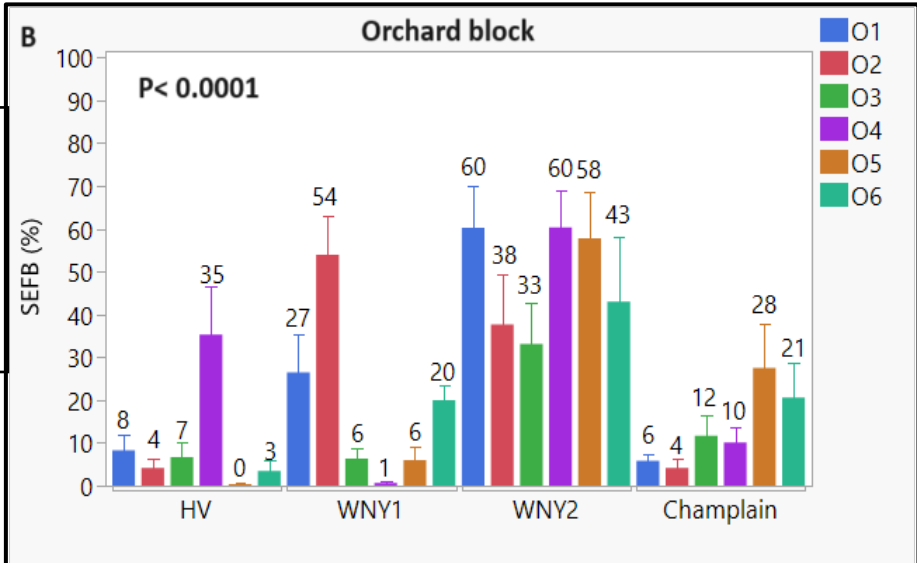
Factors affect stem end flesh browning (SEFB) development in 'Gala' apples during storage

WNY1 = west;
WNY2 = east.

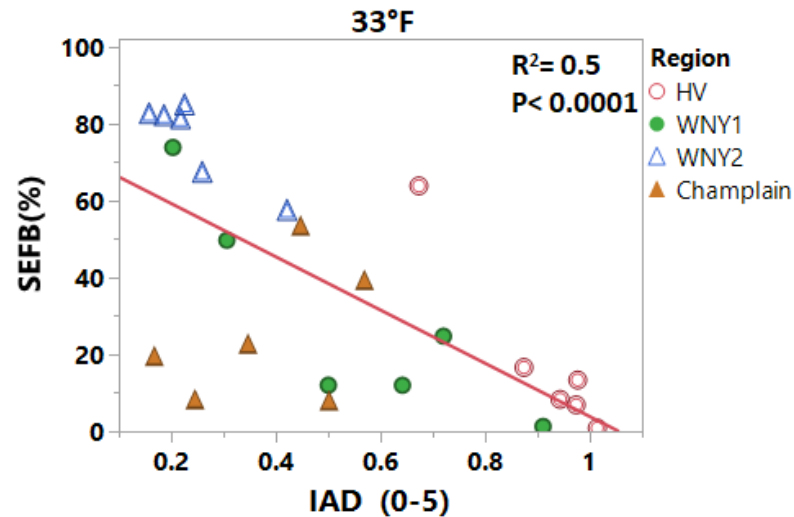
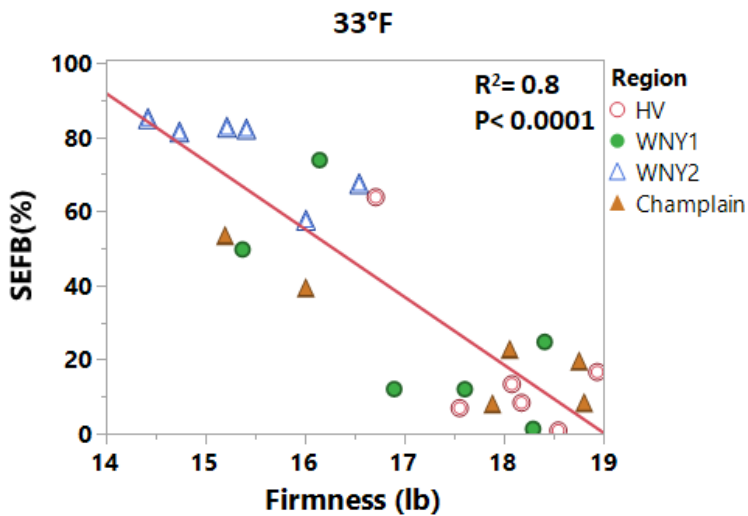


38°F reduced **29%** of FB compared with 33°F after 9 months of CA storage

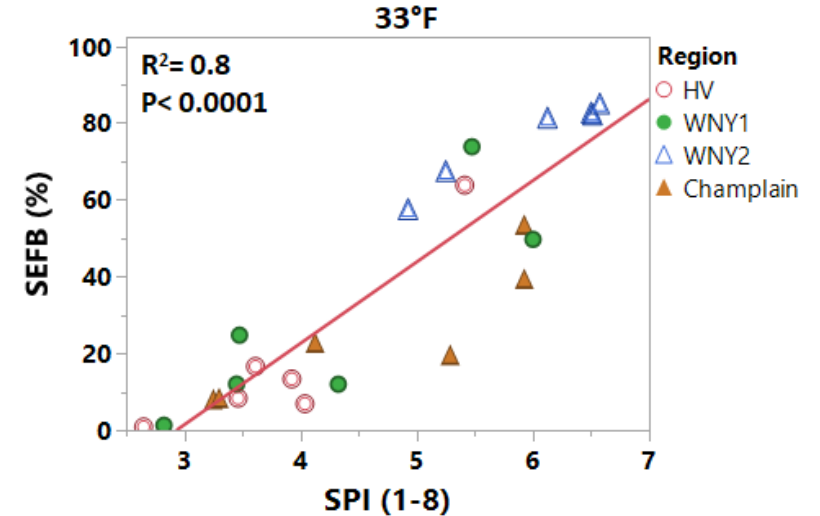
FB ranged from **0- 60%** based on orchard block



Regression of FB with maturity indices (Firmness, SPI and I_{AD} value) – 33°F



WNY1 = west; WNY2 = east.



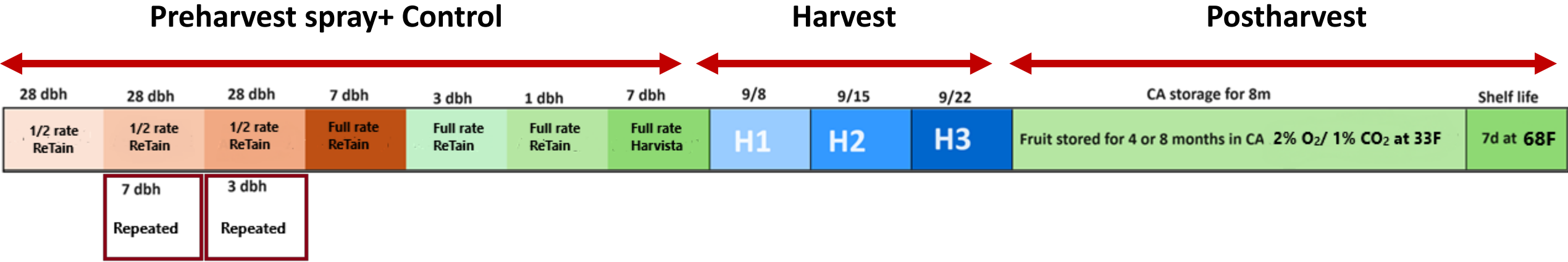
Correlation between fruit **flesh minerals** at harvest and SEFB after storage were weak.

Take home message : fruit maturity is the main driver for developing of SEFB in 'Gala' apples.

3- Optimizing Preharvest PGRs Application to Enhance Quality and Storability

Effects of preharvest ReTain® and Harvista™ on fruit maturity, quality and physiological disorder development of ‘Gala’ apples

Objective: evaluate different timing and concentration of ReTain and one time and concentration of Harvista on fruit quality and SEFB development during long-term CA storage at **33°F**.



Field treatments:

- ✓ Spray was based on TRV on Brookfield Gala grafted on M.9- High tall spindle (90 cm× 335 cm)
- ✓ Complete block design 8 rows× 4 reps/tree/ treatment
- ✓ All treatments mixed with 0.05% Silwet L-77
- ✓ Each spray treatment was applied in the early morning using a CO₂ pressurized backpack sprayer
- ✓ AVG= ReTain®=R
- ✓ 1-MCP= Harvista™= H

Fruit maturity

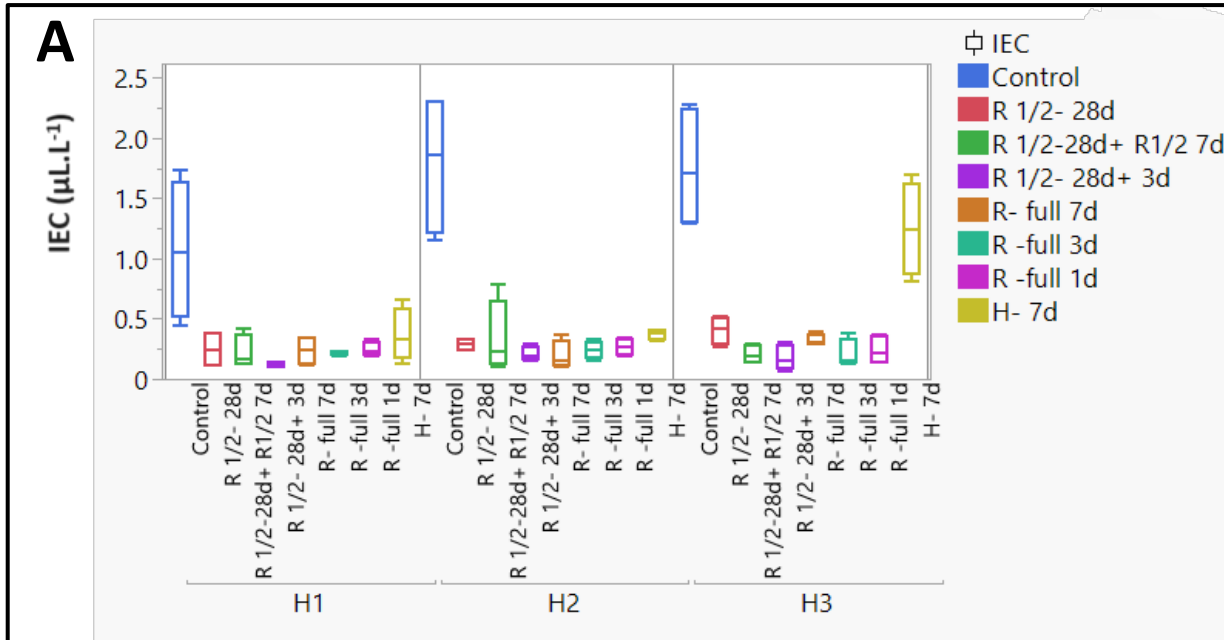
- ✓ IEC
- ✓ Firmness
- ✓ SSC (%)
- ✓ TA (%)
- ✓ SPI (0-8)
- ✓ I_{AD} index (0-5)
- ✓ Fruit color

Fruit quality and physiological disorders

- ✓ Firmness
- ✓ SSC (%)
- ✓ TA (%)
- ✓ I_{AD} index (0-5)
- ✓ Physiological disorders

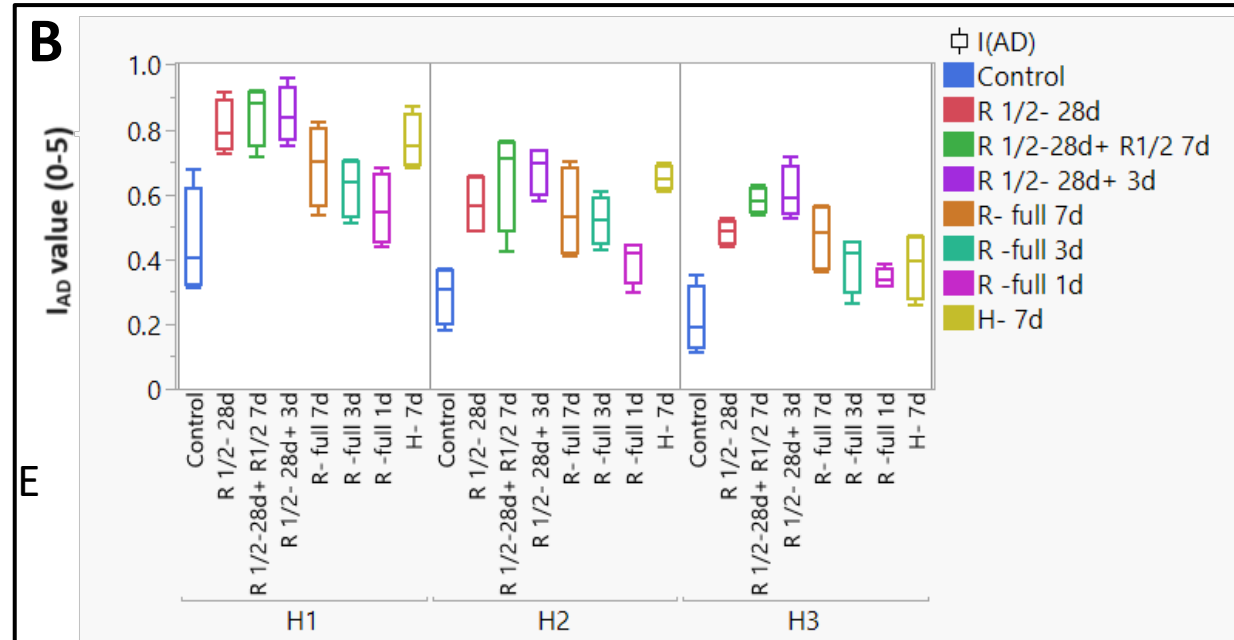
Maturity indices at harvest

IEC (ppm)



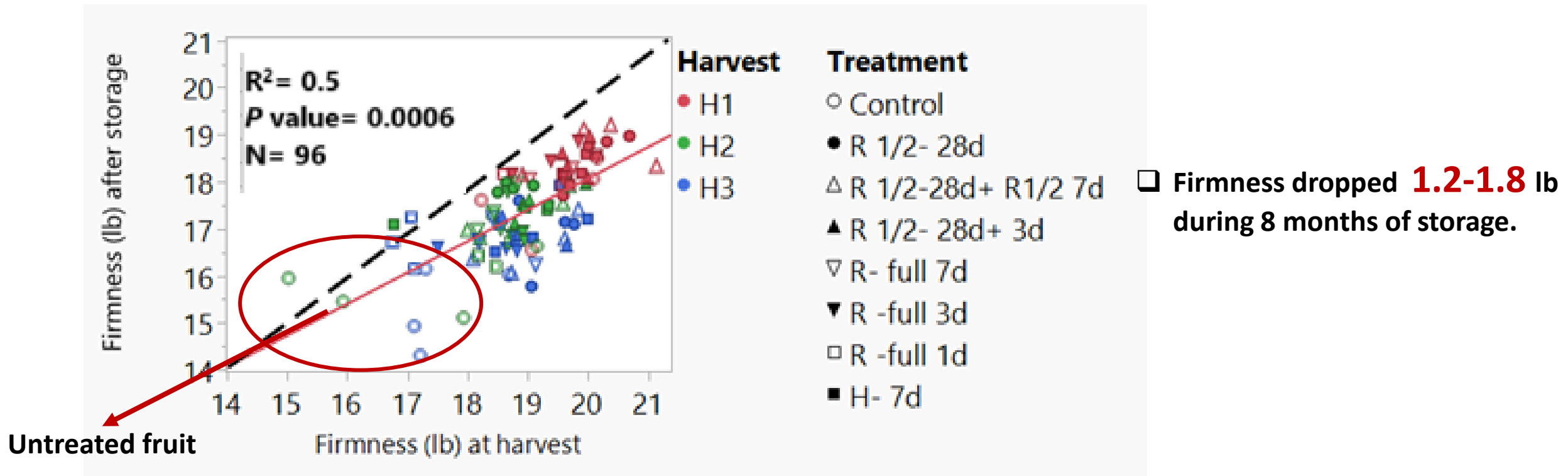
Untreated > Harvista > ReTain

I_{AD} value



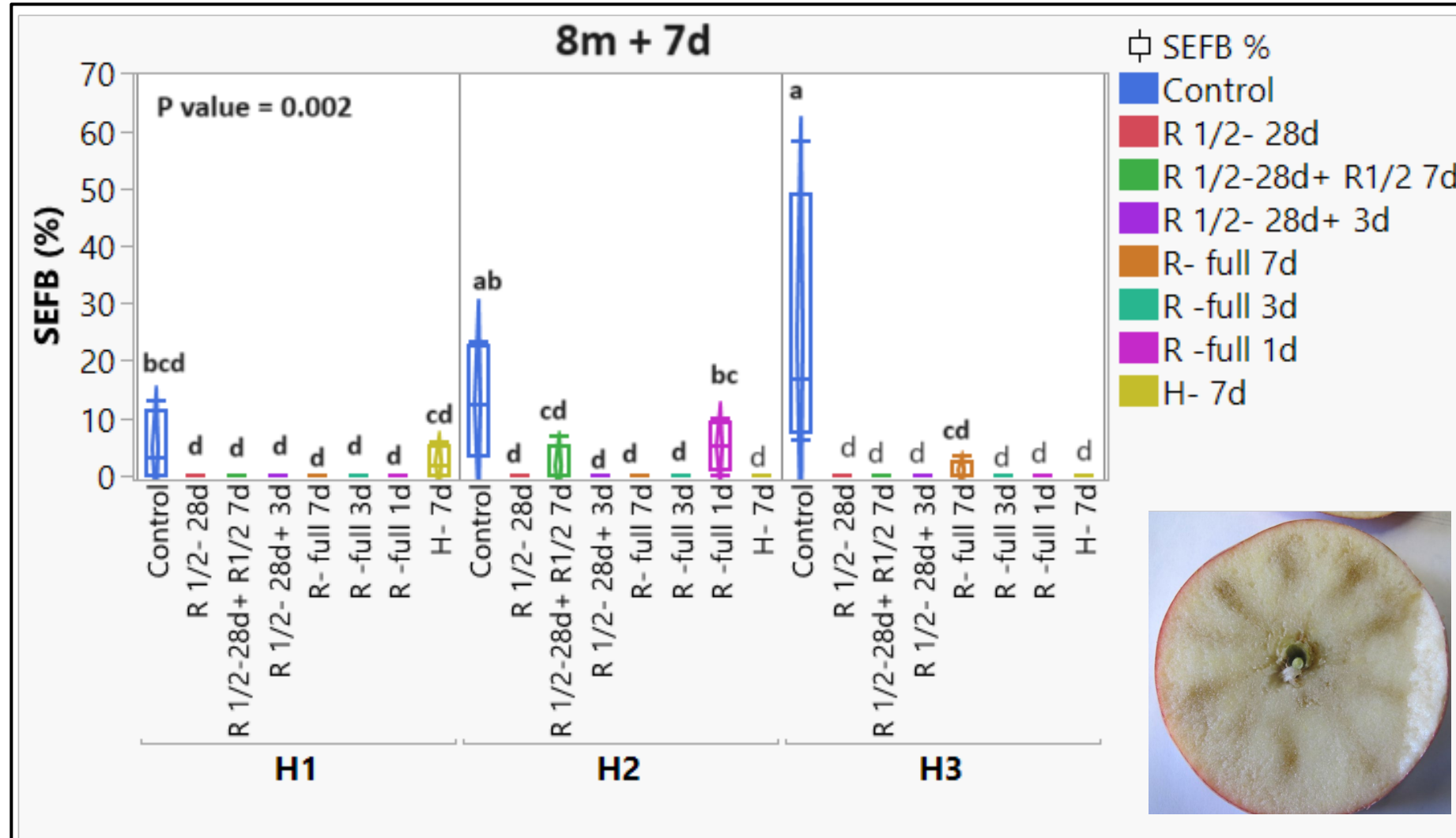
Untreated < Harvista and ReTain

Effects of PGRs on flesh firmness at harvest and during storage



Fruit quality and physiological disorders after storage

Stem end flesh browning



□ ReTain and Harvista reduced **13-14%** of flesh browning after storage compared with untreated fruit

Main takeaways:

- ❖ ReTain spray maintained fruit quality after long term storage compared with Untreated fruit.
- ❖ All sprays of ReTain and the Harvista treatment inhibited SEFB development of fruit stored for 8 months (except application one day before harvest).
- ❖ Fruit firmness decreased slightly during storage at the same level for all treatments.

4- Impact of Storage Temperature and Pre/Postharvest PGRs on SEFB Development

Effects of preharvest ReTain on fruit maturity, quality and SEFB development in 'Gala' apples

Maturity indices at harvest in Brookfield Gala

H1

H2

H3

Untreated

ReTain

'Gala' control- H1- 9/7/2022

'Gala'- ReTain- H1- 9/7/2022



"Gala" control- H2- 9/14/2022

"Gala" ReTain- H2- 9/14/2022



"Gala" control- H3- 9/21/2022

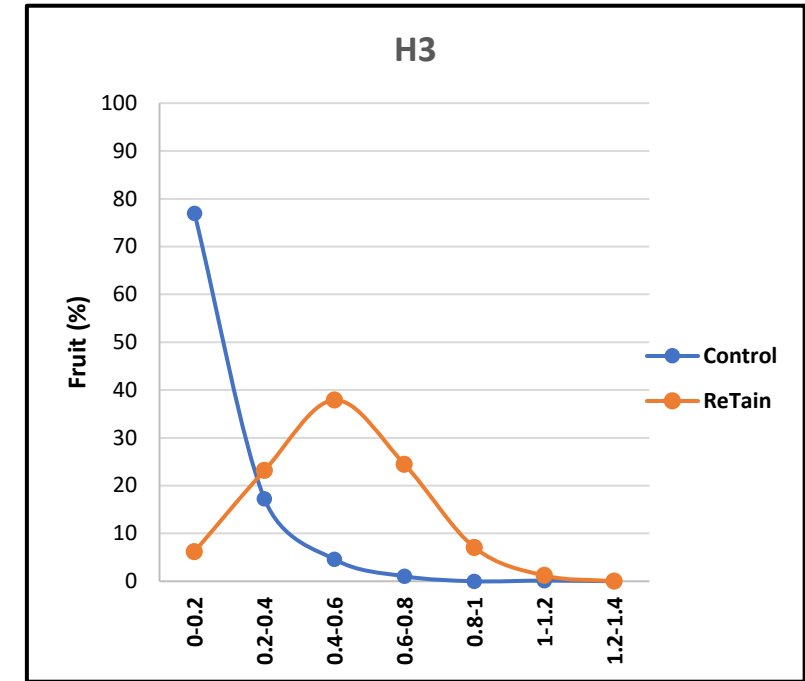
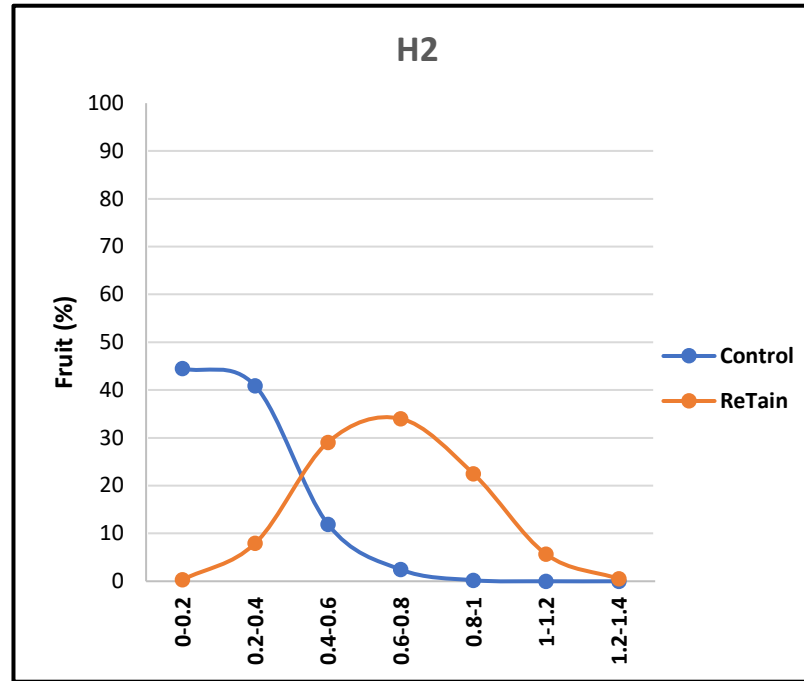
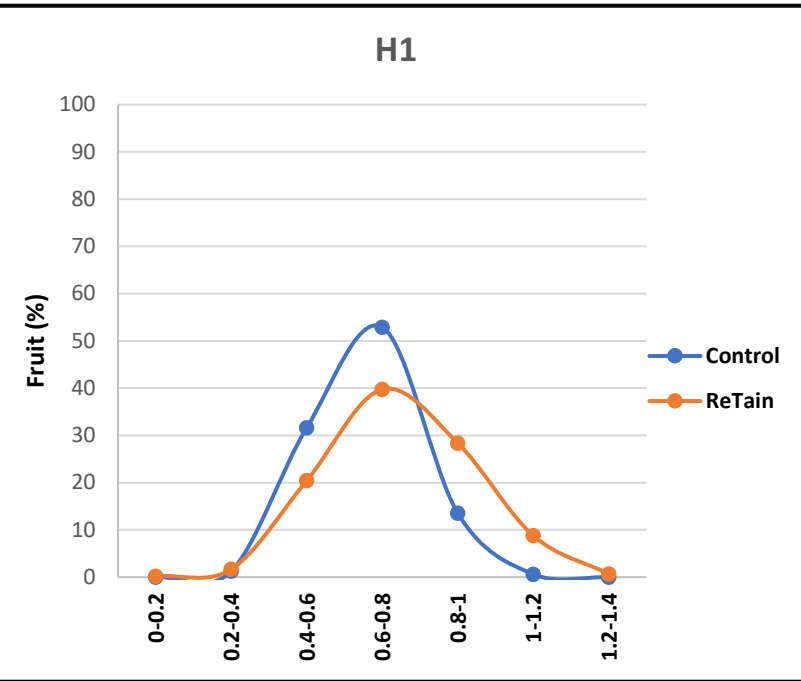
"Gala" ReTain- H3- 9/21/2022



ReTain applied 3 weeks before first harvest ($\frac{1}{2}$ pouch/ acre+ 0.05% surfactant) Brookfield Gala grafted on M9 Spray calculated based on tree row volume (TRV) High density tall spindle.

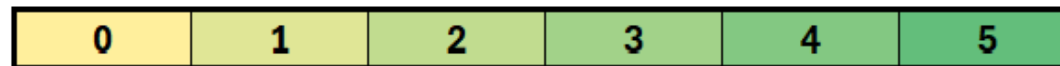
Harvest and ReTain effects on distribution of fruit by I_{AD} value (21 days before harvest ReTain $\frac{1}{2}$ rate)

Harvest date: 9/7, 9/14, 9/21



DA meter: handheld instrument for non distractive measurements of Chlorophyll

Note: increasing the I_{AD} value means more chlorophyll



Watkins and Al Shoffe (2024), Fruit Quarterly

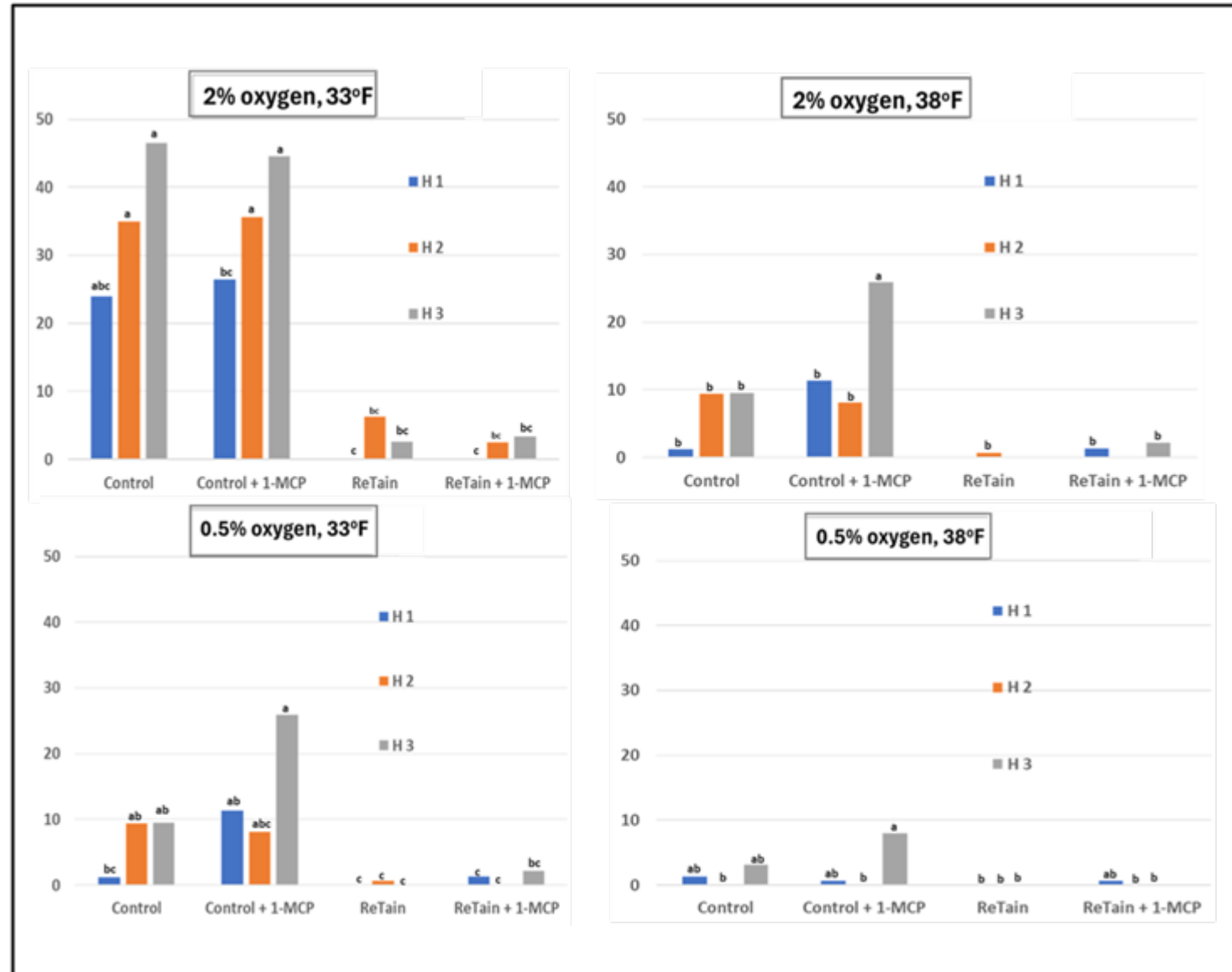
Stem end Flesh browning (SEFB %) after 8 months of storage

➤ ReTain delayed SEFB compared with control. **(15-18%)**

➤ 38°F delayed SEFB compared with 33°F. **(12%)**

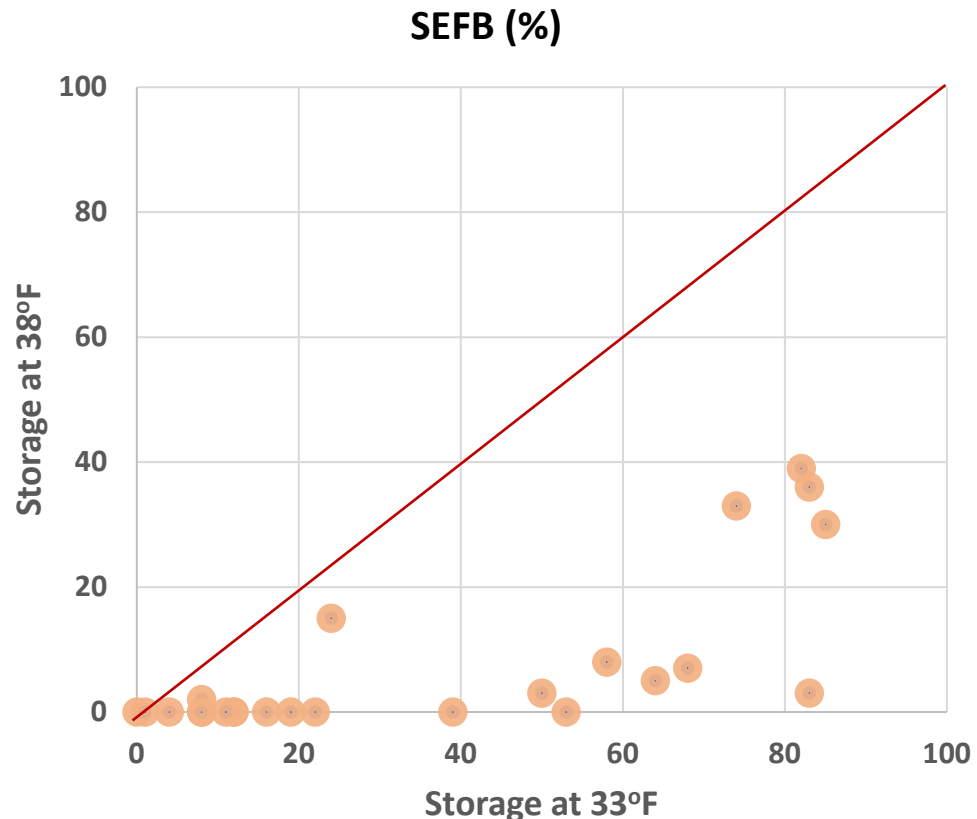
➤ 0.5% oxygen delayed SEFB compared with CA (2% oxygen). **(6%)**

➤ Advanced 1 week harvest increased SEFB **(3-4%)**



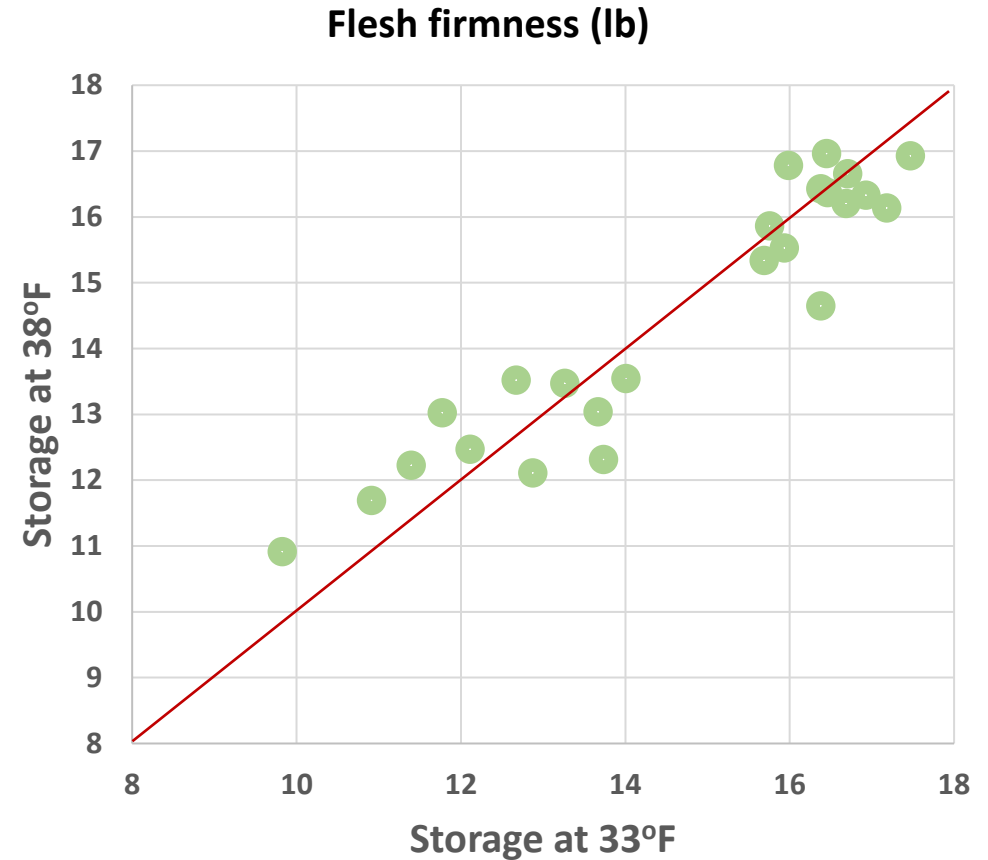
Stem end flesh browning

0.5% Oxygen / 1% carbon dioxide



High browning at 33°F compared with 38°F

12% difference



No effects on fruit firmness from the higher storage temperature (maintained fruit quality)

5. Best Practices for Long-Term Storage of 'Gala' Apples

Updated Recommendations for Long-Term Controlled Atmosphere Storage of Gala Apples

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Keywords: Gala, post harvest flesh browning, fruit quality, controlled atmosphere storage, plant growth regulators

Storage of Gala apples has become challenging as fruit plantings have increased, and as a consequence increasingly long storage times are required to market the crop. Physiological disorders that can develop during storage include stem end flesh browning (SEFB), flesh browning (FB) and core browning (Figure 1). As with most physiological disorders, incidences are highly variable across different orchard blocks. Browning of Gala typically starts in the stem end of the fruit (hence the name stem end flesh browning) but develops through the entire fruit. Both SEFB and FB are flesh breakdown disorders.

a half-rate of ReTain (0.25 g L⁻¹ = 0.033 oz per gallon) 21 days before the first harvest. Spray materials were prepared by mixing with 0.1% Silwet L-77 (Helena Chemical Company, Collierville, TN). The spray treatment was applied in the early morning using a CO₂ pressurized backpack sprayer (Bellspray, Opelousas, LA) fitted with a Tee Jet 8004VS flat fan nozzle (Spraying Systems, Wheaton, IL). Fruit were harvested from four trees per replicate on Sep-

This research was supported by the New York Apple Research and Development Program

Preharvest treatment of fruit with plant growth regulators with subsequent storage of 1-MCP-treated fruit at low oxygen and at 38°F is recommended for long term storage of Gala apples.

PGR applied at the correct time are critical for long term storage of Gala apples

Store Gala at 38°F in CA (will benefit fruit without PGR treatment)

Postharvest 1-MCP recommended and has more benefits with preharvest ReTain.

0.5% oxygen (1% carbon dioxide) recommended for long term storage.

2% oxygen (1% carbon dioxide) for standard CA

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- ❖ NY Farm Viability Institute
- ❖ NIFA Multistate Project (NE1836)
- ❖ NIFA Hatch project
- ❖ USDA-SCRI



Thank you for your attention

Questions?
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